National Aeronautics and Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

January 4, 2024

Reply to Attn of: AS01/SSFL

Mr. Steven Becker
SSFL Project Director/Project Coordinator
California Department of Toxic Substances Control
8800 Cal Center Drive
Sacramento, California 95826

Subject: Final Phase 1 Groundwater Corrective Measures Study, Santa Susana Field Laboratory, Ventura County, California

Dear Mr. Becker:

The National Aeronautics and Space Administration (NASA) is providing this final Phase 1 Groundwater Corrective Measures Study (CMS), Santa Susana Field Laboratory, Ventura County, California document for the California Department of Toxic Substances Control's (DTSC's) approval. This document addresses DTSC's and the Los Angeles Regional Water Quality Control Board (LARWQCB) comments on the September 2020 draft CMS and subsequent CMS comment discussion meetings (a response to comment table is included as Appendix J in the document). This report is uploaded electronically to EnviroStor.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Please contact me at (202) 714-0496 or at peter.d.zorba@nasa.gov if you have any questions regarding this document.

Sincerely,

Peter Zorba
Director, NASA SSFL
NASA Site Management Office
Santa Susana Field Laboratory

Attachment (electronic file deliverable)

cc:
Mindy Mathias/DTSC (1 hard copy, electronic/EnviroStor)
Paul Carpenter/DTSC (electronic/EnviroStor)
Tom Seckington/DTSC (1 hard copy, electronic/EnviroStor)
William Martinez/DTSC (electronic/EnviroStor)
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Tanya Brosnan/DTSC (electronic/EnviroStor)
Randy Dean/CH2M HILL (1 hard copy, electronic)

NASA Phase 1 Groundwater Corrective Measures Study

Final

January 2024

Prepared for

National Aeronautics and Space Administration

Professional Engineer's Certification

I certify that this document was prepared by me or under my direct control and personal supervision, based on knowledge and information in general accordance with commonly accepted standards of practice. This certification is not a guarantee or warranty, either expressed or implied.

James D. Hartley, P.E.

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CA Registration Number

Dec 15, 2023
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Executive Summary

This Phase 1 groundwater Corrective Measures Study (CMS) addresses groundwater in three high trichloroethene (TCE) concentration source areas and seep locations north of the Building 204 and Expendable Launch Vehicle (B204/ELV) Area of Impacted Groundwater (AIG) and the southwestern drainage in the Delta Area at the National Aeronautics and Space Administration (NASA) Santa Susana Field Laboratory (SSFL) site. California Department of Toxic Substances Control (DTSC) and NASA agreed to the following format with respect to the components of the Phase 1 groundwater CMS, which was implemented in the 2020 revision of the Phase 1 groundwater CMS (NASA 2020g):

- **High TCE Concentration Areas in Groundwater:** The high TCE concentration areas in groundwater were presented in the 2018 groundwater CMS (NASA 2018a) and were defined as areas in groundwater where TCE concentrations exceeded 10,000 micrograms per liter (µg/L). These areas will be collectively referred to as the Phase 1 groundwater areas. When it is necessary to refer to each of the areas individually, they will be referred to as the ND-136 target treatment area (TTA), the WS-09 TTA, and the C-6 TTA. While these TTAs are designated by the names of wells with the highest concentrations in their respective areas, the footprints of the TTAs are larger than just the well.
- **High TCE Concentration Areas in Bedrock Vapor:** High TCE concentration areas in soil and bedrock vapor were defined as vapor concentrations that could potentially result in groundwater exceeding concentrations of 10,000 µg/L. Bedrock vapor collected near wells ND-136 in the Alfa Area is identified as TTAs. While the former Liquid Oxygen (LOX) Plant ND-112 area was initially considered as an area requiring treatment in the Phase 1 groundwater CMS, samples collected after the 2015 bedrock vapor extraction (BVE) study showed that concentrations were significantly reduced (NASA 2020g). Samples collected in 2021 confirmed the reduced concentration at this location were still significantly lower than the Phase 1 groundwater CMS bedrock vapor treatment threshold (NASA 2022a). Given this, the former LOX Plant area is not further considered for treatment in this Phase 1 groundwater CMS, and it will be reevaluated in the Phase 2 groundwater CMS. NASA submitted a former LOX Plant Area BVE pilot study work plan to DTSC in August 2023 to describe rationale for further study at this location to support Phase 2 remedial evaluations (NASA 2023b).
- **Seep Areas:** Seeps of discharging groundwater were assessed in the areas north of the B204/ELV AIG, as well as in the southern component of the Coca/Delta AIG near the Burro Flats Fault Zone. DTSC and NASA agreed to include an evaluation of seep alternatives in the Phase 1 groundwater CMS because they represent areas of potential offsite migration. These respective areas will be referred to as the Northern Seep Area and Southern Seep Area in this report. No unacceptable risks were identified in the Northern Seep Area and groundwater concentrations are below regulatory levels. However, at the request of DTSC, alternatives were developed for the Northern Seep Area as a contingency. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA.

A summary of relevant facts related to the TTAs described previously is presented in the most recent Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) (NASA 2020a). The RFI presented information on site history, physical characteristics of the site, and a conceptual site model for each AIG. After the RFI was accepted by DTSC, NASA and DTSC agreed there was adequate data available to support completion of a CMS.

The Phase 1 groundwater CMS focuses on the highest concentration, highest-risk source areas in the SSFL AIGs, which are associated with chlorinated ethenes (TCE, dichloroethene isomers, and vinyl chloride), which drive over 99% of the groundwater risk (NASA 2021). This CMS is referred to as the Phase 1 groundwater CMS because there is adequate information for three groundwater source areas, one bedrock vapor source area, and two seep areas that pose the highest site risk to proceed to the remedy evaluation phase of the RCRA process as the first comprehensive remedial step toward achieving cleanup goals for groundwater and compliance with federal, state, and local laws. Initiating the recommended Phase 1 groundwater CMS alternatives will result in accelerating the implementation of groundwater corrective actions while NASA completes additional preparatory work on the Phase 2 groundwater CMS. Some elements of the Phase 1 groundwater CMS are integral to supporting work on the Phase 2 groundwater CMS, which will address the following:

- Evaluation of other chemicals of concern (COCs)
- Evaluation of other NASA groundwater areas and media within the domain of the near-surface groundwater and Chatsworth Formation Operable Unit
- Evaluation of implemented Phase 1 remedies on source areas and downgradient plumes
- Coordination, evaluation, and cleanup of contaminated groundwater plumes that are comingled with other SSFL responsible party (for example, Boeing) contaminated groundwater plumes
- Assessment of the feasibility of groundwater remediation to background levels (related to State Water Resources Control Board Resolution No. 92-49 that requires cleanup to background conditions unless the Regional Water Quality Control Board, Los Angeles Region (LARWQCB) makes a determination of technological or economic infeasibility)

  The Phase 1 and Phase 2 CMSs are linked to complete the CMS phase of work for NASA SSFL groundwater; the CMS phase of work will not be completed until both the Phase 1 and Phase 2 CMS are completed. Some elements of the Phase 1 and Phase 2 CMS may be conducted concurrently to expedite groundwater remediation. NASA is committed to completing the Phase 1 and Phase 2 CMS work and initiating groundwater remedial actions as soon as possible. NASA is currently working with DTSC and the LARWQCB to define the work that must be completed concurrent with Phase 1 Corrective Measures Implementation before initiating the Phase 2 groundwater CMS (for example, additional sampling and monitoring, evaluation of the groundwater interim measure extraction well performance, evaluation of BVE and enhanced in situ bioremediation (EISB) pilot study results, defining final cleanup levels). However, addressing contaminated soil is outside the scope of the Phase 1 and Phase 2 groundwater CMSs and is addressed separately.

Subsequent to the RFI, human health and ecological risk assessments were performed for the former LOX Plant, B204/ELV, Alfa/Bravo, and Coca/Delta AIGs to assess whether exposure to groundwater, deep soil and bedrock vapor, seeps, and springs at the four AIGs poses a potential risk to human or ecological health that requires conducting remedial actions or establishing land use controls (LUCs). Comments were received on the draft human health and ecological risk assessments (NASA 2017a, 2021); an updated risk assessment that addressed these comments was submitted in January 2021 (NASA 2021). Exposure parameters and toxicity values for the human health risk assessments were obtained from the Standardized Risk Assessment Methodology Revision 2 Addendum (Stantec 2022) and updated based on additional U.S. Environmental Protection Agency and DTSC guidance (EPA 2014a, 2015, 2023; DTSC 2019a, 2019b, 2021, 2022; Cal-EPA 2023). Additional DTSC comments were received on the 2021 risk assessment in October 2022, and a revised risk assessment is still in progress to address additional DTSC comments received on NASA responses to comments in October 2023 (NASA 2023a).

The conclusions of the risk assessment show there are multiple COCs in groundwater and surface water. Because the focus of this CMS is only on high TCE concentration areas, the only COCs identified for this CMS are TCE and its daughter products. The other COCs identified in the risk assessment will be addressed in the Phase 2 CMS.

Ecological risk was evaluated in the B204/ELV and Coca/Delta AIGs by comparing seep (and seep well cluster data where surface water data was not available) to surface water benchmarks and background values from the Standardized Risk Assessment Methodology Revision 2 (MWH 2014; Stantec 2022). No seeps or springs are associated with the Alfa/Bravo AIG, and samples from seeps associated with the former LOX Plant AIG were nondetect for chemicals of ecological concern (COECs), so ecological risk assessments were not completed for these AIGs. The ecological risk assessments include a screening-level evaluation of ecological and chemical data to determine the potential for ecological exposure and effects from surface water collected from seeps downgradient of the two AIGs, using either seep water data (Coca/Delta AIG; Southern Seep Area) or shallow seep well cluster data that were assumed to represent discharge to surface water in the absence of recent seep water data (B204/ELV AIG; Northern Seep Area). No analytes in shallow groundwater collected from seeps downgradient of the B204/ELV AIG (Northern Seep Area) were retained as COECs. Risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low (NASA 2023a). No analytes in surface water collected from seeps downgradient of the Coca/Delta AIG (Southern Seep Area) were retained as COECs, and risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low.

Final cleanup criteria have not been defined for NASA SSFL groundwater. State Water Resources Control Board Resolution No. 92-49 requires cleanup to background conditions unless the Regional Water Board makes a determination of technological or economic infeasibility. Associated with completing the Phase 2 CMS, NASA will prepare a Technical and Economic Feasibility Analysis to support cleanup levels for the Phase 2 CMS. The Technical and Economic Feasibility Analysis will evaluate results of ongoing onsite treatment to support conclusions and recommendations. In the absence of final cleanup levels for this Phase 1 CMS, the Phase 1 CMS will use California maximum contaminant levels (MCLs) as a target cleanup goal for groundwater contaminated with TCE and its daughter products for the Phase 1 CMS COCs. California MCLs are protective of human health and are generally considered technically practical and are presented in Table ES-1.

Table ES-1. Media Cleanup Objectives for Phase 1 Groundwater and Seep Water
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Chemical Analyte	Value (µg/L)	Source	B204/ELV AIG Northern Seep Area[a]	Southern Seep Area	ND-136 TTA	WS-09 TTA	C-6 TTA
Trichloroethene	5	Federal MCL	x	x	x	x	x
cis-1,2-Dichloroethene	6	CA MCL	x	x	x	x	x
trans-1,2-Dichloroethene	10	CA MCL	x	x	x	x	x
Vinyl Chloride	0.5	CA MCL	x	x	x	x	x

[a] No exceedances of P1 CMS MCOs reported.

µg/L = microgram(s) per liter

CA = California

TTA = target treatment area

Additionally, Phase 1 MCOs, Phase 1 cleanup objectives, and relevant federal, state, and local laws were identified in this report. Final MCOs will be developed in the Phase 2 groundwater CMS.

With the information available, potential technologies for groundwater areas and seep areas were identified and screened for effectiveness and implementability. The technologies evaluated and screened are presented in Table ES-2; those technologies that were retained after screening (bold in Table ES-2) were considered for inclusion as corrective measure alternatives to be evaluated in greater detail.

Table ES-2. Technologies Screened for Target Treatment Areas
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

High TCE Concentration TTAs	Seep TTAs
In Situ Thermal Treatment	Permeable Reactive Barrier
EISB^	**EISB Barrier Treatment Zone^**
Thermally Assisted EISB^	Phytoremediation
ISCO^	Constructed Treatment Wetlands
Biosparging	**Hydraulic Control^**
Air Sparging	Fine Bubble Diffused Aeration
BVE^	**MNA^**
P&T^	--
In Situ Fracking	--
MNA^	--

Bold^ = Technologies that were retained after screening and were considered for inclusion as corrective measure alternatives to be evaluated in greater detail.
ISCO = in situ chemical oxidation
MNA = monitored natural attenuation
P&T = pump and treat

Following the technology screening, retained Phase 1 technologies were assembled into the following alternatives for Phase 1 groundwater areas:

- **Alternative 1: MNA and LUCs.** This alternative relies on natural attenuation, which has been demonstrated to be successful in some locations at SSFL (Section 2), and LUCs to prevent access to groundwater and limit future site use until MCOs are achieved. LUCs include institutional controls and engineering controls.
- **Alternative 2a: Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs.** This alternative has the technology components of Alternative 1 with the addition of BVE treatment at ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TTA) using EISB technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative 2b: Groundwater treatment with EISB and thermal heating, followed by MNA for groundwater, BVE for soil vapor, and LUCs.** These are the same treatment technologies described in Alternative 2a with the addition of heating the water prior to injection to facilitate faster microbial degradation.
- **Alternative 3: Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs.** This alternative has the technology components of Alternative 1 but also includes BVE treatment at ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TTA) using P&T technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative 4: Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs.** This alternative has the technology components of Alternative 1 but also includes BVE treatment at well ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TT) using ISCO technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.

The alternatives applied to the Northern Seep Area are considered contingency Phase 1 remedies because seep water and groundwater are below Phase 1 MCO concentrations (regulatory criteria) and do not represent unacceptable risk to human health and ecological receptors (however, seep areas will be revisited in the Phase 2 groundwater CMS for all potential COCs above background). The retained seep technologies were assembled into the following Phase 1 alternatives for the seep TTAs:

- **Alternative SP-1: MNA and LUCs.** This alternative relies on natural attenuation, which has been demonstrated to be successful in some locations at SSFL (Section 2), and LUCs to prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative SP-2: Hydraulic Control of Seep Water, MNA, and LUCs.** This alternative is similar to Alternative 3 (for the Phase 1 groundwater areas) in that contaminated groundwater is extracted and treated at the groundwater extraction and treatment system (GETS). Instead of targeting source areas, this technology is deployed to intercept contaminated groundwater before it expresses as seeps. This alternative includes MNA, which would be used after hydraulic control has achieved its practical application limits. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative SP-3: EISB, MNA, and LUCs.** This alternative is similar to Alternative 2a (for the high TCE concentration groundwater TTAs) in that EISB is used to enhance degradation of contaminants in the subsurface. However, instead of applying the EISB technology in a source area, EISB would be deployed upgradient of where contaminated groundwater is expressing as seep water. This deployment is expected to treat contaminated groundwater prior to it expressing as seeps. This alternative includes MNA, which would be used after EISB has achieved its practical application. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.

After alternatives were developed, the technology components of each alternative were further defined to address how each would be integrated into an overall Phase 1 alternative. Conceptual details regarding implementation, such as components, configurations, and reagent types, were addressed to support the detailed Phase 1 analysis of each alternative and the development of a cost estimate. Each Phase 1 alternative was evaluated against RCRA detailed evaluation screening criteria.

Each alternative was evaluated and scored; summary scores for each of the alternatives were evaluated and a comparative analysis is presented in the following sections. The scoring scale used is defined in Exhibit ES-1.

Exhibit ES-1. Semi-quantitative Scoring Criteria

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Effectiveness	Technology will not be effective at site	Technology has been proven to work at other sites, but there are significant challenges and uncertainties to overcome to achieve desired effectiveness	Technology has been proven to work at other sites, but there are numerous challenges and uncertainties to overcome to achieve desired effectiveness	Technology has been proven to work at other sites, but there are several challenges to overcome to achieve desired effectiveness	Technology is proven to work in conditions similar to the site. High confidence the technology will be effective
	1 **Unacceptable**	**2** **Unlikely to Work**	**3** **Equal Plus's and Delta's**	**4** **Likely to Work**	**5** **High Confidence**
Implementability	Technology is not implementable at site	There is low likelihood that implementation challenges can be overcome	There are numerous implementation challenges and some may be difficult to overcome	There are some challenges to implementation, but they can likely be overcome with effective planning procedures	Minimal implementation challenges expected

Summary of Detailed Evaluation of Alternatives, Comparative Analysis of Balancing Criteria, and Recommended Alternatives for Groundwater

Detailed Analysis Summary of Groundwater Alternatives

Exhibit ES-2 provides a scoring summary of the detailed analysis of alternatives. The first three criterion are considered performance criteria that alternatives must achieve to be considered. The remaining criteria are balancing (decision) criteria that decision makers can use to select an alternative. The community acceptance criterion will be factored into the decision after the public has had an opportunity to review and comment on the selected remedies. The state acceptance criterion will be considered in the final decision of which alternative to implement.

Exhibit ES-2. Summary of Detailed Analysis Scores for Groundwater Alternatives

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alternative 1 - MNA and LUCs	Alternative 2a - EISB, BVE, MNA, and LUCs	Alternative 2b - Thermally Assisted EISB, BVE, MNA, and LUCs	Alt 3 - P&T, BVE, MNA, and LUCs	Alt 4 - ISCO, BVE, MNA, and LUCs
Protection of Human Health and Environment	3.0	4.0	4.0	4.0	3.5
Attain Media Cleanup Objectives	1.0	3.0	3.0	3.0	2.0
Control Source Releases	1.0	5.0	5.0	5.0	5.0
Long-term Effectiveness	1.7	5.0	5.0	5.0	4.7
Reduction in Toxicity, Mobility, and Volume	1.5	4.4	4.4	4.9	3.6
Short-term Effectiveness	4.7	3.8	3.7	2.7	3.7
Implementability (ND-136 and WS-09)	4.0	4.8	4.6	5.0	4.8
Implementability (C-6)	4.0	4.5	4.4	5.0	4.5
Cost	5.0	2.5	1.5	3.8	2.0
Total Score (ND-136 and WS-09)	**21.9**	**32.5**	**31.2**	**33.4**	**29.3**
Total Score (C-6)	**21.9**	**32.2**	**31.0**	**33.4**	**29.0**

Comparative Analysis of Groundwater Alternatives

The total score on Exhibit ES-2 differentiates between total scores for ND-136 and WS-09 and the C-6 TTAs. This is because there are slight differences in scores for construction implementability challenges for the in situ alternative (Alternatives 2a, 2b, and 4) because of the presence of the RCRA cap at the Delta Skim Pond.

All alternatives were considered reasonably protective of human health and the environment. Alternative 1 does not employ active treatment. However, the TTAs are located well within the NASA-administered areas and LUCs can prevent pathways to human health. No ecological risks were identified for the TTAs.

Uncertainty surrounds the amount of contaminant reduction that active treatment can achieve. As discussed in Section 4.2, median concentration reductions for a groundwater treatment area are anticipated to be approximately 91%. Considering the complexities of the hydrogeology at the site and the amount of contaminant mass in the rock matrix, this level of concentration reduction would be challenging. Higher levels of concentration reduction (greater than 99.99%) would be required to achieve MCOs. Alternative 1 scored the lowest for this criterion because it does not employ active treatment. While the rest of the alternatives do employ active treatment, it is uncertain if and when MCOs can be achieved. Alternative 4 was scored lower than the other active treatment alternatives because of concerns about limited oxidant persistence and its effect on treatment.

All active treatment alternatives were comparable in addressing the sources of the releases. Alternative 1 does not control the source of release through treatment and was scored lower for this criterion.

For long-term effectiveness, all four active treatment alternatives scored similarly for this criterion. While the sub-category criteria varied slightly among the four alternatives, the average score of the three sub-criteria that make up long-term effectiveness varied between 4 and 5 for the four active treatment alternatives, with Alternatives 2a, 2b, and 3 scoring the highest. Alternative 1 scored the lowest for this criterion because of lack of active treatment.

For reduction of toxicity, mobility, and volume, there was a greater separation of scores. Alternative 1 scored the lowest across the six sub-criteria. Alternatives 2a, 2b, and 3 scored comparably, with Alternative 3 scoring slightly higher, mainly because it removes contaminants and does not have treatment by-products. Alternative 4 scored the lowest of the active treatment alternatives because of concerns related to oxidant persistence and the ability of the ISCO technology to reduce contaminant concentrations.

For short-term effectiveness, Alternative 1 scored the highest because of its lesser impact on the community, workers, and the environment. It is not uncommon for low infrastructure alternatives to score high with this criterion because it has the least amount of activity that could affect the community and workers and minimal impacts on the environment. Alternatives 2a, 2b, and 4 scored comparably. Alternative 3 scored the lowest because of the potential increase in worker risk associated with the mechanical and treatment components of the alternative and the environmental impacts related to energy and material usage.

For implementability, all alternatives scored relatively high. Alternative 1 scored the lowest because of the expected administrative challenge of it being an acceptable alternative to regulators. The other four alternatives scored nearly the same. The difference in scoring for the C-6 TTA and the WS-09 and ND-136 is related to additional challenges associated with implementing an in situ remedy in the area of the RCRA cap installed at the Delta Skim Pond. While these scores were slightly lower for the C-6 TTA, the relative difference between alternatives for this TTA and the other TTAs were similar.

The capital costs for Alternatives 2a, 2b, and 4 are the highest (and thus scored the lowest), with costs ranging between approximately $11.4 and $14.6 million. Capital costs for Alternative 3 were relatively low because much of the infrastructure for this alternative is already in place. Alternative 1 had the lowest capital costs because the monitoring network is already in place.

For operation and maintenance (O&M) costs, all five alternatives have similar monitoring costs. The same network and frequency of monitoring applies to all the alternatives. Alternatives 2a and 3 had comparable O&M costs, as did Alternatives 2b and 4. Alternative 1 had the lowest O&M costs because active treatment is not employed.

Recommended Alternative for Groundwater

Overall, Alternatives 2a and 3 scored the highest, and Alternative 2b scored slightly lower. Alternative 4 scored the lowest of the active treatment alternatives, and Alternative 1 scored the lowest overall. Given the limited differentiation between Alternatives 2a and 3, both alternatives are considered acceptable and appropriate for implementation at the source areas. Infrastructure for Alternative 3 currently exists at the ND-136 and WS-09 areas. A new extraction well and conveyance line is being designed for implementation at the C-6 area to provide more groundwater flow to the GETS system, which will increase the treatment systems operational flexibility. Infrastructure for Alternative 2a currently exists at the ND-136 area because of the ongoing operation of the EISB pilot study.

Based on the previously described information, NASA recommends the following:

- Alternative 3 is the recommended alternative for the WS-09 TTA because infrastructure for this alternative is currently in operation at this location.
- Alternative 3 is the recommended alternative for the C-6 area. As noted in the detailed analysis, the location of the Delta Skim Pond may limit well installation locations for Alternatives 2a, 2b, and 4. This TTA is located very close to the GETS conveyance pipeline, so infrastructure for Alternative 3 is nearby.
- Alternative 2a is the recommended alternative for the ND-136 area. While this location has infrastructure for both Alternatives 2a and 3, Alternative 2a was selected to provide another treatment alternative that was not reliant on GETS operations. However, if the EISB pilot test results are evaluated to be less optimal than Alternative 3, Alternative 3 may be implemented in the future as the TTA already has infrastructure for this alternative in place.

Summary of Detailed Evaluation of Alternatives, Comparative Analysis of Balancing Criteria, and Recommended Alternatives for Seep Water

Detailed Analysis Summary of Seep Water Alternatives

As with Exhibit ES-2, Exhibit ES-3 provides a scoring summary of the detailed analysis of alternatives. The first two criterion are considered performance criteria that alternatives must achieve to be considered. For the seep alternatives, the "Control Source Releases" was not considered applicable because TTAs for the two site areas are downgradient of sources. The remaining criteria are balancing (decision) criteria that decision makers can use to select an alternative. The community acceptance criterion will be factored into the decision after the public has had an opportunity to review and comment on the selected remedies. The state acceptance criterion will be considered in the final decision of which alternative to implement.

Exhibit ES-3. Summary of Detailed Analysis Scores for Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Decision Criterion	Alternative SP1 (North) - Contingency, MNA and LUCs	Alternative SP1 (South) - MNA and LUCs	Alternative SP2 (North) - Contingency, Hydraulic Containment and LUCs	Alternative SP2 (South) - Hydraulic Containment and LUCs	Alternative SP3 (North) - Contingency, EISB Treatment Zone and LUCs	Alternative SP3 (South) - EISB Treatment Zone and LUCs
Protection of Human Health and Environment	5.0	5.0	5.0	5.0	3.0	3.0
Attain Media Cleanup Objectives	1.0	1.0	3.0	3.0	2.0	2.0
Long-term Effectiveness	4.3	3.7	4.7	5.0	4.3	4.3
Reduction in Toxicity, Mobility, and Volume	2.0	2.0	4.8	4.9	4.0	4.2
Short-term Effectiveness	4.7	4.7	2.7	2.7	3.7	3.7
Implementability	5.0	4.0	5.0	5.0	4.5	5.0
Cost	5.0	5.0	2.5	4.0	2.0	5.0
Total	**27.0**	**25.4**	**27.7**	**29.6**	**23.5**	**27.2**

Comparative Analysis of Seep Water Alternatives

Alternatives SP-1 and SP-2 were considered protective of human health and the environment because concentrations are below MCOs in seep water and no unacceptable risks to humans or ecological receptors were identified. Alternative SP-3 scored lower because of the potential concern related to mobilization of naturally occurring metals with EISB reducing conditions that could daylight in seeps and negatively impact ecological receptors.

The confidence in the ability to treat COCs in groundwater that could express as seep water is relatively low with all three alternatives. In the Northern Seep Area, Alternative SP-3 is unlikely to accomplish treatment goals because halorespiring bacteria require elevated concentrations of chlorinated ethenes to create a critical mass of microbes that can degrade the contaminants and these concentrations do not exist in the Northern Seep Area. Alternative SP-2 scored the highest with respect to attaining MCOs because it was considered more effective in removing groundwater contaminants before they could migrate downgradient.

The control of sources criterion was not evaluated for the seep alternatives; sources that are upgradient of seeps will be addressed in the Phase 2 groundwater CMS.

For long-term effectiveness, Alternative SP-2 scored the highest because there is greater confidence in the effectiveness of hydraulic containment, though Alternative SP-3 scored only slightly lower. The main difference in these two alternatives is that Alternative SP-2 removes contaminants, whereas Alternative SP-3 treats the contaminants in situ, thereby creating daughter products, which could be managed with proper operation. Alternative SP-1 scored lower than the other two alternatives. There is a difference in scoring for Alternative SP-1 for the Northern and Southern Seep Areas for MNA, which considers MNA more reliable in the Northern Seep Area because the concentrations are already low, compared to the Southern Seep Area, where concentrations in shallow groundwater are above groundwater screening levels.

For reduction of toxicity, mobility, and volume, Alternative SP-1 scored the lowest across the six sub-criteria evaluated. Alternatives SP-2 and SP-3 had comparable scores, with Alternative SP-2 scoring higher because of marginally better scores for toxicity, mobility, volume, and types of treatment residuals.

For short-term effectiveness, all three alternatives scored the same for community protection. Alternative SP-2 scored the lowest for this criterion because of a greater environmental footprint and risks to workers. Alternative SP-3 was scored between Alternatives SP-1 and SP-2 because the treatment technology has less worker risk and a smaller environmental footprint than Alternative SP-2.

For implementability, all three alternatives received a score of 5 in each sub-criterion category, with the exception of Alternative SP-1 in the Southern Seep Area, which is unlikely to be acceptable by regulators.

The capital costs for Alternatives SP-1, SP-2, and SP-3 for the Southern Seep Area were low, less than $250,000. The monitoring network is already in place for the seep TTAs. The extraction well for Alternative SP-2 is already in place and operating. Well ND-138A will be used for injection of EISB (ND-138A would be repurposed as an EISB injection well) for Alternative SP-3. The capital costs for Alternatives SP-2 and SP-3 ($3.8 million and $6.4 million, respectively) in the Northern Seep Area were both high because of the need to implement a groundwater extraction network for Alternative SP-2 and an EISB injection well network for Alternative SP-3.

The O&M monitoring costs for the seep alternatives are comparable because the monitoring well network and sampling frequency are the same. The O&M costs for Alternative SP-3 in the Southern Seep Area are the lowest of the active treatment alternatives because the only cost beyond annual sampling is periodic injection of EISB treatment reagents into two injection wells.

The O&M life-cycle costs for Alternatives SP-1 and SP-3 in the Southern Seep Area are less than $710,000. The higher O&M costs for Alternative SP-2 are related to GETS costs, with O&M life-cycle costs in the Northern Seep Area estimated at approximately $2 million and in the Southern Seep Area at $2.2 million. The costs are higher for the Southern Seep Area because of the higher pumping rate from well ND-138A, which is about three times greater than the combined pumping rate from the three extraction wells in the Northern Seep Area. For Alternative SP-3, the Northern Seep Area life-cycle O&M

costs are much higher than the Southern Seep Area ($2.2 million versus $709,000) because the 10 injection wells require 10 times the EISB treatment reagent as that required for the same alternative in the Southern Seep Area.

Recommended Alternative for Seep Water

At the request of DTSC, alternatives were developed for the Northern Seep Area as a contingency. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA. DTSC and NASA agreed that enough information is available to evaluate alternatives for the previously described Phase 1 groundwater CMS TTAs and could result in accelerating the implementation of groundwater actions while NASA completes additional work on the Phase 2 groundwater CMS. As implementing a contingency remedial action in the Northern Seep Area will be dictated by future offsite contamination being reported, it is premature to select a recommended alternative for the Northern Seep Area. The alternative recommendation for this area can be better made by DTSC and NASA after the need for remedial action is defined and the characteristics of the contamination are better known. For this reason, it is not appropriate to recommend a seep alternative for the Northern Seep Area at this time.

For the Southern Seep Area, Alternative SP-2 scored the highest, followed by Alternative SP-3; Alternative SP-1 scored the lowest. Alternative SP-2 was rated superior to Alternative SP-3 for protection of human health and the environment, attaining MCOs, long-term effectiveness, and reduction in toxicity, mobility, and volume. Alternative SP-3 was rated better for short-term effectiveness and cost. The two leading alternatives were considered comparable for implementability. Given this, and considering the infrastructure for Alternative SP-2 is already in place in the Southern Seep Area, Alternative SP-2 is the preferred alternative for the Southern Seep Area.

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Acronyms and Abbreviations

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
μg/L	microgram(s) per liter
$\mu g/m^3$	microgram(s) per cubic meter
μM/year	micromole(s) per year
ABFF	Alfa Bravo Fuel Farm
ABSP	Alfa Bravo Skim Pond
AGC	area of groundwater concern
AIG	area of impacted groundwater
AOC	Administrative Order on Consent
AP	Ash Pile
AST	aboveground storage tank
B204	Building 204
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
Boeing	The Boeing Company
BVE	bedrock vapor extraction
CCR	*California Code of Regulations*
CDFF	Coca Delta Fuel Farm
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFGW	Chatsworth Formation groundwater
CFOU	Chatsworth Formation Operable Unit
CFR	*Code of Federal Regulations*
CMD	corrective measures design
CMI	Corrective Measures Implementation
CMS	corrective measures study
CO_2	carbon dioxide
COC	chemical of concern
COEC	chemical of ecological concern
CSIA	compound-specific isotope analysis
CVOC	chlorinated volatile organic compound
DCA	dichloroethane
DCE	dichloroethene

DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DRO	diesel range organics
DTSC	California Department of Toxic Substances Control
EIS	Environmental Impact Statement
EISB	enhanced in situ bioremediation
ELCR	excess lifetime cancer risk
ELV	Expendable Launch Vehicle
EPA	U.S. Environmental Protection Agency
ERD	enhanced reductive dechlorination
ERH	electrical resistance heating
ESA	environmentally sensitive area
ESAAP	Environmentally Sensitive Area Action Plan
ESTCP	Environmental Security Technology Certification Program
EVO	emulsified vegetable oil
feet/day	feet per day
FEIS	Final Environmental Impact Statement
FLUTe	Flexible Liner Underground Technology
foot/foot	foot per foot
ft^2/day	square foot (feet) per day
GETS	groundwater extraction and treatment system
gpm	gallon(s) per minute
GSA	U.S. General Services Administration
GSL	groundwater screening level
HHRA	human health risk assessment
HI	hazard index
hp	horsepower
HSU	hydrostratigraphic unit
HWSA	Hazardous Waste Storage Area
IC	institutional control
in. H_2O	inch(es) of water
in. Hg	inch(es) of mercury
ISCO	in situ chemical oxidation
ISTT	in situ thermal treatment
ITRC	Interstate Technology & Regulatory Council

kg	kilogram(s)
$KMnO_4$	potassium permanganate
LARWQCB	Regional Water Quality Control Board, Los Angeles Region
LGAC	liquid-phase granular activated carbon
LOX	liquid oxygen
LUC	land use control
MBT	molecular biological tool
MCL	maximum contaminant level
MCO	media cleanup objective
mg/L	milligram(s) per liter
MNA	monitored natural attenuation
msl	mean sea level
NAA	North American Aviation
NAPL	nonaqueous phase liquid
NASA	National Aeronautics and Space Administration
NDMA	N-nitrosodimethylamine
NEPA	National Environmental Policy Act
NFZ	North Fault Zone
NGVD 29	National Geodetic Vertical Datum of 1929
NOD	natural oxidant demand
NPV	net present value
NRC	National Research Council
NRHP	National Register of Historic Places
NSGW	near-surface groundwater
NSR	non-strippable residue
O&M	operation and maintenance
OoM	order(s) of magnitude
ORO	oil range organics
OSWER	Office of Solid Waste and Emergency Response
P&T	pump and treat
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PCP	Post-Closure Permit
PFAS	per- and polyfluoroalkyl substances
PLF	Propellant Load Facility

PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
ROD	Record of Decision
RSL	regional screening level
RWQCB	regional water quality control board
SBGR	subgrade biogeochemical reactor
scfm	standard cubic foot (feet) per minute
SCM	site conceptual model
SEE	steam-enhanced extraction
SPA	Storable Propellant Area
SSFL	Santa Susana Field Laboratory
STP	Sewage Treatment Plant
SVE	soil vapor extraction
SWMU	solid waste management unit
TCDD	tetrachlorodibenzoparadioxin
TCE	trichloroethene
TCH	thermal conduction heating
TCP	trichloropropane
TEFA	Technical and Economic Feasibility Analysis
TEQ	toxicity equivalent quotient
TISR	thermal in situ sustainable remediation
TTA	target treatment area
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound
WDR	Waste Discharge Requirements
WQSAP	groundwater quality sampling and analysis plan

1. Introduction

In August 2007, the National Aeronautics and Space Administration (NASA), The Boeing Company (Boeing), the U.S. Department of Energy (DOE), and the California Department of Toxic Substances Control (DTSC) signed a Consent Order for Corrective Action (DTSC Docket No. P3-07/08-003) (2007 Consent Order; DTSC 2007) that addressed the cleanup of soil (referred to as the Surficial Media Operable Unit) and groundwater (referred to as the Chatsworth Formation Operable Unit [CFOU]) at Santa Susana Field Laboratory (SSFL) in Ventura County, California. In 2010, NASA and DTSC executed an Administrative Order on Consent (AOC) for Remedial Action (DTSC Docket No. HAS-CO-10/11-038) (DTSC 2010) that provides additional requirements for the cleanup of chemical of concern (COC)-impacted soil on the NASA-administered areas of SSFL.

In August 2018, the *NASA Groundwater Corrective Measures Study, Santa Susana Field Laboratory, Ventura County, California* (2018 groundwater CMS) (NASA 2018a) was submitted in fulfillment of the requirements of the 2007 Consent Order (DTSC 2007). The CMS summarized the key issues related to COCs in the near-surface groundwater (NSGW) and the CFOU, which comprises Chatsworth Formation groundwater (CFGW) and the unsaturated unweathered (competent) bedrock, at NASA's SSFL in Ventura County, California.

In January 2020, the DTSC and California Regional Water Quality Control Board, Los Angeles Region (LARWQCB) provided comments on the 2018 groundwater CMS (NASA 2018a). In January 2020, DTSC also provided comments on the area of impacted groundwater (AIG) human health and ecological risk assessments, which were submitted for regulatory review in June 2017 (NASA 2017a). A revised AIG human health and ecological risk assessment was submitted in January 2021 (NASA 2021), with additional DTSC comments received on NASA's comment responses in October 2022. Updated AIG human health and ecological risk assessments are currently being prepared to address DTSC comments and support the CMS (NASA 2023a).

Following the receipt of regulatory comments on the 2018 groundwater CMS (NASA 2018a), NASA met with DTSC several times to review the comments and discuss the best way to resolve them. One outcome of these meetings was to break up the NASA SSFL groundwater CMS into two separate CMS reports, specifically, a Phase 1 groundwater CMS and Phase 2 groundwater CMS. Each report would focus on specific areas and restoration objectives. The draft Phase 1 groundwater CMS (NASA 2020g) was submitted in September 2020 and NASA worked iteratively with DTSC to address comments on this document. The response to comment matrix on the draft Phase 1 groundwater CMS (NASA 2020g) is included in Appendix J.

This CMS is referred to as the Phase 1 CMS because there is adequate information for three groundwater source areas, one bedrock vapor source area, and two seep areas that pose the highest site risk to proceed to the remedy evaluation phase of the Resource Conservation and Recovery Act of 1976 (RCRA) process as the first comprehensive remedial step toward achieving cleanup goals for groundwater and compliance with federal, state, and local laws. The rationale for including the previously described areas in the Phase 1 CMS are described in this section. All other groundwater-related areas requiring NASA actions will be addressed in the Phase 2 groundwater CMS (discussed further in subsequent sections).

NASA will evaluate per- and polyfluoroalkyl substances (PFAS) on a separate track than the Phase 1 groundwater CMS because it is an emerging contaminant and final regulatory values are not yet set. PFAS may be included in the Phase 2 groundwater CMS, or other equivalent appropriate regulatory document, if there are promulgated maximum contaminant levels (MCLs) or California Notification Levels. This Phase 1 groundwater CMS has been prepared to address DTSC and LARWQCB comments to the original sitewide CMS submitted in 2018 (NASA 2018a) and the Draft Phase 1 CMS submitted in 2020 (NASA 2020g).

For the 2018 groundwater CMS, COCs were identified for the NASA-administered AIGs by completing human health and ecological risk assessments for exposure to groundwater, seeps, and bedrock vapor (NASA 2017a). In the 2018 groundwater CMS, overall cleanup objectives, media cleanup objectives (MCOs), and target treatment areas (TTAs) were identified.

Throughout this report, TTA is used to denote specific locations where an alternative will be implemented. It is typically defined by an area where an alternative will be implemented and is an important attribute of assessing remediation alternatives to demonstrate the footprint of remediation activities and estimated costs. While these TTAs are designated by the names of wells with the highest concentrations in these respective areas, the footprints of the TTAs are larger than just the well.

The technologies were initially screened based on the nature and extent of the COCs. Those technologies that passed the screening were assembled into alternatives and then evaluated using criteria established by RCRA. After RCRA criteria were considered, a comparative analysis of the alternatives was completed.

In October 2018, DTSC provided comments on the draft NASA Groundwater RCRA Facility Investigation (RFI) Report (NASA Groundwater RFI Report) submitted in May 2017 (NASA 2017b). The draft final NASA Groundwater RFI Report was submitted to DTSC in June 2020 (NASA 2020a) after substantial DTSC coordination and was finalized in November 2020 after receiving additional DTSC comments in July 2020.

In January 2020, DTSC and LARWQCB provided comments on the 2018 groundwater CMS (NASA 2018a). In January 2020, DTSC also provided comments on the AIG human and ecological risk assessments, which were submitted for regulatory review in June 2017 (NASA 2017a). A revised AIG human health and ecological risk assessment was submitted to DTSC in January 2021 (NASA 2021), with additional DTSC comments received in October 2022. NASA provided comments response and received an additional response letter in October 2023. Updated AIG human and ecological risk assessments are being prepared to address the additional DTSC comments and support the CMS.

DTSC and NASA agreed to the following format with respect to the components of the Phase 1 groundwater CMS, which was implemented in the 2020 revision of the Phase 1 groundwater CMS (NASA 2020g):

- **High Trichloroethene (TCE) Concentration Areas in Groundwater:** The high TCE concentration areas in groundwater were presented in the draft groundwater CMS (NASA 2018a) and were defined as areas in groundwater where TCE concentrations exceeded 10,000 micrograms per liter (µg/L). These wells were ND-136 in the Alfa Area, WS-09 in the Bravo Area, and C-6 in the Delta Area. These areas will be collectively referred to as the Phase 1 groundwater areas. When it is necessary to refer to each of the areas individually, they will be referred to as the ND-136 TTA, the WS-09 TTA, and the C-6 TTA in this report.
- **High TCE Concentration Areas in Bedrock Vapor:** High TCE concentration areas in soil vapor were defined as soil vapor concentrations that could potentially result in groundwater exceeding concentrations of 10,000 µg/L. ND-136 is the only location where bedrock vapor exceeds this concentration. This location will be referred to as the Phase 1 bedrock vapor extraction (BVE) area. While the ND-112 TTA location was initially considered as an area requiring treatment in the Phase 1 groundwater CMS, sampling completed after the 2015 pilot study showed that concentrations were significantly reduced. Samples collected in 2021 and 2022 confirmed the reduced concentrations at this location were still significantly lower than the Phase 1 groundwater CMS bedrock vapor treatment threshold; the highest concentration of TCE was 760,000 micrograms per cubic meter ($\mu g/m^3$) (NASA 2022a). Given this, the liquid oxygen (LOX) location is not further considered for treatment in

this Phase 1 CMS, and it will be reevaluated in the Phase 2 CMS. NASA submitted a former LOX Plant Area BVE pilot study work plan to DTSC in August 2023 (NASA 2023b) to describe the rationale for further study at this location. Results from this study will be incorporated into the Phase 2 groundwater CMS.

- **Seep Areas:** Seeps of discharging groundwater were assessed in the areas north of the Building 204/ Expendable Launch Vehicle (B204/ELV) AIG, as well as in the southern component of the Coca/Delta AIG. DTSC and NASA agreed to include an evaluation of seep alternatives in the Phase 1 groundwater CMS. These respective areas will be referred to as the Phase 1 Northern Seep Area and Southern Seep Area in this report. Seep and seep well clusters have been identified and/or installed in the general vicinity of the B204/ELV AIG associated with the Northern Seep Area, the majority of which occur outside the NASA SSFL Area 1 and II property boundaries to the north of the AIG (Section 2.3.3). Over the period of record, groundwater COCs have been detected at seep OS-08/S-25 and seep well SP-29C (Boeing 2015) and more recently at seep well SP-30D. The Southern Seep Area is defined by wells in the SP-890 cluster and is associated with the Coca/Delta AIG, this cluster is located upgradient of the Burro Flats Fault Zone.

The Phase 1 groundwater CMS focuses on the highest concentration, highest-risk source areas in the NASA SSFL AIGs that are associated with chlorinated ethenes (TCE, dichloroethene [DCE] isomers, and vinyl chloride [VC]), which drive over 99% of the groundwater risk (NASA 2021). For the purpose of this Phase 1 CMS, TCE, DCE isomers, and VC are considered Phase 1 CMS COCs. Other constituents detected in groundwater and bedrock vapor will be addressed in the Phase 2 CMS.

DTSC and NASA agreed that enough information is available to evaluate alternatives for the previously mentioned Phase 1 areas. Initiating the recommended Phase 1 groundwater CMS alternatives will result in accelerating the implementation of groundwater corrective actions while NASA completes additional preparatory work on the Phase 2 groundwater CMS. Some elements of the Phase 1 groundwater CMS are integral to supporting work on the Phase 2 groundwater CMS, which will address the following:

- Evaluation of other COCs
- Evaluation of other NASA groundwater areas and media within the domain of the NSGW and CFOU
- Evaluation of implemented Phase 1 remedies on source areas and downgradient plumes
- Coordination, evaluation, and cleanup of contaminated groundwater plumes that are comingled with other SSFL responsible party (for example, Boeing) contaminated groundwater plumes
- Assessment of the feasibility of groundwater remediation to background levels (related to State Water Resources Control Board Resolution No. 92-49 that requires cleanup to background conditions unless the LARWQCB Regional Water Board makes a determination of technological or economic infeasibility)

The Phase 1 and Phase 2 CMSs are linked to complete the CMS phase of work for NASA SSFL groundwater; the CMS phase of work will not be completed until both the Phase 1 and Phase 2 CMS are completed. Some elements of the Phase 1 and Phase 2 CMS may be conducted concurrently to expedite groundwater remediation. NASA is committed to completing the Phase 1 and Phase 2 CMS work and initiating groundwater remedial actions as soon as possible. NASA is currently working with DTSC and the LARWQCB to define the work that must be completed concurrent with Phase 1 Corrective Measures Implementation before initiating the Phase 2 groundwater CMS (for example, additional sampling and monitoring, evaluation of the groundwater interim measure extraction well performance, evaluation of BVE and EISB pilot study results, and defining final cleanup levels). Further information regarding the areas addressed in this Phase 1 groundwater CMS are presented in Section 4.

Addressing contaminated soil is outside the scope of the Phase 1 and Phase 2 groundwater CMSs. Potential soil-to-groundwater impacts are being addressed as part of a revised sitewide groundwater quality sampling and analysis plan (WQSAP) effort in coordination with DTSC, following the soil-to-groundwater impact analysis flow chart in the NASA groundwater RFI (NASA 2020a) and the WQSAP guidance provided by DTSC (DTSC 2023), and will be included in the Phase 2 groundwater CMS.

For NASA-administered areas at SSFL, NASA is following the corrective action process established by RCRA and the associated Hazardous and Solid Waste Amendments of 1984. The corrective action process requires the cleanup of contamination at RCRA-regulated facilities. So that cleanup remedies are appropriate for a particular site, the corrective action process includes steps to evaluate the nature and extent of contamination; estimate risks; and identify, develop, and implement appropriate actions to protect human health and the environment.

Under the RCRA corrective action process, NASA must determine the extent of contamination, determine what should be done to address the contamination, and take steps to clean it up, under the direction of DTSC.

Investigation and cleanup activities at the sources and seeps, described previously, are also conducted pursuant to the Comprehensive Environmental, Response, Compensation, and Liability Act of 1980 (CERCLA). The investigation and cleanup process under CERCLA and RCRA are similar.

In July 2013, DTSC provided conditional approval of the 2009 feasibility study work plan with several conditions. One condition of approval was that "…remedies shall comply with the regulations and guidance for a CMS and the document submittal shall be a CMS Report."

This Phase 1 groundwater CMS was conducted in accordance with the RCRA corrective action requirements and is in general accordance with the U.S. Environmental Protection Agency (EPA) guidance for preparing a CMS report (EPA 1994, 2000a). As previously stated, the Phase 1 groundwater CMS represents the first comprehensive remedial step toward achieving cleanup goals for groundwater and compliance with federal, state, and local laws. Implementing recommended Phase 1 groundwater CMS remedial actions will address the highest risk chlorinated VOC source areas in NASA SSFL. Final NASA SSFL sitewide remedial actions and cleanup goals will be established in the Phase 2 groundwater CMS. Together, submittal of the Phase 1 and Phase 2 CMSs will complete the NASA SSFL groundwater CMS phase of work for the site.

1.1 Objectives of the CMS

The NASA Groundwater RFI Report (NASA 2020a) contains information on the nature and extent of the highest-risk COCs identified in NSGW and the saturated and unsaturated media in the CFOU associated with the competent bedrock. Since the submittal of the draft NASA Groundwater RFI Report in May 2017 (NASA 2017b), significant discussions occurred between NASA and DTSC that informed the final RFI document. This RFI information is considered sufficient to support the groundwater CMS-phase of the site remedial options analysis. The RFI was used to identify the priority remedial locations in the Phase 1 areas, as defined previously, within the scope of the Phase 1 groundwater CMS and to complete the technology screening and detailed analysis of the alternatives. Each of these steps was completed in the context of Phase 1 MCOs and cleanup objectives, which are presented in Sections 3.2 and 3.3.

The main objectives of this Phase 1 groundwater CMS are as follows:

1. Present the portions of SSFL's history and physical characteristics and the site conceptual model (SCM) that are relevant to technology and alternative identification for the Phase 1 groundwater CMS.

2. Identify potential technologies for the remediation of contaminated groundwater, bedrock vapor, and Northern and Southern Seep Areas in the NASA-administered areas of SSFL.
3. Screen those technologies for effectiveness and implementability.
4. Assemble those technologies that pass the screening into remediation alternatives.
5. Complete a detailed evaluation of the alternatives using RCRA criteria.
6. Complete a comparative analysis of the Phase 1 alternatives based on the detailed evaluation described in the previous step.

1.2 Report Organization

This report is organized into the following sections:

- **Section 1, Introduction –** Presents the objectives of the Phase 1 groundwater CMS and report organization.
- **Section 2, Site History, Physical Characteristics, and Conceptual Model –** Describes current site conditions, including physical features, and discusses the SCM.
- **Section 3, Summary of Risk Assessment, Media Cleanup Objectives, Overall Cleanup Objectives, and Applicable Laws –** Summarizes relevant NASA SSFL AIG risk assessment findings to support the development of Phase 1 MCOs, presents overall cleanup objectives, and identifies applicable federal, state, and local laws.
- **Section 4, Technology Identification and Screening –** Summarizes the treatability evaluations, identifies the groundwater technologies evaluated in the technology screening step, describes the screening of the treatment technologies, and provides the technologies that could be considered for development into remediation alternatives. The rationale for eliminating those technologies that did not pass the screening is also provided. Additionally, areas for achieving cleanup objectives, referred to as TTAs, are presented.
- **Section 5, Development of Alternatives–** Describes the remediation alternatives created from technologies retained from Section 4.
- **Section 6, Detailed Analysis of Alternatives –** Describes each alternative and how it would be applied to the TTAs identified in Section 4 and provides a detailed evaluation of each alternative against threshold criteria and balancing criteria.
- **Section 7, Recommended Alternatives –** Provides a comparative analysis of each alternative evaluated in Section 6 to show the relative strengths and weaknesses of each alterative with respect to the evaluation criteria.
- **Section 8, References –** Provides a list of references used in the preparation of this report.

Supporting tables, figures, and appendixes, as referenced in this Phase 1 groundwater CMS, are included in their respective sections after the main report.

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2. Site History, Physical Characteristics, and Conceptual Model

This section summarizes the findings in the NASA Groundwater RFI Report (NASA 2020a). NASA will include evaluation of post-RFI groundwater data and the collection of additional data as part of the groundwater Phase 1 Corrective Measures Implementation (CMI) and Phase 2 groundwater CMS/CMI work. As noted in response to DTSC comments on the NASA Groundwater RFI Report (NASA 2020a) and the CMS (Appendix J), relevant DTSC comments not already addressed in the NASA Groundwater RFI Report or this document will be addressed as part of the Phase 2 groundwater CMS and the Phase 1 and Phase 2 CMI, including corrective measures designs (CMDs). However, the site has been substantively characterized in the NASA Groundwater RFI Report (NASA 2020a) to a level of confidence that allows for completion of this Phase 1 groundwater CMS.

SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County above the Simi Valley (Figure 2-1). SSFL occupies approximately 2,850 acres of hilly, rocky terrain, with approximately 1,100 feet of topographic relief near the crest of the Simi Hills. Figure 2-2 shows the geographic location and property boundaries of the site, as well as the surrounding areas. The site is divided into four administrative areas (Areas I, II, III, and IV) and includes undeveloped land to the north and south (Figure 2-2). Most of Area I and all of Areas III and IV are owned by Boeing. Area II (409.5 acres) is owned by the federal government and administered by NASA, along with a small portion of Area I (NASA-administered Area I; 41.7 acres). Ninety acres of Area IV were leased to the DOE, which also owns facilities in Area IV. The northern and southern undeveloped lands of SSFL were not used for industrial activities and are owned by Boeing.

Current zoning for SSFL is Open Space (OS-160) and Agricultural (AE-40ac) for the offsite Shooting Range area (associated with Boeing property). In November 2017, the Ventura County Board of Supervisors approved an ordinance amending the zoning classifications of seven parcels within the SSFL site, including Areas I, II, III, and IV from Rural Agricultural (RA-5) to Open Space (OS-160). The purpose of rezoning these parcels was to establish consistency between the zoning and the General Plan designation. Buildings that formerly housed research and testing support facilities are inactive, have been demolished or are undergoing or planned for demolition, or are being used to support the environmental cleanup. Currently two Alfa Test Stands, the Alfa Control Building, and the NASA field trailer and storage containers are the only structures that will remain on the NASA SSFL property. The SSFL property was recently nominated as a Traditional Cultural Property and is in the process of being submitted to the National Register of Historic Places.

2.1 Site History

From the establishment of SSFL to 1967, North American Aviation (NAA) was the primary landowner. In 1967, NAA merged with Rockwell to become North American Rockwell. In 1973, North American Rockwell changed its name to Rockwell International. Rocketdyne remained a division of Rockwell International. Boeing acquired Rocketdyne in 1996 when acquiring the aerospace divisions of Rockwell International.

Prior to development, the land at the SSFL was used for ranching. In 1948, NAA, a predecessor to Rockwell International Corporation, began using (by lease) what is now known as the northeastern portion, or Area I, of SSFL. The majority of SSFL was acquired with the purchase of the Silvernale property in 1954, and development of the western portion of SSFL began soon after. NAA established Rocketdyne as a separate division in 1955. In December 1958, Rocketdyne deeded some of the property to the U.S. Air Force (USAF) that operated as USAF Plant 57. In the 1970s, the U.S. General Services Administration (GSA) transferred custody and accountability from the USAF to NASA. From 1968 to 1976, North American Rockwell and Rockwell International acquired undeveloped land parcels to the south of SSFL with the intent of creating an unused zone between testing operations and areas outside the SSFL boundaries. In 1998, Boeing acquired additional undeveloped properties to the north of SSFL.

Since 1948, research, development, and testing of liquid-fueled rocket engines and associated components (such as pumps and valves) were the primary site activities at SSFL (SAIC 1994). In addition, nuclear energy research, testing, and support facilities were located within the 90-acre portion of Area IV that was leased to DOE or DOE's predecessor with operations primarily from the 1950s through the mid-1990s.

Engine testing at SSFL primarily used petroleum-based compounds as the "fuel" and LOX as the "oxidizer." TCE was the primary solvent used for cleaning rocket engine components and for other cleaning purposes. The vast majority of rocket engine testing and ancillary support operations occurred from the 1950s through the early 1970s. Rockwell International and other predecessors of Boeing conducted these operations in Areas I and III in support of various government space programs and in Area II on behalf of the USAF and later on behalf of NASA. In Area II, rocket engine testing occurred at the four test stand areas constructed between 1954 and 1957 in the Alfa, Bravo, Coca, and Delta Areas. The areas also contain additional buildings for support activities and infrastructure. NASA has recommended the six remaining individual test stands, along with related nearby structures and features, as eligible for listing in the National Register of Historic Places based on the historical importance of the testing achievements completed at the site and the engineering and design of the structures (NASA 2014a).

NASA gradually discontinued test activities beginning in the 1980s and conducted its final tests in 2006. Boeing performed operation and maintenance (O&M) activities on facilities within the NASA portion of SSFL between 1996 and 2014, after which NASA resumed O&M of its facilities. NASA currently administers 451.2 acres in two areas of SSFL: Area II and the former LOX Plant portion of NASA-administered Area I.

As part of historical operations, NASA used four surface impoundments for hazardous wastewater management: Storable Propellant Area (SPA) Impoundment 1 (SPA-1), SPA-2, Alfa Bravo Skim Pond (ABSP), and Delta Skim Pond. Use of the impoundments was discontinued in the mid-1980s, and the impoundments were formally closed under a 1991 DTSC-approved Closure Plan, as documented in the 1994 Closure Reports (McLaren/Hart 1994a, 1994b, 1994c, 1994d) for each unit. The former impoundments are currently in post-closure care under a Hazardous Waste Facility Post-Closure Permit (PCP) Number PC-94/95-3-03 (DTSC 2013). Solid waste management units (SWMUs) and areas of concern around each of the impoundments have contributed to groundwater contamination in the former impoundment areas as indicated in the NASA Groundwater RFI Report (NASA 2020a), making it difficult to differentiate the exact sources of groundwater contamination in the AIG. Therefore, groundwater beneath these PCP-regulated units is being addressed in the AIGs for their respective areas in the NASA Phase 1 and Phase 2 groundwater CMSs.

In August 2007, NASA, Boeing, DOE, and DTSC signed the 2007 Consent Order (DTSC 2007) that addressed the cleanup of soil (referred to as the Surficial Media Operable Unit) and groundwater (referred to as the CFOU) at SSFL (DTSC 2007). In 2010, NASA and DTSC executed an Agreement in Principle for soil cleanup. Subsequently, on December 6, 2010, NASA and DTSC executed an AOC for Remedial Action (DTSC Docket No. HAS-CO-10/11-038) (DTSC 2010) that stipulates specific remedial requirements, including the characterization and cleanup of COC-impacted soil on the NASA-administered areas of SSFL (DTSC 2010).

As NASA's mission evolved, there was a transition of launch system testing work to other NASA facilities. Following a lengthy period of consideration and review of its current and future needs, NASA concluded it has no further need for the property located at SSFL. In September 2009, NASA submitted a "report of excess" to the GSA regarding the property administered by NASA at SSFL. GSA conditionally accepted the report in 2014.

Figure 2-3 shows the NASA-administered areas of SSFL. NASA designated four AIGs within its property at SSFL that include the following (NASA 2020a):

- The former LOX Plant AIG is located in NASA-administered Area I. A LOX Plant operated in this area between 1955 and 1971 and provided LOX to each of the six large-engine test areas at SSFL. The AIG previously included several buildings, a potential septic tank and leach field (unconfirmed), debris points, the Northern Drainage, and two SWMUs (the waste oil sump and clarifier and the Asbestos and Drum Disposal Area). All of the aboveground structures have been removed from the former LOX Plant area. TCE was used to clean LOX tanks and pipelines. Other potential chemicals used in the former LOX Plant AIG include waste oil, waste fuels, sodium hydroxide, and refrigerants (Freon and ammonia).
- The B204/ELV AIG is located in the northern portion of Area II. The B204/ELV AIG includes the Building 204 Area, the ELV, and the Ash Pile (AP)/Sewage Treatment Plant (STP).
  - The B204 Area extends into Boeing's Area III and DOE's Area IV and into Boeing's undeveloped area to the north. It operated as a Plant Services Area and Maintenance Area for SSFL. It included several buildings, underground storage tanks (USTs), aboveground storage tanks (ASTs), a metal cutting equipment area, pole-mounted transformers, and the Western Debris Area. Potential chemicals used at the B204 Area include solvents, waste oil, fuels, metals, polychlorinated biphenyl (PCBs), and dioxins.
  - The ELV is east of the B204 Area and it also extends into Boeing's undeveloped area to the north. It included two SWMUs (ELV Final Assembly Building 2206 where rocket engine components were tested and PCB Storage Facility Building 2231) and two areas of groundwater concern (AGCs) (Building 2206 Diesel UST and the Building 2207 UST). It also includes the ELV Catchment Pond where wastewater may have drained. Most of the aboveground structures have been removed from the ELV. Potential chemicals used at the ELV include solvents, isopropyl alcohol, oils, fuels, metals, PCBs, dioxins, and furans.
  - The AP/STP is located south of the ELV in a drainage (gully) feature. It included two SWMUs (the AP and Incinerator and the RD-9 Area Ultraviolet/Hydrogen Peroxide Treatment System, both of which have been removed) and two AGCs (the Building 515 STP Area and the Building 211 Leach Field). Potential chemicals used at the AP/STP include solvents, oils, fuels, metals, PCBs, dioxins, and asbestos.
- The Alfa/Bravo AIG is located in the central portion of Area II. The Alfa/Bravo AIG includes the Alfa Area, Bravo Area, Alfa Bravo Fuel Farm (ABFF), SPA, and Hazardous Waste Storage Area (HWSA).
  - The Alfa Area is located in the central-eastern portion of Area II and included three engine test stands (designated) and associated pipelines. It also included support buildings, debris areas, ASTs (three of which were designated an SWMU), septic leach fields, the Alfa Skim Pond, and the Alfa Retention Pond (also an SWMU; ponds received fuel- and solvent-impacted cooling waters from the test stands). Potential chemicals used at the Alfa Area include solvents (large quantities of TCE were used to flush the engines at the test stands), oils, fuels, PCBs, and oxidizers.
  - The Bravo Area is located in the central-western portion of Area II and also included three engine test stands (designated an SWMU) and associated pipelines, as well as support buildings, debris areas, ASTs (including the Bravo Waste Tank that is an SWMU), septic leach fields (two designated as AGCs), former groundwater air stripping towers (an SWMU), and the ABSP (an SWMU and a closed hazardous waste-regulated unit) and Bravo Skim Pond (an SWMU). The ABSP is a RCRA-closed regulated unit and the drainage piping beneath the ABSP is designated as an AGCs.

Potential chemicals used at the Bravo Area include solvents (including large quantities of TCE), oils, fuels, and oxidizers.

- The ABFF, which is designated an AGC, is located in Area II, northwest of the Bravo Area. It included petroleum-based fuel ASTs and associated pipelines and pumps to support the Alfa and Bravo Test Stands. Potential chemicals used at the ABFF include solvents, fuels, lead-based paint, and PCBs.
- The SPA is located in Area II, just west of the ABFF, and expands into Areas III and IV to the west. The SPA was used to store bulk quantities of hazardous materials associated with the test stand use. It contains two former surface impoundments, SPA-1 and SPA-2 (designated as SWMUs and closed hazardous waste-regulated units). The support area between the two impoundments is designated as the SPA AGC. Potential chemicals used at the SPA are wide-ranging and include solvents, fuels, acids, oxidizers, formaldehyde, fluoride, PCBs, energetics, N-nitrosodimethylamine (NDMA), metals, and pesticides.
- The HWSA consists of two SWMUs, the HWSA Container Storage Area (a RCRA-permitted unit used to store drummed wastes, which is a closed container storage unit) and the Waste Coolant Tank. Potential chemicals used at the HWSA include solvents, oils, fuels, acids, oxidizers, bases, and metals.

- The Coca/Delta AIG is located in the southern portion of Area II. The Coca/Delta AIG includes the Coca Area, Delta Area, Coca Delta Fuel Farm (CDFF), R-2 Ponds, and Propellant Load Facility (PLF).
  - The Coca Area is in the southeast portion of Area II and included four engine test stands (designated an SWMU) and associated pipelines. It also included support buildings, debris areas, ASTs, USTs, leach fields, transformers, and the Coca Skim Pond (an SWMU). Potential chemicals used at the Coca Area include solvents (including large quantities of TCE), oils, fuels, metals, fluoride, energetics, formaldehyde, Freon, PCBs, dioxins, and oxidizers.
  - The Delta Area is in the southwest portion of Area II and included three engine test stands (designated an SWMU) and associated pipelines. It also included support buildings, debris areas, ASTs, USTs, a leach field (an AGC), transformers, Delta Area Groundwater Extraction/Treatment Unit (including a Purge Water Tank and Delta Air Stripping Towers, designated as SWMUs), fluorine scrubber, and the Delta Skim Pond (an SWMU and a closed hazardous waste-regulated unit). Potential chemicals used at the Delta Area include solvents (including large quantities of TCE), oils, fuels, metals, anions, energetics, PCBs, dioxins and furans, Freon, amines, acids, bases, and oxidizers.
  - The CDFF, which is designated an AGC, is in the southwestern portion of Area II and extends into Area III. It included petroleum-based fuel ASTs and associated pipelines and pumps to support the Coca and Delta Test Stands. Potential chemicals associated with the operations conducted at the CDFF area include solvents, oils, fuels, metals, anions, PCBs, dioxins and furans, formaldehyde, acids, and bases.
  - The R-2 Ponds are an SWMU located northwest of the Delta Area. The two adjacent ponds (R-2A and R-2B) received drainage water from skim and retention ponds in Areas I through IV. Potential chemicals associated with water received in the R-2 Ponds include solvents, oils, fuels, PCBs, dioxins and furans, energetics, fluorine, and nitrates.
  - The PLF is north of the Delta Area and east of the R-2 Ponds. It was the control center for the Delta Teas Area and contained three SWMUs: the PLF Waste Tank, the PLF Ozonator Tank, and the PLF Surface Impoundment. It also contains an AGC leach field. Potential chemicals associated with the operations conducted at the PLF include solvents, oils, fuels, metals, chromium VI, perchlorate, NDMA, energetics, PCBs, dioxins and furans, formaldehyde, and anions.

Details regarding the background, operational history, and potential release areas associated with the former LOX Plant, B204/ELV, Alfa/Bravo, and Coca/Delta AIGs can be found in the NASA Groundwater RFI Report (NASA 2020a). Demolition activities are ongoing at SSFL and only a few historic structures will remain at NASA-administered areas of SSFL. These structures include two test stands in Alfa and the Alfa Control Building (NASA 2020f). The NASA SSFL field office trailer and associated storage Conex containers will also remain in the parking lot area of the former B204 in the B204/ELV AIG.

2.2 Physical Characteristics of SSFL

This section presents information on the topography, geology, hydrogeology, climate, and cultural and biological resources at SSFL. This information is provided in more detail in the Site-wide Groundwater Remedial Investigation Report (MWH 2009a) and the NASA Groundwater RFI Report (NASA 2020a).

2.2.1 Surface Features and Topography

SSFL lies within the Simi Hills, a northeast-southwest trending sub-range of the Santa Monica Mountains. The Simi Hills extend to the Santa Susana Mountains northeast of the site and to the Santa Monica Mountains to the south. To the north, the Simi Hills form the south boundary of the Simi Valley, which is a relatively flat valley that slopes gently toward the west-southwest. To the east, the Simi Hills form the western boundary of the San Fernando Valley, which slopes gently to the southeast. Both of these valleys are located approximately 1.25 to 2 miles from SSFL property boundary.

SSFL occupies approximately 2,850 acres of hilly terrain that expresses approximately 1,100 feet of topographic relief near the crest of the Simi Hills. Site topographic contours are provided on Figure 2-3. The highest surface elevation at SSFL occurs near the center of the site at an approximate elevation of 2,245 feet above mean sea level (msl) associated with two general ridges that trend northeast-southwest, consistent with the geology of the Chatsworth Formation. The lowest elevation within SSFL occurs at the eastern property boundary in Dayton Canyon, which has an elevation of approximately 1,175 feet above msl. The lower elevations at SSFL occur primarily along the eastern, southern, and north-central to northwestern perimeters of the property. A broad, relatively flat area of topography exists within the northwestern portion of SSFL, which is referred to as the Burro Flats area.

Surface elevations within NASA-administered Area I (which includes a large portion of the former LOX Plant AIG) range from approximately 1,700 feet above msl, where a drainage along the North Fault Zone (NFZ) crosses the eastern boundary of NASA-administered Area I, to 2,018 feet above msl near the eastern end of a topographic ridge located north of the former LOX Plant. Within Area II, elevations range from approximately 1,610 feet above msl, where a drainage emanating from the AP/STP crosses the northern boundary of Area II, to 2,210 feet above msl at a topographic ridge along Skyline Drive north of the Coca Area. The B204/ELV, Alfa/Bravo, and Coca/Delta AIGs are located within Area II.

2.2.2 Geology

SSFL is located in the Western Transverse Ranges physiographic province of southern California. The geology and physiographic expression of the Western Transverse Ranges reflects at least 70 million years of geologic history. Within this province, the region encompassing SSFL includes the Simi and Thousand Oaks Valleys, the western San Fernando Valley, the Simi Hills, and portions of the Santa Susana and Santa Monica Mountains (MWH 2009a).

2.2.2.1 Geologic Units

The primary geologic units present at the NASA-administered portions of SSFL are the unconsolidated Quaternary alluvium/colluvium deposits and the underlying Late-Cretaceous age Chatsworth Formation (MWH 2007). Where present, alluvium/colluvium deposits overlie the Chatsworth Formation as a relatively thin and discontinuous layer in the valley bottoms and other localized channelized areas, such as ephemeral drainage features. The thickness of the Quaternary deposits is typically 1 to 5 feet thick, but in some localized areas, it is more than 15 feet thick. The alluvium consists of a mixture of sand and silty sand, with minor amounts of silt and clay.

Within the NASA-administered area, the Chatsworth Formation is generally divided (from oldest to youngest) into Sandstone 1, Shale 2 Members, and Sandstone 2 (Figure 2-4). The upper portion of Sandstone 1 includes the Sage Member, which underlies a portion of the NASA-administered area and which also includes the Upper and Lower Bravo Beds. Shale 2 Members include a Lower Shale 2 Member and Upper Shale 2 Member, which are separated by a sandstone layer. Sandstone 2, which overlies the Upper Shale 2 Member, includes the Silvernale Member, SPA Member, Lower Burro Flats Member, ELV Member, and the Upper Burro Flats Member. The members are identified based on general grain size with the finer-grained members (Upper and Lower Shale 2 Members, SPA Member, and ELV Member) and beds (Lower and Upper Bravo Beds within the Sage Member) separating the coarser-grained members (Sage, Silvernale, and Lower and Upper Burro Flats Members).

The Chatsworth Formation consists primarily of massively bedded, prominent sandstones interbedded with thinner beds of shale, siltstone, and conglomerate (Figure 2-5). However, based on the results of field mapping and geophysical logging in the NASA-administered areas (NASA 2020a; CH2M 2020), the interbeds consist of siltstone and conglomerate, with no shale identified. The sandstone generally consists of fine- to medium-grained angular sand. Weathered surfaces of the sandstone may crumble, whereas fresh surfaces remain well cemented. The siltstone, which was previously mapped as “shale,” consists of laminated to thinly bedded silt with minor amounts of clay. Weathered surfaces are fissile, and the siltstone may be mistaken for shale. Similar to shale, the layered siltstone represents a potential barrier or semi-permeable barrier to groundwater flow because of its lower hydraulic conductivity in relation to the encasing sandstone.

Depositionally, the sediments of the Chatsworth Formation accumulated as turbidite sequences on a marine shelf (Link et al. 1984). The sandstones and conglomerates represent the main portions of the turbidite sequence and the sediment grain size within a sequence fines upward from basal conglomerate/sandstones to the overlying siltstones, which represent either the upper portion of the turbidite deposits or accumulation during quiescent periods between turbidite flows. Based on the predominance of sandstone in the area, the Chatsworth Formation in SSFL likely represents the mid-fan facies of a submarine fan (Link et al. 1984).

2.2.2.2 Geologic Structures

The Chatsworth Formation has undergone a complex history of regional tectonic stresses, exposing it to multiple orientations of compressional, extensional, and shear forces. Exposures of the Chatsworth Formation present across the Simi Hills and Santa Susana Mountains indicate that it is synclinally folded with an approximately east-west-striking axis. SSFL is located on the south limb of this west-plunging syncline (Dibblee 1992). Bedding orientations at SSFL are locally variable but typically strike approximately N70°E and dip 25 to 35 degrees to the north-northwest (Aydin and Cilona 2014). The average bedding plane strikes about N65°E with a dip of 28 degrees northwest (NASA 2020a), which is within the range of the previously measured orientation at SSFL (Aydin and Cilona 2014).

Additionally, SSFL has been subjected to local stresses, including faulting and erosional unloading. As a result, SSFL and its vicinity are traversed by numerous, steeply dipping to near-vertical geologic structures, such as faults and joints, of various orientation, length, displacement, and type. Structural features developed within the Chatsworth Formation occur both in large-scale features, such as folds and fractures (joints and faults), and in small-scale features, such as microfractures and contorted bedding. Although the joint orientation across the site is variable, the predominant orientation is about N30˚E with a dip of 65 degrees southeast, which is about 90 degrees to the bedding plane (that is, the pole lies along the arc of the bedding plane) (NASA 2020a; CH2M 2020). The relationship between the bedding planes and predominant joint orientation suggests that the majority of the joints may be related to the regional tectonic fabric. The interplay between bedding planes, faults, and joints in the subsurface can have a significant influence on groundwater flow and, by extension, to the potential migration of COCs in the groundwater. A fault may represent a barrier to groundwater flow if the fault gouge and shale smear are composed of low-permeable materials or has a low fracture density, or it may represent a conduit to groundwater flow if the fault gouge is coarser-grained or has a high fracture density, or if the shale smear is less prominent. Also, the juxtaposition of finer-grained beds adjacent to coarser-grained beds will also affect groundwater flow.

The primary geological faults identified in the NASA-administered portion of SSFL include the Burro Flats Fault Zone and Bell Canyon Faults south of the Coca/Delta AIG, the Coca Fault within the Coca/Delta AIG, the Skyline Fault, which traverses the Coca/Delta and Alfa/Bravo AIGs, and the NFZ, which extends through the former LOX Plant and B204/ELV AIGs (refer to Figure 2-5). Other than the Skyline Fault, which trends roughly north-south, the faults trend roughly east-west. The Tank Structure and the Alfa Deformation Band did not display indications of displacement and, therefore, are identified as joints, whereas the Coca Fault, Burro Flats Fault, Skyline Fault, and NFZ were confirmed as faults. For the Coca Fault, there was at least one main fault splay mapped, and for the NFZ, several parallel and subparallel fault traces were mapped. The faulting along these traces show the complex nature of the fault structures in the area. Although no obvious fault features were noted in the field during mapping of the Delta Deformation Band, a review of the boring and geophysical logs from wells drilled adjacent to the deformation band show subsurface voids and large, open fractures that suggest the presence of a fault (NASA 2020a).

A schematic south-north geologic cross section was prepared that extends from the southern portion of the Coca/Delta AIG, through the Alfa/Bravo AIG, to the northern portion of the B204/ELV AIG (Figure 2-6). The geologic members of the Chatsworth Formation encountered on the Figure 2-6 cross section include the Sage Member (with the Lower and Upper Bravo Beds), Shale 2 Members (Upper and Lower), Silvernale Member, SPA Member, Lower Burro Flats Member, ELV Member, and the Upper Burro Flats Member. The beds show a dip toward the north in the plane of the cross section. The section also crosses portions of the Coca Fault, Skyline Fault, and the NFZ.

Additional geologic mapping focusing on addressing the uncertainty associated with the location and nature of offset fine-grained units north and south of the Coca Fault, as identified in the NASA Groundwater RFI Report (NASA 2020a), is planned for the NASA-administered Area II. If necessary for remedial design and monitoring, additional geologic characterization will be performed as part of the groundwater Phase 1 groundwater CMI and Phase 2 groundwater CMS/CMI work.

2.2.3 Hydrogeology

The hydrogeologic conceptual models for the AIGs are discussed in detail in the NASA Groundwater RFI Report (NASA 2020a). A brief summary is presented in this section. If necessary for remedial design and monitoring, additional hydrogeologic characterization will be performed as part of the groundwater Phase 1 groundwater CMI and Phase 2 groundwater CMS/CMI, as described in the NASA Groundwater RFI Report.

2.2.3.1 Hydrostratigraphic Units

NASA-administered Areas I and II are underlain by the sedimentary deposits of the Upper Chatsworth Formation, which is further subdivided based on lithology and grain size. Hydrostratigraphic units (HSUs) include, from oldest to youngest, the Sage Member of Sandstone 1 (including the fine-grained Upper and Lower Bravo Beds), the Shale 2, the Silvernale, SPA, Lower Burro Flats, ELV, and Upper Burro Flats Members of Sandstone 2, the Shale 3, and the alluvium/overburden. Table 2-1 provides a summary of the function of each HSU in the groundwater system.

In general, the coarser-grained sandstone units act as aquifers (saturated formations that have sufficient permeability to supply groundwater in quantities of economic value), while the finer-grained siltstone units act as aquitards (a low-permeability formation that can store groundwater and/or slowly transmit groundwater between overlying/underlying aquifers). Groundwater flow and/or COC transport can also be influenced by a variety of other structural and lithologic features, including the following (NASA 2020a):

- Fault zones, which can act as zones of increased permeability (conduits for preferential groundwater flow), zones of decreased permeability (barriers to groundwater flow), or a combination of the two.
- Fracture zones and networks, which can result in zones of increased permeability and provide flow paths across fine-grained units.
- Bedding planes, which can create preferential flow paths.
- Coarse-grained sandstone and/or conglomerates, which may have sufficient primary porosity to transmit groundwater and/or COCs.
- Interbedded fine-grained units, which can act as aquitards.
- Open boreholes, which can create preferential vertical flow paths between HSUs.

2.2.3.2 Aquifer Properties

Aquifer systems function as a combination of reservoirs for storage of groundwater and conduits for the transmission of groundwater. The physical and hydraulic properties of both the fluid (groundwater and/or COCs) and subsurface materials determine the occurrence, direction, and rate of movement through the aquifer system.

The aquifer system in NASA-administered Area I and Area II consists of relatively highly fractured/faulted sandstone of varying grain size. As such, the aquifer is characterized as a dual-porosity system, with the sandstone matrix providing the primary porosity and the fracture system(s) representing the secondary porosity. The effective matrix porosity of unweathered sandstone at SSFL ranges from approximately 4 to 20% with a mean of approximately 14% (MWH 2009a). The total porosity of the fracture network at SSFL was previously computed based on the range of measured fracture spacing and an assumed hydraulic aperture of 50 microns (MWH 2000). These calculations yielded an estimate of secondary porosity of 0.0005 to 0.01%. The conceptual model for the dual-porosity aquifer system at SSFL is such that the primary (matrix) porosity acts primarily as a reservoir for storage, while the secondary (fracture networks) porosity acts primarily as a conduit for flow. However, the matrix porosity can transmit fluid and portions of the fracture network can act as reservoirs for storage.

Details of hydraulic conductivity and transmissivity estimates for the NASA AIGs are provided in the NASA Groundwater RFI Report (NASA 2020a). Both these terms are used to describe the capacity of an aquifer to transmit water. Transmissivity is equal to the hydraulic conductivity multiplied by the saturated aquifer thickness. Hydraulic conductivity results from depth-discrete packer testing in open boreholes by HSU suggest that the geometric mean hydraulic conductivity of packer zones within the aquifer units (generally averaging about 10^{-4} to 10^{-5} centimeters per second) were generally one order of magnitude (OoM) or more greater than the hydraulic conductivity of the finer-grained units (generally averaging about 10^{-5} to 10^{-6} centimeters per second). Further, the geometric mean hydraulic conductivity among the sandstone units does not vary significantly.

Bulk aquifer transmissivity refers to the overall ability of the aquifer to convey groundwater and reflects both matrix and fracture permeability. Bulk aquifer transmissivity is typically estimated from aquifer tests that do not isolate specific lithologic units or fracture patterns. As such, these tests generally characterize the most hydraulically conductive units over the entire test interval. As described in the NASA Groundwater RFI Report (NASA 2020a), a series of potable water injection aquifer tests were conducted during AIG characterization activities to better inform the hydraulic properties of major structures (faults and fine-grained units) as well as bulk aquifer properties. During injection aquifer testing at the former LOX Plant AIG, draw-up in groundwater levels was propagated rapidly along the strike of the NFZ, yielding estimates of bulk transmissivity on the order of 5,000 to 7,000 square feet per day (ft^2/day). The bulk transmissivity of the aquifer system at the B204/ELV and Alfa/Bravo AIGs calculated from aquifer injection testing was on the order of 400 to 500 ft^2/day. Injection aquifer testing at the Coca/Delta AIG was limited by the lowest injection rates and the most delayed water level responses experienced in all the tests on NASA-administered property. Coca/Delta AIG aquifer transmissivity is inferred to be lower than the aquifer system in other portions of NASA Area I and Area II (NASA 2020a). Additional aquifer testing work was performed post-RFI in the Burro Flats Area of the Coca/Delta AIG at ND-138B (NASA 2020i), in the Bravo Area at ND-169 (NASA 2022c), and in the Delta Area at ND-168 (NASA 2022e) which have been incorporated in the AIG-specific groundwater flow and transport modeling (NASA 2022b, 2023c).

Storativity (or storage coefficient) is the volume of water released from (or taken into) storage in the aquifer system per unit area per unit change in head. In general, unconfined aquifer systems have relatively higher storativity values (typically known as specific yield) while confined aquifer systems have lower storativity values. Estimates of storativity at the B204/ELV and Alfa/Bravo AIGs are similar (generally in the 10^{-2} to 10^{-4} range), while higher storativity values were estimated at the former LOX Plant AIG (generally within the 10^{-1} to 10^{-3} range). The higher storativity estimates at the former LOX Plant AIG may be related to the highly fractured nature of the NFZ in this area, which results in the aquifer system behaving as a more unconfined, equivalent porous medium. The delayed response to the onset of injection observed at the Coca/Delta AIG implies a relatively higher storativity within the aquifer system in this area (NASA 2020a).

2.2.3.3 Groundwater Occurrence and Flow

Groundwater beneath SSFL is divided into two categories (MWH 2003):

- **NSGW –** Groundwater that occurs within the alluvium and weathered bedrock
- **CFGW –** Groundwater that occurs in the competent bedrock aquifer and is deeper than the NSGW

The NASA Groundwater RFI Report presents the distribution of NSGW wells, CFGW wells, and seeps/springs within and near NASA-administered Area I and Area II (NASA 2020a).

Groundwater recharge to the SSFL aquifer system originates as infiltration through the ground surface, flows through alluvial and/or weathered bedrock where present (NSGW), and continues downward to flow through the fracture network present in the competent Chatsworth Formation bedrock aquifer. The primary source of recharge to the aquifer systems underlying NASA-administered Area I and Area II is deep percolation of precipitation. This component includes precipitation that infiltrates to the aquifer system (that is, is not lost to surface runoff or evapotranspiration). Other components of recharge to the aquifer system include deep percolation of imported or applied water (such as the former Alfa Spray fields), water from leaking pipes, or losses from surface water bodies (such as streams or ponds). The majority of surface water features at SSFL are ephemeral; therefore, they would be expected only to provide recharge to the aquifer system during wetter periods where a downward gradient between the surface water body and the groundwater system is present. Perennial features, such as Silvernale Reservoir or the R-2 Ponds, may act as more significant sources of inflow to the groundwater system. Once this infiltrating water encounters the CFGW, it migrates both vertically and horizontally to either flow toward and potentially discharge to seeps, springs, and/or phreatophytes or to continue to move as subsurface flow into the surrounding aquifer system. Subsurface groundwater also inflows to the AIGs from hydraulically upgradient areas. Groundwater pumping is the largest hydraulic stress (outflow component) that has influenced groundwater elevations at SSFL. Prior to 1984, groundwater was extracted primarily for water supply purposes. More recently (mid-1980s through early 2000s), smaller volumes of groundwater have been extracted as part of interim remedial activities (MWH 2009a).

The occurrence and spatial extent of NSGW is highly climate dependent; there is a larger extent of NSGW during wetter periods and a more limited extent under drier conditions. NSGW occurs under two general conditions with respect to the CFGW system:

- Perched, with groundwater elevations higher than those in the underlying CFGW aquifer
- Continuous, having similar groundwater elevations as the CFGW aquifer

Where present, NSGW flow generally follows surface water drainage patterns. The majority of the NSGW system in NASA-administered Area I and Area II is ephemeral with piezometers observed to be dry in years of limited precipitation. The exceptions to this are the ELV and AP/STP of the B204/ELV AIG, portions of the Alfa Drainage at the Alfa/Bravo AIG, and the drainage south of the Coca/Delta AIG, where NSGW is temporally persistent. NSGW extent is shown in the NASA Groundwater RFI Report (NASA 2020a).

In addition to recharge from precipitation, the occurrence and movement of CFGW in the Sage Member, Shale 2 Members, Silvernale Member, Lower Burro Flats Member, and Upper Burro Flats Member in NASA-administered Areas I and II are influenced by groundwater extraction, major fault zones, bedding plane fractures, and fine-grained units. A CFGW elevation contour map from the NASA Groundwater RFI Report (NASA 2020a) is presented on Figure 2-7. The CFGW flow regime can be divided into two broad categories based on HSU:

- Within the Shale 2, Silvernale, SPA, Upper and Lower Burro Flats, and ELV Members of Sandstone 2 in the northern portion of the site, flow is generally to the north (for example, at the B204/ELV AIG and the northern portion of the Alfa/Bravo AIG). Although portions of the former LOX Plant AIG overlie these HSUs, groundwater flow is highly influenced by the NFZ. In this area, CFGW groundwater converges on the NFZ (from the north and south) and then flows west.
- Within the Sage Member of Sandstone 1 in the central portion of the site at the Alfa/Bravo AIG, groundwater flow is dominated by a large pumping depression created during the groundwater extraction period in the mid-1980s through early 2000s. Groundwater near the Alfa/Bravo AIG flows toward this depression from the south and northwest and then flows east-northeast. In the southern portion of the site (in the Coca/Delta AIG), groundwater flow within the Sage Member is dominated by a groundwater divide interpreted as being located just south of the Coca Fault. North of this divide, groundwater flows to the north; south of the divide, groundwater flows to the south toward the Burro Flats Fault Zone. The Burro Flats Fault Zone is considered a general barrier to groundwater flow and forces groundwater upward. The COCs associated with the Coca/Delta AIG are detected in shallow groundwater just beyond the fault, within the undeveloped area south of NASA-administered property.

Vertical hydraulic gradients vary in the NASA SSFL AIGs. At the former LOX Plant AIG, there is little to no vertical hydraulic gradient in the CFGW in wells within or hydraulically connected to the NFZ. Vertical hydraulic gradients over the bulk of the B204/ELV AIG are primarily downward (other than the AP/STP, which has neutral vertical hydraulic gradients). Upward vertical hydraulic gradients are also present north of the B204/ELV AIG in the artesian well pair RD-68A/B, located in the undeveloped area north of the AIG.

There are generally downward vertical hydraulic gradients in the Alfa/Bravo AIG within the Sage Member. There are also large offsets in groundwater elevations (nearly 200 feet) between the Shale 2 and the underlying Sage Member at the AIG. At the Coca/Delta AIG, vertical hydraulic gradients are generally downward within the CFGW system of Sage Member, transitioning to upward vertical hydraulic gradients in the groundwater discharge area south of the site in the vicinity of the Burro Flats Fault system (NASA 2020a).

2.2.4 Climate and Precipitation

The climate at SSFL and the surrounding area falls within the Mediterranean sub-classification, and monthly mean temperatures range from 50 degrees Fahrenheit (°F) during winter months to 70°F during summer months (SAIC 1994). During the summer months (April through October), a landward wind pattern occurs as a result of the site's proximity to the Pacific Ocean; during the winter months, this is interrupted by weather fronts (SAIC 1994). Based on wind measurements collected at SSFL in Area IV from 1994 through 1997, the prevailing wind pattern is northwest-southeast. The pattern is consistent with historical data collected in both the 1960s and 1990s (MWH 2009a).

The Mediterranean climate of southern California is typified by dry conditions in the late spring through early fall, with the majority of precipitation occurring in the late fall through early spring. Historically, precipitation has been affected by the El Niño-Southern Oscillation, a periodic variation in winds and ocean surface temperatures in the eastern Pacific Ocean resulting in cycles of above- and below-average annual precipitation. Precipitation at SSFL over the past 31 years has ranged from 5.7 to 41.2 inches, averaging approximately 17.1 inches (NASA 2020a). In general, groundwater levels, particularly in the NSGW system, increase during periods of higher precipitation and decrease during drier periods, such as drought conditions earlier this decade in California. The temporal variability of deep percolation of precipitation to groundwater is controlled by climatic conditions. The spatial distribution of deep percolation of precipitation is influenced by physical factors such as topography, type and extent of vegetation, soil moisture, extent of alluvium/overburden and weathered bedrock, and bedrock lithology and structure.

2.2.5 Cultural Resources

Cultural resources within the project area include architectural and archeological resources, as well as Traditional Cultural Properties, cultural landscapes, and Indian Sacred Sites. There is one National Register of Historic Places (NRHP)-listed archeological site, the Burro Flats Painted Cave (CA-VEN-1072), within the project area, as well as many other NRHP-eligible sites. Historic architectural resources include the Alfa, Bravo, and Coca Test Area Historic Districts, which include 15 extant building and structures, 10 of which are individually eligible for the NRHP. The NASA-administered portion of SSFL has been formally designated by the Santa Ynez Band of Chumash Indians as an Indian Sacred Site under Executive Order 13007, "Indian Sacred Sites" (1996). The entirety of the SSFL has been determined eligible for the NRHP as a cultural district (Traditional Cultural Property).

2.2.6 Biological Resources

Biological resources refer to vegetation communities, wildlife, sensitive species, invasive species, and wetlands occurring on the NASA-administered portion of SSFL. The local distribution and density of plant communities vary substantially at SSFL due to differences in habitat quality and historical disturbances (such as development or wildfires). A list of the habitat types identified during the fall 2010 habitat mapping (NASA 2011a), and descriptions of these habitat types, are provided in Table 3.4-1 and Appendix D of the Final Environmental Impact Statement (FEIS) (NASA 2014b), respectively. Wildlife identifications during the surveys included 10 butterfly species, 11 reptile and amphibian species, 59 bird species, and at least 14 mammal species. SSFL habitat and species diversity, physical attributes, and geographic location make the area a potentially important route for species migrations. Open space at SSFL could play a role for habitat linkage among the Santa Susana Mountains, the Simi Hills, and possibly, the Santa Monica Mountains (NASA 2011a). The U.S. Fish and Wildlife Service (USFWS) has identified eight threatened or endangered listed plant species that potentially are located on the NASA-administered portion of SSFL (USFWS 2012). In terms of wildlife, one state-listed species, one fully protected species, and nine Species of Special Concern have been identified within the vicinity of SSFL (NASA 2011a, 2011b). Tables 3.4-2 and 3.4-3 of the FEIS (NASA 2014b) list these sensitive plant and wildlife species, respectively. A reconnaissance-level survey was conducted in September 2019 to assess changes in wildlife use and invasive plant infestations after the November 2018 Woolsey Fire. In addition to opportunistic wildlife observations, the habitat mapping was updated to reflect the larger invasive plant infestations, as documented in the brief technical memorandum (NASA 2019).

2.3 Site Conceptual Model by AIG

The following sections provide SCM information specific to each AIG based on the NASA Groundwater RFI Report (NASA 2020a) and address notable areas of groundwater impacted by TCE contamination, the nature and extent of the highest-risk COCs, and an overview of COC plume migration.

NASA AIG risk-based COCs were identified for the NASA AIGs by completing human health and ecological risk assessments for exposure to groundwater, seeps, and bedrock vapor (NASA 2017a, 2021, 2023a). As of the time of publication of this report, NASA is in the process of addressing DTSC comments on the revised AIG groundwater risk assessment report (NASA 2021, 2023a). Section 3 summarizes the results of the updated groundwater risk assessment and evaluates the COCs identified in the human health and ecological risk assessments that are appropriate to carry forward in the Phase 1 groundwater CMS as site-specific COCs.

Additional evaluation of risk assessment COCs identified in the revised groundwater risk assessment, as well as an evaluation of potential COCs based on background, will be included in the Phase 2 groundwater CMS, with COCs assessed for remedial action, if needed and feasible. The Phase 2 groundwater CMS will also provide an updated evaluation of plume extents, natural attenuation, and stability for each AIG. This Phase 1 groundwater CMS relies on the NASA Groundwater RFI Report (NASA 2020a) SCM evaluation and conclusions and focuses on the Phase 1 groundwater areas defined in Section 1.

COC plumes included in this document are drawn based on SSFL-specific groundwater screening levels (GSLs). DTSC-approved GSLs were established for the SSFL sitewide groundwater monitoring program as documented in the *Site-Wide Water Quality Sampling and Analysis Plan* (Haley & Aldrich, Inc. 2010).

If necessary for remedial design and monitoring, additional COC source and plume nature and extent characterization will be performed as part of the groundwater Phase 1 groundwater CMI and Phase 2 groundwater CMS/CMI work.

2.3.1 Phase 1 CMS Site Selection

The NASA Groundwater RFI Report (NASA 2020a) provides a summary of the operational history and a detailed assessment of source areas and potential source areas evaluated during the RFI. Source areas were delineated in each AIG using site history information, as well as soil, soil gas (including passive soil gas sorbers), bedrock vapor, and groundwater COC data (NASA 2020a).

Identification of dense nonaqueous phase liquid (DNAPL) is difficult. One EPA guidance document states, "…It is difficult to verify the presence of DNAPLs through direct observations. Generally, their presence is indirectly estimated. One approach is based on groundwater concentrations and the 1 percent solubility rule-of-thumb. Under this approach, DNAPL is suspected to be present when the concentration of a chemical in groundwater is greater than 1 percent of its pure-phase solubility" (EPA 2004a). The solubility of TCE in water is 1,100 milligrams per liter (mg/L) (EPA 1996). One percent of this value is equivalent to 11,000 µg/L. For the purpose of this Phase 1 groundwater CMS, this concentration was rounded down to 10,000 µg/L to represent indirect potential evidence of DNAPL being present.

A vadose zone model was completed as part of the NASA Groundwater RFI Report (NASA 2020a) to identify bedrock vapor concentrations just above the water table (12,000,000 µg/m^3) that could potentially result in porewater concentrations greater than 10,000 µg/L (Appendix A).

Therefore, Phase 1 sites are identified as either source areas with groundwater TCE concentrations greater than 10,000 µg/L or bedrock vapor greater than 12,000,000 µg/m^3. Also, as described in Section 1, the Phase 1 groundwater CMS alternative evaluation locations also include the B204/ELV AIG and Coca/Delta AIG seeps. The SCMs for the Phase 1 sites and their associated plumes, as well as the seep areas, are described in the following sections.

2.3.2 Former LOX Plant AIG

The former LOX Plant AIG does not have any Phase 1 CMS TTAs because it does not have current vapor or groundwater concentrations above the Phase 1 treatment threshold (Section 2.3.1). Recent groundwater data indicate groundwater TCE concentrations are below 10,000 µg/L at the former LOX Plant AIG (NASA 2020a, 2020b). Therefore, free-phase TCE is not considered to be present in the saturated groundwater aquifer system at the former LOX Plant AIG.

A TCE concentration of 14,000,000 µg/m^3 was measured in ND-112 during the RFI investigations; however, the vapor concentration was reduced to 390,000 µg/m^3 following a brief BVE period (NASA 2020a). A subsequent sample was collected in 2021 and the TCE concentration was 760,000 µg/m^3 (NASA 2022a). This site will be evaluated as part of a BVE pilot study that will address treating lower vapor concentrations associated with the Phase 2 CMS (NASA 2023b). The results of this pilot study will be included in the Phase 2 CMS to support remedial decisions.

Groundwater migration to seeps north of SSFL, is discussed in the B204/ELV AIG conceptual site model (Section 2.3.3.2).

2.3.3 B204/ELV AIG Site Conceptual Model

The B204/ELV AIG SCM presented here is a brief synopsis of the detailed SCM presented in the NASA Groundwater RFI Report and B204/ELV AIG Data Evaluation Report (Appendix B of the NASA Groundwater RFI Report; NASA 2020a). As noted in the NASA Groundwater RFI Report, data for the SCM were obtained from historical documents, NASA-maintained databases, and the 2014 through 2016 AIG field work. Figures 2-8 through 2-10 support the text in this section.

The B204/ELV AIG comprises three distinct subareas in the northern portion of Area II: B204 Area, ELV, and the AP/STP (Figure 2-3). The NASA Groundwater RFI Report (NASA 2020a) provides information on the operational history and a detailed assessment of source areas and potential source areas evaluated during the RFI.

2.3.3.1 Notable Areas of Groundwater Impacted by TCE Contamination

No recent groundwater data indicated the potential for free-phase TCE in groundwater, conservatively determined to be approximately 10,000 µg/L in groundwater as an indication of potential free-phase TCE nearby (NASA 2020a, 2020b). Also, no locations of bedrock vapor indicated the potential for porewater greater than 10,000 µg/L in the B204/ELV AIG (Appendix A). Therefore, there are no locations in this area that would warrant groundwater and bedrock vapor treatment as part of Phase 1.

The potential for offsite migration of B204/ELV AIG COCs to northern seeps and the previous low-level detections of COCs at associated seep wells (discussed in this section) necessitate the inclusion of this pathway in the Phase 1 groundwater CMS groundwater evaluation, as discussed in Section 1.

2.3.3.2 Nature and Extent of COCs

This section provides a brief summary of the nature and extent of COCs in the vadose zone and groundwater at the B204/ELV AIG. Detailed information on the B204/ELV AIG nature and extent is provided in the NASA Groundwater RFI Report (NASA 2020a). The COCs associated with the Phase 1 CMS identified in the NASA Groundwater RFI Report at the B204/ELV AIG are TCE, cis-1,2-dichloroethene (DCE), and VC (NASA 2020a). Based on the updated AIG risk assessment summarized in Section 3 of this document, trans-1,2-DCE was added a Phase 1 CMS B204/ELV AIG groundwater COC.

The extent of COCs identified in the NASA Groundwater RFI Report for the B204/ELV AIG (NASA 2020a) in the NSGW and CFGW is presented on Figure 2-9, which can be referenced when reading the following sections. The nature and extent of COCs presented in the NASA Groundwater RFI Report (NASA 2020a) and, therefore, in this CMS report, preferentially use analytical results prior to AIG aquifer injection testing (Section 2.2.3.2). Site groundwater level and analytical water quality data continued to be collected following the RFI as part of the PCP and sitewide groundwater monitoring programs. An evaluation of pre- and post-injection test analytical results, incorporating additional sitewide and/or PCP monitoring data, has been performed (NASA 2020c). Based on the evaluation results, it was concluded that no significant long-term impacts resulted from the aquifer injection testing on the COC plumes and the testing does not impact remedial evaluations in the CMS.

Bedrock Vapor

Elevated vadose zone TCE concentrations have been observed in the following areas (NASA 2020a):

- In the Building 204 Area, north of Building 2205 (BE-SA-3)
- In the ELV near the former ELV catchment pond by corehole C-7 (BE-SA-4)
- Within and east of ELV Building 2232 (potential source area BE-PSA-5)
- Between ELV Buildings 2202 and 2203 (BE-SA-1)
- In the AP/STP, mainly in the AP (BE-SA-2B) and by well RD-09 (BE-SA-2C), with a potential source area in the STP (BE-PSA-2A)

The highest TCE concentrations in the vadose zone are associated with BE-SA-3 (up to 410,000 µg/m^3 in bedrock vapor) and BE-SA-4 (up to 610,000 µg/m^3 in bedrock vapor). The nature and extent of cis-1,2-DCE, trans-1,2-DCE, and VC (daughter products of TCE degradation and B204/ELV AIG COCs) in the B204/ELV AIG soil gas and bedrock vapor are similar to those of TCE and do not exceed the 12,000,000 µg/m^3 estimated value of TCE in soil vapor that could potentially result in TCE concentrations greater than 10,000 µg/L (Appendix A) at the groundwater interface. Lower historical groundwater elevations (present when groundwater extraction was occurring at the water supply wells, as discussed in Section 2.2.3.3) would have contributed to a thicker vadose zone at the time of potential source releases at the B204/ELV AIG. However, current conditions are used to evaluate the source area extents within the B204/ELV AIG.

The results of mass estimates for TCE suggest that the total vadose zone mass of TCE in the B204 Area is approximately 165 pounds (approximately 75 kilograms [kg]) and the total vadose zone mass in the ELV is approximately 55 pounds (approximately 25 kg). The mass of TCE residing in the AP/STP source areas was insignificant (less than 0.5 pound) compared to the B204 Area and ELV source areas (NASA 2020a). These values are based on environmental data collected to support the bedrock vapor analysis and calculations presented in the NASA Groundwater RFI Report to develop these estimates. These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

Groundwater

The horizontal extent of COCs in groundwater at the B204/ELV AIG was assessed by using COC concentration data collected during a comprehensive groundwater monitoring event performed in 2015, prior to site aquifer injection testing. The combined extent of these COC plumes included in the NASA Groundwater RFI Report (NASA 2020a), as well as the individual estimated GSL boundaries for individual COCs within the combined plume area in NSGW and CFGW, is presented on Figure 2-9. Updated plume evaluations will be included in the Phase 2 groundwater CMS. Uncertainty remains in the plume nature and extent, including understanding the extent of COCs in NSGW and the AP/STP area, understanding the migration of COCs from the B204 source area BE-SA-3, and refining sources and the geometry of the plumes related to ELV source areas BE-SA-4 and BE-PSA-5, but the site has been substantively characterized to a level of confidence that allows for completion of this Phase 1 groundwater CMS document. The areas with the highest concentration of TCE were identified within B204/ELV AIG CFGW at the following wells:

- RD-09 was reported with TCE greater than 1,000 μg/L between 1986 and 1992. Subsequent data reported TCE at less than 1,000 μg/L, and the most recent data from 2023 show a TCE concentration of 220 μg/L.
- NS-42B, installed in 2015, has had TCE concentrations between 45 and 1,600 μg/L, but most typically above 200 μg/L TCE (and was 480 μg/L in 2023).
- Other areas with historical TCE concentrations above 1,000 μg/L (before 1990) in the B204/ELV AIG include ES-21, ES-22, and WS-SP. The most recent (2022 to 2023) TCE concentrations for these wells are 5.7, 120, and 240 μg/L TCE.

The total TCE mass present in the groundwater plumes at the B204/ELV AIG, calculated in the NASA Groundwater RFI Report (NASA 2020a), is about 13 pounds (about 6 kg) in NSGW and about 132 to 171 pounds (60 to 77 kg) in CFGW. These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

The maximum TCE groundwater concentrations collected through the 2015 field season and prior to aquifer injection testing in the area were used to assess the plume extent for the Phase 1 CMS. Figure 2-10 shows these maximum TCE concentrations, along with arrows indicating suspected migration pathways. The red arrows depict potential groundwater migration pathways associated with NSGW. The blue arrows depict potential migration groundwater pathways associated with CFGW in the Lower Burro Flats Member.

In the B204 Area, the only significant COC plumes exist within the CFGW system. The B204 Area has source zone BE-SA-3, which is defined by wells ND-128 and RD-60. Releases from this source area have generated a COC plume that moves north and is interpreted to extend as far as well RD-56A at the north of the NFZ (Figure 2-9). The NFZ offsets the ELV Member in the subsurface, which may allow COC transport north of the B204 Area source (BE-SA-3) to downgradient well RD-56A, north of the NFZ (NASA 2020a). Given the lithologic and hydrogeologic complexity of this area, significant uncertainty remains regarding the exact migration pathways across the NFZ and into downgradient monitoring wells to the north. Despite these uncertainties, the overall migration patterns of contamination impacting groundwater in the ND-128/RD-60 area and moving north to where it is observed in RD-56A is the most likely overall pathway in the area. Additional data may be necessary to refine the understanding of the plume movement in this area during remedial design to support remedy implementation. The need for additional data will be further evaluated in the Phase 2 groundwater CMS/CMI.

Two main COC plumes are present in the ELV: one in the NSGW system associated with BE-SA-1 and BE-PSA-5 and one in the CFGW system associated with BE-SA-4 and potentially BE-PSA-5. The TCE plume in the NSGW system is defined by wells PZ-141, PZ-140, and PZ-139. Groundwater elevation data from these wells show a horizontal flow direction to the east in the NSGW aquifer, carrying COCs from source areas impacting PZ-141 and PZ-140 toward well PZ-139, located farther to the east. However, NSGW is limited in extent in the area and does not represent a significant pathway for offsite migration of COCs. In CFGW, TCE in well C-7 reaches a depth of at least 500 feet below ground surface (bgs) in the vicinity of the ELV Catchment Pond. As the plume moves to the west-northwest and enters the area around well ND-125, the vertical plume extent appears more limited. This plume migration pattern generally follows the orientation of the bedding plane fractures in this area (NASA 2020a). However, there is uncertainty in the COC transport in the ELV and plumes could be associated with north-to-northeasterly flow, with BE-PSA-5 contributing to the ELV plume. Further refinement of the sources and the geometry of the plumes related to source areas BE-SA-4 and BE-PSA-5 may be warranted as part of the Phase 2 groundwater CMS/CMI. Well ND-127 is being deepened from 300 to 500 feet bgs to support plume extent and migration evaluations north of ELV for CMS/CMI work (NASA 2023d).

The COC plumes present in the AP/STP area appear to emanate from multiple sources (BE-PSA-2A, BE-SA-2B, and BE-SA-2C) identified along, and in proximity to, the topographic drainage. TCE originated from shallow source areas and likely migrated downward. This vertical migration pathway is consistent with the orientation of the bedding plane fractures in this area. The plumes follow the northeasterly orientation of both the local topography and the surface water flow paths in the area. This plume is currently bounded in the downgradient (north-northeast) direction by CFGW well ND-126 and is not considered a threat for offsite migration (NASA 2020a). The existing data set does not provide full delineation of the AP/STP plume laterally and vertically, and additional data collection in this area may be necessary to support the Phase 2 CMI design and implementation if a groundwater remedy is deemed necessary in this area.

Seeps

The ultimate pathway for potential offsite COC migration under current hydraulic conditions is through seep water that emerges to the north of the B204/ELV AIG (Northern Seep Area). To date, 15 seep and seep well clusters have been identified or installed north of the B204/ELV AIG, the majority of which occur outside SSFL property boundaries (NASA 2020a). Over the period of record, groundwater COCs have been detected at seep OS-08/S-25 and seep well SP-29C (Boeing 2015) and more recently at seep well SP-30D (NASA 2020a) and SP-33C (NASA 2019). However, seep cluster COC detections are sporadic and below GSLs. Seep and seep well detections, the majority of which are flagged as estimated concentrations (J-flagged), occurred at the following seep locations (refer to Figure 2-8):

- TCE at seep OS-08/S-25 in both 1987 (1 μg/L) and 1997 (0.66 J μg/L), but not in subsequent samples.
- TCE and cis-1,2-DCE at seep well SP-30D in 2016 (0.52 J μg/L and 0.59 J μg/L, respectively); the two samples collected prior to these 2016 samples and the six subsequent samples collected between 2017 and 2022 were nondetect for TCE and cis-1,2-DCE.

- cis-1,2-DCE was detected at seep well SP-30A in 2019 (021 J µg/L) with all other samples nondetect before and after this sample.

Groundwater COCs have not reached, and are not expected to reach, the seeps north of the B240/ELV AIG at concentrations above their GSLs because of these low and sporadic detections (NASA 2020a).

2.3.3.3 COC Groundwater Plume Migration

Groundwater at the B204/ELV AIG is present in the NSGW (alluvium and weathered bedrock) and CFGW (competent bedrock) aquifer systems. NSGW in the ELV is temporally persistent and perched, with groundwater elevations on the order of 200 feet higher than those in the underlying CFGW. NSGW in the B204 Area, when present, is also perched with respect to the underlying CFGW. Unlike the ELV, NSGW at B204 is not persistent and recent data indicate dry conditions. Groundwater elevations in the NSGW system are highest in the northwestern ELV, with inferred radial flow outward from this area.

In the AP/STP drainage, groundwater flow is toward the north-northeast and elevations in the NSGW (when present) and CFGW are similar (contiguous). Groundwater elevations in the CFGW at the B204/ELV AIG are strongly influenced by lithology and geologic structures. Bedding plane fractures also show a strong influence on hydraulic connectivity at the B204/ELV AIG. The NFZ creates enhanced hydraulic connection between HSUs in the B204/ELV AIG. Fracturing within the NFZ also appears to result in drainage of groundwater within the Upper Burro Flats Member north of the B204 Area, with significantly lower groundwater elevations north of the fault. CFGW flow is generally toward the north, with local components of flow to the northeast and northwest (NASA 2020a).

Vertical migration pathways appear to be predominantly downward originating from B204/ELV AIG source areas and moving through fractures in the vadose zone. Under perched conditions, the bedrock fracturing at the B204/ELV AIG would allow for potential migration of COCs above the water table to the northwest toward the NFZ. Also, near-vertical fractures would allow for potential migration of groundwater and COCs below the water table primarily to the northwest, though potential migration to the southwest and southeast is also possible. In addition to bedrock fractures, fine-grained siltstone ELV and SPA Members, which dip toward the northwest beneath potential source areas, could affect groundwater and COC migration in the B204/ELV AIG.

Natural attenuation is interpreted as occurring at several wells in the B204/ELV AIG based on the following:

- Presence of daughter products, including cis-1,2-DCE, VC, ethene, and ethane
- Increasing cis-1,2-DCE-to-TCE ratios over time
- Presence of microbes with functional genes known to be capable of both anaerobic and aerobic degradation of TCE and its daughter products at concentrations relevant to supporting natural attenuation
- Enriched $\delta^{13}C$ TCE and $\delta^{13}C$ cis-1,2-DCE values relative to newly manufactured TCE

Based on the significant populations of halorespiring bacteria detected in groundwater and observed shifts in isotopic ratios, reductive dechlorination of TCE can be inferred to be occurring within the fracture networks that yielded these groundwater samples. However, research conducted on the SSFL Chatsworth Formation sandstone and groundwater since 2007 has shown that TCE degradation to cis-1,2-DCE also occurs within the sandstone matrix (Darlington et al. 2008, 2013). Further degradation of cis-1,2-DCE through an abiotic degradation pathway that does not produce VC as a degradation product also occurs within the sandstone matrix. These degradation processes can be expected to contribute to natural attenuation of these volatile organic compounds (VOCs) in groundwater at SSFL. The data further suggest that the COCs observed in RD-56A are more likely associated with the source area in the vicinity of the Building 204 Area (source well ND-128) than from source areas located farther east in the ELV near well C-7.

Groundwater COC concentrations in wells across the B204/ELV AIG show decreasing or no trends, suggesting that while COC concentrations in wells internal to the plume footprint continue to fluctuate in response to the periodic climate-driven flushing of mass from vadose zone sources, the distal portions of the plumes in the area are generally not expanding. The only exception is cis-1,2-DCE concentrations in well RD-56A in the Building 204 Area. Although this well exhibits small increases in cis-1,2-DCE over time, these increases result from the degradation of TCE to cis-1,2-DCE. Because TCE concentrations in this well are declining (currently at a maximum of 96 µg/L), cis-1,2-DCE concentrations are also anticipated to begin declining in the future.

Long-term groundwater monitoring will be a fundamental element of any eventual groundwater remedy at the B204/ELV AIG to confirm these hypotheses and identify any unanticipated plume behavior. A long-term groundwater monitoring program to assess remedy effectiveness, including monitored natural attenuation (MNA), if applicable, will be developed as part of the remedial design process. MNA data collection to support the Phase 2 CMS will also be included in a revised sitewide WQSAP that will be developed in 2024. The ultimate pathway for potential offsite COC migration under current hydraulic conditions is through seep water that emerges to the north of the B204/ELV AIG. However, the existing analytical data results show no COC detections above GSLs in seep clusters to the north, and no threat of offsite migration of the B204/ELV AIG COC plumes has been identified.

2.3.4 Alfa/Bravo AIG Site Conceptual Model

The Alfa/Bravo AIG SCM presented here is a brief synopsis of the detailed SCM provided in the NASA Groundwater RFI Report and Alfa/Bravo AIG Data Evaluation Report (Appendix C of the NASA Groundwater RFI Report; NASA 2020a). Data for the SCM were obtained from historical documents, NASA-maintained databases, and the 2014 through 2016 AIG field work. Figures 2-11 through 2-13 support the text in this section.

The Alfa/Bravo AIG comprises five distinct subareas In the central portion of Area II: Alfa Area, Bravo Area, ABFF, SPA, and HWSA (Figure 2-3). The NASA Groundwater RFI Report (NASA 2020a) provides information on operational history and a detailed assessment of source areas and potential source areas evaluated during the RFI.

2.3.4.1 Notable Areas of Groundwater Impacted by TCE Contamination

In two Alfa/Bravo AIG areas, TCE groundwater concentrations indicate the potential for the presence of free-phase TCE, shown on Figure 2-11 (conservatively determined to be approximately 10,000 µg/L in groundwater as an indication of potential free-phase TCE nearby). Also, one area was determined to have bedrock vapor concentrations (over 12,000,000 µg/m^3 TCE in vapor) that could potentially result in porewater greater than 10,000 µg/L (Appendix A). The two groundwater areas and the one bedrock vapor area will be considered for targeted treatment (discussed in Section 4):

- AB-PSA-5 encompasses an area around well WS-09. Since 2006, TCE concentrations have been equal to or greater than 10,000 µg/L, except when WS-09 is pumped significantly (for GETS). Long-term pumping decreases TCE concentrations to between 190 to 2,400 µg/L (associated with water levels dropping below a high concentration contributing fracture).
- AB-SA-3A encompasses an area around well ND-136 and potentially expanded to Alfa Test Stands 2 and/or 3 if design investigations indicate a high concentration source exists in these areas. Depth-discrete FLUTe well data collected between 2016 and 2019 indicated TCE concentrations

range from 20 to 14,000 µg/L at depth intervals between 260 and 530 feet. Open borehole data since 2019 has TCE groundwater concentrations between 5,00 and 14,000 µg/L. Bedrock vapor concentrations of TCE ranged from 4,200,000 to 36,000,000 µg/m^3.

Additional data associated with these two areas is being obtained as part of preliminary work for the Phase 1 groundwater CMI. An enhanced in situ bioremediation (EISB) pilot study is being performed in the vicinity of ND-136. The study included installation of six new wells near ND-136 (ND-162 through ND-167); performing a conservative fluorescent dye tracer test; and injecting and recirculating reagents, including emulsified vegetable oil (EVO), a nutrient package that includes nitrogen, phosphorus, and vitamin B12, a buffering agent, and a bioaugmentation culture (NASA 2020d, 2020h). TCE concentrations range from 230 to 120,000 µg/L in the new EISB pilot study wells.

An Alfa Area BVE pilot study with a mobile, solar powered BVE system is also being performed (NASAA 2022e). A BVE well (NV-003), and two multilevel vapor monitoring wells (NV-004a-d and NV-005a-d). TCE vapor concentrations from these new wells range from 280 to 4,600,000 µg/m^3 (NASA 2023f). Pilot study results will support the Phase 1 CMI design.

A new, deep multilevel well (ND-160) has also been installed near Alfa Test Stand 2, east of the ND-136 TTA (NASA 2023e). TCE concentrations range between 320 and 7,400 µg/L in ND-160.

An additional, deep, multilevel monitoring well was installed west of WS-09 to better evaluate the vertical distribution of COCs in the different HSUs in the area (NASA 2022d). TCE concentrations in this new multilevel well (ND-168) range from 5.1 to 5,600 µg/L.

Table 2-2 provides a summary of the Alfa/Bravo AIG Alfa Test Stand and AB-PSA-5 source area concentrations and mass.

2.3.4.2 Nature and Extent of COCs

This section provides a brief summary of the nature and extent of the COCs in the vadose zone and groundwater at the Alfa/Bravo AIG. Detailed information is provided in the NASA Groundwater RFI Report (NASA 2020a). The COCs identified at the Alfa/Bravo AIG in the NASA Groundwater RFI Report associated with the Phase 1 CMS are TCE, cis-1,2-DCE, trans-1,2-DCE, and VC (NASA 2020a). The extent of COCs identified in the NASA Groundwater RFI Report Alfa/Bravo AIG (NASA 2020a) in NSGW and CFGW is presented on Figure 2-12, which can be referenced when reading the following sections.

The nature and extent of COCs presented in the NASA Groundwater RFI Report (NASA 2020a) and, therefore, in this CMS report, preferentially use analytical results prior to AIG aquifer injection testing (Section 2.2.3.2). Site groundwater level and analytical water quality data continued to be collected following the RFI as part of the PCP and sitewide groundwater monitoring programs. An evaluation of pre- and post-injection test analytical results, incorporating additional sitewide and/or PCP monitoring data, has been performed (NASA 2020c). Based on the evaluation, it was concluded that no significant long-term impacts resulted from the aquifer injection testing on the COC plumes and the testing does not impact remedial evaluations in the CMS. There is uncertainty in the lateral and vertical extents of the Alfa/Bravo AIG plumes, including the degree of connection of the plumes between the two areas. As discussed above, several new wells have been installed in the Alfa/Bravo AIG to support TCE source delineation. Additional evaluation will be performed as part of the Phase 2 groundwater CMS and through data collected during the CMD and implementation phase.

Bedrock Vapor

Elevated vadose zone COCs have been observed in three primary areas: the Alfa Test Stands, the Bravo Test Stand, and the Bravo Skim Pond. The following source areas define the primary distribution of TCE in the vadose zone (NASA 2020a). The DCE and VC detections reported in the vadose zone have similar footprints to the TCE distribution, which is expected because these constituents are breakdown products of TCE.

- Alfa Test Stands Area, including the spillways and drainage channels, and the Alfa Pretest Building (AB-SA-3A and -3C, and AB-PSA-3B, -3D, and -3E). The extent of the Alfa Test Stands source areas is uncertain and is being further evaluated as part of an EISB pilot study in the ND-136 well area (NASA 2020d) and will also be assessed further in the CMI remedial design for this area.
- Bravo Test Stands and spillways and the Bravo Waste Tank (AB-SA-4A and -4B, and AB-PSA-4C through -4E). AB-PSA-4C through -4E are identified as potential sources based on their historical use.
- Bravo Skim Pond is a source area extending slightly beyond the formal boundaries of the pond to the northwest to incorporate well HAR-19, where high concentrations of COCs in bedrock vapor have been observed (prior to the BVE pilot test [Appendix F]).

Additional (minor) potential TCE source areas are identified in the Alfa/Bravo AIG Data Evaluation Report (Appendix C of the NASA Groundwater RFI Report; NASA 2020a), including source areas at the SPA (where TCE is currently below GSLs). The Alfa Test Stand 1 source area AB-SA-3A includes well ND-136, where the highest vapor concentrations of TCE found within the NASA AIGs were measured both in vadose zone rock core and bedrock vapor (up to 36,000,000 $\mu g/m^3$). Alfa Test Stand Area 3 may also be a TCE source area and the vapor concentrations in this area are being further evaluated during the Alfa BVE pilot test and the CMI. The high bedrock vapor concentration near Alfa Test Stand 1 exceeds the 12,000,000 $\mu g/m^3$ estimated value of TCE in soil vapor and could potentially result in TCE concentrations greater than 10,000 µg/L at the groundwater interface (Appendix A). The next highest bedrock vapor concentration in the Alfa/Bravo AIG is below the 12,000,000 $\mu g/m^3$ threshold in the Bravo Skim Pond area (up to 370,000 $\mu g/m^3$) (NASA 2020a). Lower historical groundwater elevations (present when groundwater extraction was occurring at the water supply wells, as discussed in Section 2.2.3.3) would have contributed to a thicker vadose zone at the time of potential source releases at the Alfa/Bravo AIG. However, current conditions are used to evaluate source area extents in the Alfa/Bravo AIG.

The results of mass estimates for TCE suggest that the total vadose zone mass of TCE in the Alfa Area is approximately 18,700 pounds (8,500 kg) and the total vadose zone mass in the Bravo Area is approximately 350 pounds (159 kg). The mass of TCE residing in the SPA source areas was insignificant compared to the Alfa Area and Bravo Area source areas. The ABFF does not have TCE source areas (NASA 2020a). These values are based on environmental data collected to support the bedrock vapor analysis and calculations presented in the NASA Groundwater RFI Report to develop these estimates. These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

Groundwater

The extent of COCs in groundwater at the Alfa/Bravo AIG was assessed by using COC concentration data collected during a comprehensive groundwater monitoring event performed in early 2016, prior to site AIG aquifer injection testing. The combined extent of these COC plumes included in the NASA Groundwater RFI Report, as well as the individual estimated GSL boundaries for individual COCs within the combined plume area in NSGW and CFGW, is presented on Figure 2-12 (NASA 2020a). Updated plume evaluations will be included in the Phase 2 groundwater CMS. Uncertainty remains in the source and plume nature and extent, but the site has been substantively characterized to a level of confidence that allows for completion of this Phase 1 groundwater CMS document.

COC plumes impact both the NSGW and CFGW aquifers in the Alfa/Bravo AIG. The NSGW TCE plume in the Alfa Area is inferred to extend downgradient to the west-southwest, just beyond well RD-49A. The Alfa Area CFGW TCE plume is inferred to have migrated to the northwest, apparently along bedding plane fractures, to encompass well ND-137B. The COC plumes are inferred not to cross the Shale 2 Members at depth (refer to the Alfa Area cross sections in Appendix D). The Bravo Area CFGW TCE plume is inferred to have migrated to the northwest, apparently along bedding plane fractures. It is likely that the Alfa/Bravo AIG TCE plumes were historically commingled but have retreated to their current extents as a result of ongoing degradation to cis-1,2-DCE, trans-1,2-DCE, and VC. This is supported by the larger commingled cis-1,2-DCE plume at the site. The degree of commingling between the Alfa and Bravo Area COC plumes is uncertain and can be further evaluated, if needed, associated with CMI monitoring. The extent of VC concentrations above GSLs at the Alfa/Bravo AIG roughly mirrors that of TCE. However, in an area of the SPA where TCE is below its GSL, additional small DCE and VC plumes are present at concentrations above their GSLs and associated with potential source area AB-SA-1A (NASA 2020a).

The areas with the highest concentration of TCE in the Alfa/Bravo AIG are located at wells ND-136 (and adjacent well ND-167) and WS-09, where TCE concentrations were in excess of 10,000 µg/L, representing a concentration for potential free-phase TCE to be near the sampling location (RFI report maximum TCE concentrations of 13,000 µg/L and 30,000 µg/L were measured in the shallowest monitoring port of ND-136 and in WS-09, respectively, during the RFI investigation; refer to Figure 2-11 [NASA 2020a]). The NASA Groundwater RFI Report data (NASA 2020a) indicates the portion of the TCE plume exceeding 10,000 µg/L extends approximately 55 to 60 feet below the water table at ND-136. This area is being further evaluated as part of the EISB pilot study (NASA 2020d, 2020h). The TCE plume depth is uncertain at WS-09, given that depth-discrete data could not be collected for this well. TCE was detected at WS-09 at 30,000 µg/L in 2016, which is in an open borehole with a greater than 450-foot water column (NASA 2020a). An additional deep, multilevel monitoring well was installed west of WS-09 (ND-168 [NASA 2022e]) to better evaluate the vertical distribution of COCs in the different HSUs in the area to support the Phase 1 groundwater CMI.

The calculations in the NASA Groundwater RFI Report (NASA 2020a) estimated the Alfa/Bravo AIG NSGW plumes contain about 120 pounds (54 kg) of TCE and the CFGW plume TCE mass ranges from about 24,200 pounds (10,975 kg) to 29,300 pounds (13,290 kg). The high concentrations detected in wells ND-136 and WS-09 account for the majority of the TCE mass in the Alfa/Bravo AIG (NASA 2020a). These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

The maximum TCE groundwater conce"trat'ons collected through the 2015 field season and prior to aquifer injection testing in the area were used to assess the plume extent for the Phase 1 CMS. Figure 2-13 shows these maximum TCE concentrations, along with arrows indicating suspected migration pathways. The red arrows depict potential groundwater migration pathways associated with NSGW. The blue arrows depict potential migration groundwater pathways associated with CFGW in the Silvernale Member. The green arrows depict potential migration groundwater pathways associated with CFGW in the Sage Member. Although the Sage Member CFGW arrow north of well ND-136 in the Alfa Area crosses the Shale 2 Member on the 2-D projection, the dip of this siltstone member is approximately 30 degrees north-northwest and it is encountered at depth north of wells ND-137A and ND-137B such that the Alfa Area plumes are inferred not to cross this fine-grained unit (refer the Alfa Area cross section in Appendix D).

In the Alfa Area, COCs in the NSGW system flow to the west along the Alfa Area drainage channel. However, TCE concentrations observed in wells and piezometers screened in the NSGW aquifer suggest that the TCE plume moving through this unit drops below GSLs just downgradient (west) of well RD-49A. In the Sage Member, which underlies the Alfa Area, groundwater in the upper portion of the Sage Member flows north to northwest, driven by the hydraulic gradient between the ND-136 source area and well

ND-137B. The presence of COCs in ND-137B may also be explained by down-dip migration of DNAPL from Alfa Area sources along bedding planes and/or the potential influence of historical pumping at WS-13 (near the former LOX Plant AIG; Figure 2-8), which occurred from 1959 to 1963 and 1984 to 1986. In addition, groundwater pumping from water supply well WS-06 from 1955 to 1963 and 1988 to 2001 likely influenced historical groundwater flow directions and COC migration pathways. Historical pumping at WS-06 likely induced the migration of groundwater and COCs from the Alfa Area source areas to the southeast, which explains the presence of TCE and cis-1,2-DCE in WS-06 (Appendix C of the NASA Groundwater RFI Report; NASA 2020a).

In the Bravo Area, COCs in the NSGW system move to the northwest, following the Bravo Area drainage toward the SPA Impoundments. Recent TCE concentrations indicate that the TCE plume in the NSGW has very limited extent in the Bravo Area. The cis-1,2-DCE plume extends farther downgradient but terminates just downgradient of RS-08, in the vicinity of the ABFF. In the Bravo Area CFGW system, COC migration is primarily to the northeast, following the hydraulic gradient observed in the Sage Member. The only exception to this may be in the vicinity of the ND-134 area (AB-SA-4A). Historical observations of abrupt increases in COC concentrations in nearby wells WS-09 and RD-04 when groundwater levels rise above discrete large aperture fractures suggest the presence of fracture-controlled flow pathways in this area. However, the migration pathways between ND-134 and nearby wells WS-09 and RD-04 are likely limited to this specific area and may not represent regional pathways at the scale of the Alfa/Bravo AIG. This conclusion is supported by the much lower levels of TCE detected in soil gas in isolated well locations north and west of the Bravo Skim Pond and in the SPA; the northeasterly hydraulic gradient in the Bravo Area plume; the relatively low COC concentrations in ND-134; and the orientation of bedding and significant fractures that dip to the northwest and suggest that the Bravo Area plume extent is also limited to the south (Appendix C of the NASA Groundwater RFI Report; NASA 2020a). Finally, although COC concentrations observed in wells completed within the Shale 2 and Sandstone 2 units are generally below GSLs, any COCs present in this area would move to the west and north in response to the hydraulic gradients (NASA 2020a).

Although some uncertainty remains with regard to the nature and extent of COC plumes, the current characterization of the COC source areas and plumes within the Alfa/Bravo AIG is considered sufficient for the purposes of preparing the CMS and screening potential remedial technologies that may be implemented. If additional characterization of the nature and extent (both lateral and vertical) of COCs at the Alfa/Bravo AIG is needed to support future remedial design and implementation, such data may be collected prior to and during the CMI. The ND-136 area EISB pilot study, Alfa Area BVE pilot study, and installation of deep, multilevel monitoring will support the Phase 1 groundwater CMI work in the Alfa/Bravo AIG.

Seeps

No seeps have been identified within, or in the vicinity of, the Alfa/Bravo AIG; therefore, there is no potential for COCs originating from Alfa/Bravo AIG source areas to impact site seeps (NASA 2020a). Accordingly, seeps are not discussed further for the Alfa/Bravo AIG.

2.3.4.3 COC Groundwater Plume Migration

Many potential horizontal migration pathways are possible within the Alfa/Bravo AIG, given the complex structural geology at this site. Figure 2-13 depicts potential migration pathways, along with maximum TCE concentrations.

As with the other AIGs, vertical migration pathways appear to be predominantly downward from source areas along fractures in the vadose zone. Potential nonaqueous phase liquid (NAPL) likely existed only in the fracture apertures, and concentrations approaching values that suggest the presence of residual NAPL have been observed only in wells ND-136 and WS-09, where groundwater concentrations are as high as 13,000 (measured at ND-136 in 2016) to 30,000 µg/L (measured at WS-09 in 2016) (Figure 2-11). TCE concentrations since 2020 have been as high as 18,000 µg/L in ND-136, 120,000 µg/L, and remained at 30,000 µg/L as a high in WS-09.

The effect of the dipping siltstone beds on COC migration is of particular interest at the Alfa/Bravo AIG because of the presence of the Upper and Lower Shale 2 Members and the Upper and Lower Bravo Beds. The presence of the Upper Bravo Bed appears to retard downward migration of the plume except in areas where long, open coreholes may act as preferential COC transport pathways if they intersect fractures conducting potentially impacted groundwater (Appendix C of the NASA Groundwater RFI Report; NASA 2020a).

Overall, the available COC concentrations and geochemical data used to assess natural attenuation degradation rates, or evaluate in situ processes, are limited within the Alfa/Bravo AIG. However, the following lines of evidence suggest that natural attenuation is occurring:

- Presence of daughter products, including cis-1,2-DCE, VC, ethene, and ethane
- Decreasing TCE-to-cis-1,2-DCE ratios over time
- Presence of microbes with functional genes known to be capable of both anaerobic and aerobic degradation of TCE and its daughter products at concentrations relevant to supporting natural attenuation
- Enriched $\delta^{13}C$ TCE and $\delta^{13}C$ cis-1,2-DCE values relative to newly manufactured TCE

Based on the significant populations of halorespiring bacteria detected in groundwater and observed shifts in isotopic ratios, reductive2-23ichlorinationn of TCE can be inferred to be occurring within the fracture networks that yielded these groundwater samples. However, research conducted on the SSFL Chatsworth Formation sandstone and groundwater since 2007 has shown that TCE degradation to cis-1,2-DCE also occurs within the sandstone matrix (Darlington et al. 2008, 2013). Further degradation of cis-1,2-DCE through an abiotic degradation pathway that does not produce VC as a degradation product also occurs within the sandstone matrix. These degradation processes can be expected to contribute to natural attenuation of these VOCs in groundwater at SSFL.

Groundwater COC concentrations across the Alfa/Bravo AIG show a decreasing trend or no trend, suggesting that the distal portions of the plumes in the area are generally not expanding. Over the period of record, TCE concentrations in Alfa Area wells have shown overall decreasing concentration trends according to the results of the Mann-Kendall trend analysis (Appendix C of the NASA Groundwater RFI Report; NASA 2020a), indicating that the TCE extent in this area is shrinking, potentially due to natural attenuation processes. The concentrations of cis-1,2-DCE in these wells also have decreased over time, except in well RD-49A, where concentrations generally have increased over the 20+ years of record but have shown no trend over the last 10 years.

In the Bravo Area, the wells with sufficient COC time series to draw conclusions regarding the potential expansion of the distal portions of the plumes include WS-09 and RD-04 in the southern Bravo Area and HAR-09, HAR-11, HAR-19, HAR-20, HAR-21, PZ-155, and RS-08 in the northern Bravo Area. As discussed in Section 2.3.4.2, COC exceedances in wells WS-09 and RD-04 may be associated with the source areas near WS-09 and the newly constructed multiport well ND-134. The mechanism for COC transport from the source areas to these wells is uncertain, but it appears to be associated with discrete fractures that provide a hydraulic connection between the nearby source areas to these locations. This hypothesis is based on historical observations of rapidly increasing TCE concentrations in these wells as groundwater levels recovered from several periods of regional pumping that produced depressed regional groundwater levels.

In well WS-09, as groundwater levels rose above 1,525 feet National Geodetic Vertical Datum of 1929 (NGVD 29) in 2003, concentrations of TCE and cis-1,2-DCE increased by almost 2 OoM over several months, with lesser increases in trans-1,2-DCE and VC occurring at this same time. Similar behavior was observed in well RD-04 in 2005, potentially suggesting the same mechanism is responsible for increases in COC concentrations during 2005 in this well. In well RD-04, the TCE concentration increases sharply when the water level reaches approximately 1,570 feet NGVD 29, which roughly corresponds to the elevation of the Upper Bravo Bed fractures at well WS-09. Many of the COC concentrations in these two wells have shown continued increases since the 2003–2005 period. At the time of this report the (nonpumping) water table is 100 feet or more above these noted fracture elevations, so the contributing fractures are not currently vadose zone features (for potential BVE consideration).

In the northern Bravo Area, the primary wells with sufficient COC time series to draw conclusions related to potential expansion of the distal portions of the plumes and with COC concentrations above GSLs are HAR-19, HAR-20, and PZ-155, which are located near the Bravo Skim Pond. Trends in wells HAR-19 and HAR 20 are decreasing for most COCs. While PZ-155 had elevated chlorinated COC concentrations in 2011 (during a high precipitation year), concentrations have since declined, but periodically exceed the GSL of 5 µg/L for TCE. However, wells farther downgradient (north) from these three wells show no exceedances of site COCs.

Overall, it appears that while COC concentrations in wells internal to the plume footprint continue to fluctuate in response to the periodic climate-driven flushing of mass from vadose zone sources, distal portions of the plumes within this AIG are either not expanding or are shrinking. In the limited areas where small increases have been observed, it is possible that concentrations will show decreasing trends in the near future and limited expansion of the current plume footprints as a result of ongoing natural attenuation processes.

Given the central location of the Alfa/Bravo AIG within NASA-administered Area II, no pathways from plumes within this AIG to seeps located to the north or south exist, and no COC migration beyond the boundaries of the AIG is anticipated. Long-term groundwater monitoring will be a fundamental element of any eventual groundwater remedy at the Alfa/Bravo AIG to confirm these hypotheses and identify any unanticipated plume behavior. A long-term groundwater monitoring program to assess remedy effectiveness, including MNA, if applicable, will be developed as part of the remedial design process. MNA data collection to support the Phase 2 CMS will also be included in a revised sitewide WQSAP that will be developed in 2024.

2.3.5 Coca/Delta AIG Site Conceptual Model

The Coca/Delta AIG SCM presented here is a brief synopsis of the detailed SCM provided in the NASA Groundwater RFI Report and the Coca/Delta AIG Data Evaluation Report (Appendix D of the NASA Groundwater RFI Report; NASA 2020a). Data for the SCM were obtained from historical documents, NASA-maintained databases, and the 2014 to 2016 AIG field work. Figures 2-14 through 2-18 support the text in this section. This plume figure shows combined NSGW and CFGW plumes because there are no distinct NSGW plumes in the Coca/Delta AIG.

The Coca/Delta AIG comprises five distinct subareas in the southern portion of Area II: Coca Area, Delta Area, R-2 Ponds, CDFF, and PLF (Figure 2-3). The NASA Groundwater RFI Report (NASA 2020a) provides information on operational history and a detailed assessment of source areas and potential source areas evaluated during the RFI.

2.3.5.1 Notable Areas of Groundwater Impacted by TCE Contamination

One Coca/Delta AIG area where TCE groundwater concentrations are potentially indicative of the presence of free-phase TCE is shown on Figure 2-14 and is associated with the Delta Skim Pond. Free-phase TCE is conservatively determined to be potentially present when approximately 10,000 µg/L TCE is detected (Appendix A). However, as specified in the 2009 sitewide RFI and the 2020 NASA AIG RFI, free-phase DNAPL has not been identified at the site and is not expected to be encountered. No bedrock vapor concentration areas were identified that could result in porewater concentrations of TCE greater than 10,000 µg/L.

The Delta Skim Pond is downgradient of the Coca and Delta Test Stands, which are known source areas of TCE based on operating facility history and investigation results. The concentration of TCE in groundwater measured in C-6 (130,000 µg/L in 2015 and 150,000 µg/L in 2016) is above 10% of TCE solubility and is the highest TCE concentration in groundwater measured at any well in NASA-administered areas. Also, several rock core samples from C-6 indicated calculated porewater concentrations of over 1,000,000 µg/L, though the most recent bedrock vapor concentrations did not indicate the potential for TCE porewater concentrations of more than 10,000 µg/L at the groundwater interface.

Additional data associated with the Delta Skim Pond was obtained as part of preliminary work for the Phase 1 groundwater CMI. An additional 500-foot-deep monitoring well (ND-169) was installed adjacent to C-6 to better evaluate the primary TCE source in this area (NASA 2022c). ND-169 TCE concentrations from depth-discrete groundwater sampling (using packers) ranged from to 6,200 to 98,000 µg/L. Open borehole concentrations are about 50,000 µg/L. This additional well also could be used for remedial action in the TTA.

Table 2-2 provides a summary of the Coca/Delta AIG Delta Skim Pond source area concentrations and mass.

The potential for offsite migration of Coca/Delta AIG COCs to southern seeps, and previous detections of COCs above GSLs at associated seep wells necessitate the inclusion of this pathway in the Phase 1 groundwater CMS groundwater evaluation, as discussed in Section 1. Additional characterization work to support the groundwater CMS/CMI is ongoing in the Burro Flats Fault area. This fieldwork includes the installation and hydraulic testing of new wells ND-138A and ND-138B, as documented in the *Groundwater Interim Measures ND-138A and ND-138B Groundwater Sampling, Packer Testing, and Aquifer Testing Summary Report* (NASA 2020e). The locations of ND-138A and ND-138B are shown on Figure 2-18.

2.3.5.2 Nature and Extent of COCs

This section provides a brief summary of the nature and extent of the COCs in the vadose zone and groundwater at the Coca/Delta AIG. Detailed information on the Coca/Delta AIG nature and extent is provided in the NASA Groundwater RFI Report (NASA 2020a). The COCs identified for the Coca/Delta AIG in the NASA Groundwater RFI Report associated with the Phase 1 CMS are TCE, cis-1,2-DCE, trans-1,2-DCE, and VC.

The extent of groundwater COCs identified in the NASA Groundwater RFI Report for the Coca/Delta AIG (NASA 2020a) is presented on Figure 2-15, which can be referenced when reading the following sections. The nature and extent of COCs presented in the NASA Groundwater RFI Report (NASA 2020a) and, therefore, in this CMS report, preferentially use analytical results prior to AIG aquifer injection testing (Section 2.2.3.2). Site groundwater level and analytical water quality data continued to be collected following the RFI as part of the PCP and sitewide groundwater monitoring programs. An evaluation of pre- and post-injection test analytical results, incorporating additional sitewide and/or PCP monitoring data, has been performed (NASA 2020c). Based on the evaluation, it was concluded that no significant long-term impacts resulted from the aquifer injection testing on the COC plumes and the testing does not impact remedial evaluations in the CMS.

Bedrock Vapor

Elevated vadose zone TCE concentrations have been observed in the following areas:

- Drainage channels east of the Coca Skim Pond (CD-SA-4)
- Bedrock wells west and north of the Coca Skim Pond
- Drainage channels to the Delta Skim Pond (CD-SA-1A, CD-PSA-1B, and CD-PSA-3)
- Delta Skim Pond

The highest TCE concentrations in the vadose zone have been observed in the area surrounding the Coca and Delta Skim Pond channels, particularly in bedrock vapor (up to 2,400,000 μg/m^3). This highest bedrock vapor concentration does not exceed the 12,000,000 μg/m^3 estimated value of TCE in soil vapor that could potentially result in TCE concentrations greater than 10,000 μg/L at the groundwater interface (Appendix A). The DCE and VC concentrations reported in the vadose have a similar footprint to the TCE distribution, which is expected because these constituents are breakdown products of TCE (NASA 2020a). Lower historical groundwater elevations (present when groundwater extraction was occurring at the water supply wells, as discussed in Section 2.2.3.3) would have contributed to a thicker vadose zone at the time of potential source releases at the Coca/Delta AIG. However, current conditions are used to evaluate source area extents in the Coca/Delta AIG.

The results of vadose zone mass estimates for TCE suggest that about 100 pounds (45 kg) of TCE mass are in the Coca Area and about 745 pounds (338 kg) of TCE mass are in the Delta Area. The remaining source area (R-2 Ponds) adds about 10 pounds (5 kg) of TCE mass in the vadose zone, for a total vadose zone mass of approximately 855 pounds (about 388 kg) of TCE in the Coca/Delta AIG (NASA 2020a). These values are based on environmental data collected to support the bedrock vapor analysis and calculations presented in the NASA Groundwater RFI Report (NASA 2020a) to develop these estimates. These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

Groundwater

The horizontal extent of NASA Groundwater RFI Report COCs in groundwater at the Coca/Delta AIG was assessed by using COC concentration data collected during a comprehensive groundwater monitoring event performed in late 2015, before AIG aquifer injection testing (Appendix D of the NASA Groundwater RFI Report; NASA 2020a). Updated plume evaluations will be included in the Phase 2 groundwater CMS. The combined extent of these plumes, as well as the individual estimated GSL boundaries for individual COCs included in the NASA Groundwater RFI Report (NASA 2020a) within the combined plume area, is presented on Figure 2-15, and a TCE-specific map is presented on Figure 2-14. Uncertainty remains in the source and plume nature and extents in the Coca/Delta AIG, but the site has been substantively characterized to a level of confidence that allows for completion of this Phase 1 groundwater CMS document.

NSGW in the Coca/Delta AIG is temporally persistent under wetter climatic conditions and, when present, appears to be perched in certain areas, such as the Coca and Delta Areas, and vertically continuous with CFGW in other areas, such as the CDFF. However, long-term declining trends in NSGW elevations have been observed and a majority of Coca/Delta AIG NSGW wells are typically dry, with the exception of several Burro Flats Fault and Bell Canyon seep well clusters. When present, NSGW is generally not temporally or laterally continuous at the Coca/Delta AIG; therefore, NSGW plume extents were not inferred for this document.

Two primary TCE plumes exist within the Coca/Delta AIG (Figure 2-14). In the Coca Area, the COC plumes generally extend from Coca Test Stand 4 (CD-SA-4 and Coca Skim Pond) westward down the valley, past the Coca Skim Pond.

In the Delta Area, the COC plumes generally extend from the R-2 Ponds, Delta Skim Pond, and CD-SA-1A south-southwest toward the WS-09A area and the Southwest Drainage near the Burro Flats Fault Zone. A plume cross section figure through Delta and the Southern Seep Area is included in Appendix D of this report. COCs introduced at the Delta Skim Pond/CD-SA-1A sources appear to have migrated to depths exceeding 500 feet, likely as a result of historical DNAPL migration by gravity through corehole C-6, as well as driven downward by vertical hydraulic gradients in the area. The rock core for C-6 was densely sampled at intervals of less than 1 foot. These data indicate that high concentrations of TCE are present at depths of up to 300 feet bgs, and to a lesser extent, between 400 and 500 feet bgs in the source areas. These data indicate that downward migration of COCs likely occurred, probably as NAPL initially.

Existing data sets suggest that Boeing Area III sources contribute to the COC plumes in the NASA-administered Area II Delta Area, in addition to plume source contributions within the Delta Area itself (NASA 2020a; Boeing 2017). The northwestern-most component of the Delta Area plumes is likely related to potential sources in Area III, from which TCE and cis-1,2-DCE mass has migrated southeastward across property lines and commingled with mass originating from Delta Area sources (NASA 2020a). The cis-1,2-DCE plume extends the farthest downgradient.

Significant uncertainty is associated with the inferred lateral extents of the Coca/Delta AIG COC plumes because of the complex lithology and hydrogeology of this area. Inferred plume extents in the Delta Area are complicated by the presence of the Delta Structure and Burro Flats Fault Zone and the limited understanding of the influence of these features on groundwater flow and COC transport. Further, the plume footprints are interpreted based on wells with highly variable construction. Despite the uncertainty, interpretation of the plumes in the Coca/Delta AIG is considered reasonable and sufficient for the purposes of Phase 1 remedial action decision making. Additional data may need to be collected during remedial design to refine the understanding of plume movement in this area and support remedy implementation. However, the ability to collect data to refine the understanding of the distribution of COCs, especially between the Delta Area source areas and the Southwest Drainage, is constrained by limitations on intrusive activities in this area because of the presence of steep topography and culturally and biologically sensitive sites.

Two wells in the Coca/Delta AIG, C-6 and ND-168 in the Delta Skim Pond source area, are associated with TCE concentrations in excess of 10,000 µg/L, which is the value presented previously to represent indirect potential evidence of residual DNAPL (TCE concentrations up to 150,000 µg/L were measured in C-6 and up to 98,000 µg/L in ND-169). The vertical extent of the TCE plume exceeding 10,000 µg/L is unknown (depth-discrete samples could not be collected from thC-6 which is a 900-foot well and TCE was still above 6,000 at 500-foot depth of ND-169); however, rock core porewater data suggest the highest TCE concentrations are within the top 450 feet of this boring (NASA 2020a). Since the collection of these C-6 open corehole samples during the RFI fieldwork, a deep well screened from approximately 800 to 900 feet bgs was installed at C-6 and has substantially lower TCE concentrations (between 140 and 2,100 µg/L TCE).

Additional characterization work to support the groundwater CMS/CMI is ongoing in the Coca/Delta AIG Burro Flats Fault Zone. Two new wells ND-138A and ND-138B were installed and hydraulically tested in this area (Figure 2-18). Data from this study indicate that COC concentrations are higher in the shallow, weathered bedrock NSGW of the Burro Flats Fault area than in the deeper CFGW. The TCE concentration in ND-138A, screened from 20 to 40 feet bgs, was 60 µg/L, versus a TCE concentration of 3.6 µg/L in ND-138B, which has an open interval between 48 and 198 feet bgs. Also, short-term aquifer testing at ND-138A and ND-138B indicates a strong hydraulic connection within the Burro Flats Fault Zone between wells ND-138A, ND-138B, WS-09A, and the SP-890 seep cluster in NASA-administered Area II. However, pumping at ND-138A and ND-138B does not appear to influence water levels in Boeing area seep wells south of the Burro Flats Fault Zone within Bell Canyon (SP-881 and SP-882 well clusters) (NASA 2020e).

Well ND-138A replaced well WS-09A for interim remedial pumping to the groundwater extraction treatment system (GETS) (NASA 2020e). Monitoring and data evaluation is ongoing in this area associated with GETS pumping and monitoring and will be used for the Phase 1 groundwater CMI.

The influence of the singularly high result in the 2015 groundwater sample from corehole C-6 on a Coca/Delta AIG TCE plume mass estimate is significant. Ranges of potential TCE masses were developed in the NASA Groundwater RFI Report (NASA 2020a) by including and excluding the C-6 result from the estimates, because this could be a localized mass source. When the C-6 result is included in the mass estimate, the estimated mass of TCE in the CFGW plumes for the Coca/Delta AIG ranges from about 156,590 pounds (about 71,060 kg) to about 346,360 pounds (157,110 kg), depending on if depth-discrete groundwater sample results are included (associated with samples collected with packers). When the C-6 result is excluded from the calculation, the estimated total mass of TCE for the Coca/Delta AIG ranges from about 8,060 pounds (3,660 kg) to 28,280 pounds (12,830 kg) (NASA 2020a), depending on if packered depth-discrete groundwater sample results are included. The Coca/Delta AIG area-specific CFGW plume saturated mass results are listed as follows (NASA 2020a):

- **Coca Area:** 1,230 pounds (560 kg) (3,860 pounds [1,750 kg] TCE with packered depth-discrete groundwater sample results)
- **Delta Area/R-2 Ponds:** 155,360 pounds (70,500 kg) TCE with C-6; 342,500 pounds (155,360 kg) with C-6 and packered depth-discrete groundwater sample results; 6,830 pounds (3,100 kg) TCE without C-6; 24,420 pounds (11,080 kg) without C-6 with packered depth-discrete groundwater sample results

These mass estimates are uncertain and could vary by an OoM; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values).

Seeps

To date, 14 seeps and pools have been identified south of the Coca/Delta AIG (Southern Seep Area), the majority of which are inside the SSFL property boundaries. The seeps and seep well clusters to the south of the Coca/Delta AIG could potentially be along a COC migration pathway originating from the Coca/Delta AIG source areas, as well as source areas in Boeing Area III (NASA 2020a). The northernmost seep and seep well cluster in the Southwest Drainage Area in NASA-administered Area II is the location of primary concern (SP-890; Figure 2-16). Concentrations of TCE, cis-1,2-DCE, and VC have been detected above their respective GSLs in seep well cluster SP-890. Concentrations of cis-1,2-DCE are detected at lower, and sometimes nondetect, levels at seep well cluster SP-881. Further declines in concentrations occur between SP-881 and SP-882, such that the concentrations at this most-downgradient seep cluster well are less than 20 times the GSL for cis-1,2-DCE (NASA 2020a).

As discussed previously, well ND-138A is replacing well WS-09A for interim remedial pumping to GETS (NASA 2020e). This targeted GETS well is being pumped to control NASA-related potential COC seep discharge associated with the SP-890 area. Monitoring and data evaluation are ongoing for ND-138A GETS pumping and the results will be used for the Burro Flats Fault Zone SP-890 seep remedial action design.

2.3.5.3 COC Groundwater Plume Migration

Groundwater at the Coca/Delta AIG is present in the NSGW (alluvium and weathered bedrock) and CFGW (competent bedrock) aquifer systems. Potential migration pathways are presented on Figure 2-17. NSGW (when present) is either perched or contiguous with the CFGW in the Coca/Delta AIG. In the Coca Area, CDFF, and PLF areas, groundwater elevations in the NSGW are continuous with those in the underlying CFGW. NSGW persists under perched conditions in the eastern Coca Area; however, the extent of the NSGW under drier conditions is spatially limited. NSGW in the Delta Area, when present, exists under perched conditions, and NSGW in the Southern Buffer Zone (south of the Coca/Delta AIG) is both temporally and spatially persistent and contiguous with the CFGW. NSGW flow is interpreted as generally following topography along surface water drainages. A potential CFGW divide is centered on the Coca Area, inferred by the relatively higher groundwater elevations at wells RD-40 and ND-114. CFGW on either side of the divide is interpreted as flowing either north toward the historical pumping depression north of the Coca Fault or south toward the groundwater discharge areas south of the Coca/Delta AIG. Groundwater also enters the Coca/Delta AIG from Boeing Area III sources to the northwest and west of the Coca/Delta AIG (Boeing 2017). Neither the Coca Fault nor the Delta Structure are barriers to groundwater flow. The Burro Flats Fault Zone, south of the Delta Area, is at least a partial barrier to groundwater flow. Bedding plane fractures influence groundwater behavior at the site (NASA 2020a).

The characterization data for the Coca/Delta AIG indicate that COCs from identified source areas have impacted groundwater and resulted in plumes within the fractured bedrock. As with the other AIGs, vertical migration pathways appear to be predominantly downward from source areas along fractures in the vadose zone.

Investigation results also suggest that groundwater COCs associated with the Coca Area plume that migrate north to northwest from the Coca Test Stands are not expected to migrate off NASA-administered property. However, groundwater COCs associated with the R-2 Ponds and Delta Area sources, as well as the Boeing Area III sources to the northwest and west, that are migrating down the Southwest Drainage have been detected in seep well water south of the Area II boundary (but within the SSFL buffer zone) at concentrations above GSLs. COC masses in the plume shown in the NASA-administered Area II Delta Area are complex and difficult to definitively attribute to sources. The plume location and extents shown on Figure 2-15 are for general reference only and do not establish the probable sources. Existing data sets suggest that Boeing Area III sources contribute to the COC plumes in the NASA-administered Area II Delta Area, in addition to plume sources within the Delta Area itself (NASA 2020a; Boeing 2017a). The exact origin, transport direction, extent, and shape of such COC mass contributions from sources within Boeing Area III are not shown and are unknown at this time.

The following evidence suggests that natural attenuation is occurring at several wells in the Coca/Delta AIG:

- Presence of daughter products cis-1,2-DCE, VC, ethene, and ethane
- Increasing cis-1,2-DCE-to-TCE ratios over time
- Presence of microbes with functional genes known to be capable of both anaerobic and aerobic degradation of TCE and its daughter products at concentrations relevant to supporting natural attenuation
- Enriched $\delta^{13}C$ TCE and $\delta^{13}C$ cis-1,2-DCE values relative to newly manufactured TCE

Based on the significant populations of halorespiring bacteria detected in groundwater and observed shifts in isotopic ratios, reductive dechlorination of TCE can be inferred to be occurring within the fracture networks that yielded these groundwater samples. However, research conducted on the SSFL Chatsworth Formation sandstone and groundwater since 2007 has shown that TCE degradation to cis-1,2-DCE also occurs within the sandstone matrix (Darlington et al. 2008, 2013). Further degradation of cis-1,2-DCE through an abiotic degradation pathway that does not produce VC as a degradation product also occurs within the sandstone matrix. These degradation processes can be expected to contribute to natural attenuation of these VOCs in groundwater at SSFL.

The results of the evaluation of potential expansion of the distal portions of the plumes suggest that while COC concentrations in wells internal to the plume footprint continue to fluctuate in response to the periodic climate-driven flushing of mass from vadose zone sources, plumes in the distal areas of the plume are not expanding or will show very limited growth in the future. The Coca Area plume that migrates north-northwest from the Coca Test Stands is not expected to migrate off NASA-administered Area II property. The Delta Area/R-2 Ponds-related COC plume, as well as Boeing sources within Area III, migrating down the Southern Drainage has not migrated farther south than well RD-06, which is south of Area II in the SSFL buffer zone, at concentrations above the GSLs. Long-term groundwater monitoring will be a fundamental element of any eventual groundwater remedy at the Coca/Delta AIG to confirm these hypotheses and identify any unanticipated plume behavior. A long-term groundwater monitoring program to assess remedy effectiveness, including MNA, if applicable, will be developed as part of the remedial design process. Collection of MNA data to support the Phase 2 CMS will also be included in a revised sitewide WQSAP that will be developed in 2024.

3. Summary of Risk Assessments, Media Cleanup Objectives, Overall Cleanup Objectives, and Applicable Laws

As described in Section 2.1, NASA has organized its groundwater investigation and cleanup efforts into AIGs. All four of the AIGs are subject to the 2007 Consent Order (DTSC 2007) signed by NASA, Boeing, DOE, and DTSC. The 2007 Consent Order addresses the cleanup of soil and groundwater at SSFL and identifies the activities for groundwater remediation, which use a risk-based cleanup methodology.

This section provides summaries of the draft risk assessments for the former LOX Plant, B204/ELV, Alfa/Bravo, and Coca/Delta AIGs; identifies Phase 1 MCOs and cleanup objectives; and identifies the federal, state, and local laws and regulations that apply to remedial alternatives evaluated in this Phase 1 groundwater CMS.

3.1 Summary of Risk Assessments

Human health and ecological risk assessments were performed for the former LOX Plant, B204/ELV, Alfa/Bravo, and Coca/Delta AIGs is to assess whether exposure to groundwater, deep soil and bedrock vapor, seeps, and springs at the four AIGs poses a potential risk to human or ecological health that requires conducting remedial actions or establishing land use controls (LUCs). Comments were received on the draft human health and ecological risk assessments (NASA 2017a; NASA 2021); an updated risk assessment that addressed these comments was submitted in January 2021 (NASA 2021). Exposure parameters and toxicity values for the human health risk assessments (HHRAs) were obtained from the Standardized Risk Assessment Methodology Revision 2 Addendum (Stantec 2022) and updated based on additional EPA and DTSC guidance (EPA 2014a, 2015, 2023; DTSC 2019a, 2019bb, 2021, 2022; Cal-EPA 2023). Additional DTSC comments were received on the 2021 risk assessment in October 2022 and a revised risk assessment is still in progress to address additional DTSC comments received on NASA RTC in October 2023 (NASA 2023a).

Available AIG data of appropriate quality were used in the risk assessments, including VOCs, semivolatile organic compounds, dioxins/furans, PCBs, and metals. The risk assessments preferentially used data associated with the NASA Groundwater RFI Report (NASA 2020a) available through mid-year 2016 for consistency. For each AIG, groundwater monitoring and CFOU vapor data from the most recent 3-year period for each sampling station were used. Note that calendar dates encompassing these 3-year data collection periods varied widely between sampling stations and do not always include samples from the most recent 3 years (NASA 2017a, 2021, 2023a). For example, the most recent 3 years of data from one monitoring well could include samples collected in 2008, 2012, and 2016, while the most recent 3 years of data for another monitoring well could include data collected during 2013, 2014, and 2015 sampling events. Data collected from 2017 through 2020 were also evaluated to determine if the conclusions of the risk assessments would change (NASA 2021]), specifically if additional risk-based COCs were identified. Data from 2020 to 2022 were later added and evaluated to determine if additional risk-based COCs were identified (NASA 2023a2023 [in progress]).

The luture intended land use flr SSFL is open space for day-use recreational purposes only. However, the HHRA evaluated hypothetical residential and industrial/commercial worker exposure scenarios because they are considered more protective of human health and ecological risk than the actual anticipated end use for the site. Per EPA guidance, in cases where future residential land use is unlikely (for example, a former industrial area expected to be used for another purpose), the risk may be calculated for a residential scenario to establish the need for appropriate LUCs (EPA 1989, 1991, 1995). This approach is being conducted to support site management decision making for the four NASA-administered AIGs, specifically the need for LUCs or other actions to support the planned use of the AIGs for open space day-use recreational purposes.

Ecological risk was evaluated in the B204/ELV and Coca/Delta AIGs by comparing seep (and seep well cluster data where surface water data was not available) to surface water benchmarks and background values from the Standardized Risk Assessment Methodology Revision 2 (MWH 2014; Stantec 2022). No seeps or springs are associated with the Alfa/Bravo AIG, and samples from seeps associated with the former LOX Plant AIG were nondetect for chemicals of ecological concern (COECs), so ecological risk assessments were not completed for these AIGs. The ecological risk assessments include a screening-level evaluation of ecological and chemical data to determine the potential for ecological exposure and effects from surface water collected from seeps downgradient of the two AIGs, using either seep water data (Coca/Delta AIG; Southern Seep Area) or shallow seep well cluster data that were assumed to represent discharge to surface water in the absence of recent seep water data (B204/ELV AIG; Northern Seep Area). No analytes in shallow groundwater collected from seeps downgradient of the B204/ELV AIG (Northern Seep Area) were retained as COECs. Risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low (NASA 2023g [in progress]). No analytes in surface water collected from seeps downgradient of the Coca/Delta AIG (Southern Seep Area) were retained as COECs, and risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low.

The summary of the COCs identified in the HHRAs for the AIGs (NASA 2023a3 [in progress]) are presented in this section. The HHRA COCs were identified for an AIG when the potential excess lifetime cancer risk (ELCR) or hazard index (HI) for a receptor group exceeded threshold values (a total ELCR of 1×10^{-4} or a target organ-specific HI of 1). Total ELCR and total HI are the summation of the individual chemical-specific ELCR or HI. HHRA COCs are the chemicals that, at the completion of the risk assessment, are found to be risk drivers or those that may actually pose unacceptable human risks (EPA 2002). The COCs typically drive the need for a remedial action (EPA 1999a). Guidance for determining if site risks are unacceptable is discussed in the EPA Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (EPA 1991). As stated in the EPA memorandum, “EPA uses the general 10^{-4} to 10^{-6} risk range as a “target range” within which the Agency strives to manage risks as part of a Superfund cleanup.” The risk used in this decision generally is the “cumulative site risk” to an individual using reasonable maximum exposure assumptions for either current or future land use and includes all exposure pathways which the same person may consistently face. Therefore, when a potential ELCR of 1×10^{-4} was exceeded for a receptor group, the chemicals of potential concern (COPCs) posing an individual ELCR greater than 1×10^{-6} in the environmental medium responsible for the unacceptable risks were identified as human health COCs. When a potential target organ-specific HI exceeded 1 for a receptor group, the COPCs posing a hazard quotient greater than 1 for that target organ in the environmental medium responsible for the unacceptable HI were identified as human health COCs.

A summary of the groundwater COCs identified in the revised risk assessment (NASA 2023a2023 [in progress]) is presented in this section for the B204/ELV AIG, the Alfa/Bravo AIG, and the Coca/Delta AIG. The former LOX Plant AIG is excluded from this section because it does not have any Phase 1 CMS TTAs. The COCs represented for the AIGs are representative of AIG-specific groundwater. In this respect, the COCs identified in the following AIG summaries can be considered AIG-specific COCs.

3.1.1 B204/ELV AIG

3.1.1.1 B204/ELV AIG Human Health Risk Assessment Chemicals of Concern

The following chemicals were identified as B204/ELV AIG COCs in the HHRA (NASA 2023a2023 [in progress]) for the indicated medium and exposure pathway:

- **NSGW Domestic Use:** Lead, hexavalent chromium, arsenic, VC, TCE, cobalt, aluminum, and thallium were identified as risk assessment COCs for the B204/ELV NSGW, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: cis-1,2-DCE, NDMA, formaldehyde, benzene, 2,3,7,8- tetrachlorodibenzoparadioxin (TCDD) toxicity equivalent quotient (TEQ), 1,4-dioxane, chloroform, vanadium, mercury, beryllium, fluoride, nickel, manganese, diesel range organics (DRO) – aliphatic, DRO – aromatic, and antimony. A review of the 2017 to 2022 groundwater sampling data resulted in the following additional NSGW COCs: cadmium, bis(2-ethylhexyl)phthalate (BEHP), oil range organics (ORO) – aromatic, and tetrachloroethene (PCE).
- **CFGW Domestic Use:** Lead, VC, TCE, 1,4-dioxane, cis-1,2-DCE, 1,2,3- trichloropropane (TCP), DRO – aliphatic, and DRO –aromatic were identified as risk assessment COCs for the B204/ELV CFGW, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: formaldehyde, 1,2-DCA, hexavalent chromium, BEHP, benzene, thallium, ORO – aromatic, and toluene. A review of the 2017 to 2022 groundwater sampling data resulted in the following additional CFGW COCs: 2-nitrotoluene, nitrate, fluoride, antimony, arsenic, hydrazine, NDMA, methylene chloride, PCE, trans-1,2-DCE, and chloroform.
- **Seeps and Springs:** Based on the RFI dataset of the shallow groundwater collected from seeps downgradient of the B204/ELV AIG (Northern Seep Area), no chemicals were retained as HHRA COCs based on the day-use recreational exposure scenario. No analytes in shallow groundwater samples collected from seeps downgradient of the B204/ELV AIG (Northern Seep Area) were retained as COCs based on the samples collected between 2017 to 2022.
- **Vapor Intrusion:** The current vapor intrusion pathway is incomplete based on the lack of a groundwater vapor intrusion source for the onsite NASA trailer; no other buildings are located at the B204/ELV AIG. The vapor intrusion pathway in the HHRA was completed to assess hypothetical future exposure scenarios. TCE, VC, and cis-1,2-DCE, along with chloroform (which represents 0.4% of the total cancer risk estimate and 0.002% of the total cancer HI), and 1,2-DCA (which represents 0.1% of the total cancer risk estimate and 0.009% of the total cancer HI) are considered vapor intrusion COCs based on a residential exposure scenario and bedrock vapor sampling results.

3.1.1.2 B204/ELV AIG Ecological Risk Assessment Chemicals of Ecological Concern

No analytes in shallow groundwater collected from seeps downgradient of the B204/ELV AIG (Northern Seep Area) were retained as COECs. Risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low (NASA 2023a).

3.1.1.3 B204/ELV AIG Summary

HHRA COCs for the NSGW, based on the RFI dataset and the 2017 to 2022 samples, include lead, hexavalent chromium, arsenic, VC, TCE, cobalt, aluminum, and thallium, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: cis-1,2-DCE, NDMA, formaldehyde, benzene, 2,3,7,8-TCDD TEQ, 1,4-dioxane, chloroform, vanadium, mercury, beryllium, fluoride, nickel, manganese, DRO – aliphatic, DRO – aromatic, and antimony each. A review of the 2017 to 2022 groundwater sampling data resulted in the following additional NSGW COCs: cadmium, BEHP, ORO – aromatic, and PCE.

B204/ELV AIG groundwater-related HHRA COCs for the CFGW, based on the RFI dataset and the 2017 to 2017 samples, include lead, VC, TCE, 1,4-dioxane, cis-1,2-DCE, 1,2,3-TCP, DRO – aliphatic, and DRO – aromatic, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: formaldehyde, 1,2-DCA, hexavalent chromium, BEHP, benzene, thallium, ORO – aromatic, and. A review of the 2017 to 2022 groundwater sampling data resulted in the following additional CFGW COCs: 2-nitrotoluene, nitrate, fluoride, antimony, arsenic, hydrazine, NDMA, methylene chloride, PCE, trans-1,2-DCE, and chloroform. These COCs are observed in three distinct groundwater plumes associated with the Building 204 Area, ELV, and AP/STP (Figure 2-9) (NASA 2020a).

TCE, VC, and cis-1,2-DCE, along with chloroform, and 1,2-DCA are considered vapor intrusion COCs based on bedrock vapor sampling results. Because there are no NSGW, CFGW, or vapor Phase 1 sources associated with the B204/ELV AIG, these media COCs will be assessed in the Phase 2 groundwater CMS. Vapor intrusion COCs and other B204/ELV AIG COCs will be assessed in the Phase 2 groundwater CMS.

No HHRA COCs or ecological risk assessment COECs were identified for the seeps and springs medium in the Northern Seep Area associated with the B204/ELV AIG (NASA 2023a2023 [in progress]). GSL exceedances were not identified in seeps or seep wells associated with the B204/ELV AIG (Figure 2-8). However, as discussed in Section 2.3.3.2, sporadic, low-level detections (below GSLs) of some COCs (TCE, cis-1,2-DCE, and 1,4-dioxane) were detected in two seep wells north of the B204/ELV AIG. Groundwater COCs have not reached, and are not expected to reach, the B204/ELV AIG-related seeps at concentrations above their GSLs or risk-based screening levels (NASA 2020a). However, the groundwater concentrations will continue to be monitored. However, because of the possibility that seep and spring COC concentrations could increase in the future and pose a potential risk to human or ecological receptors, contingency remedial alternative analysis is being considered for this Northern Seep Area in the Phase 1 groundwater CMS.

3.1.2 Alfa/Bravo AIG

3.1.2.1 Alfa/Bravo AIG Human Health Risk Assessment Chemicals of Concern

The following chemicals were identified as Alfa/Bravo AIG COCs in the HHRA (NASA 2023a2023 [in progress]) for the indicated medium and exposure pathway:

- **NSGW Domestic Use**: TCE, VC, cis-1,2-DCE, NDMA, chlorotrifluoroethylene, and arsenic were identified as risk assessment COCs for the Alfa/Bravo NSGW, with 1,4-dioxane, formaldehyde, chromium VI, n-nitroso-di-n-propylamine, 2,3,7,8-TCD' TEQ, 3,3'-dichlorobenzidine, 1,1,2-trichloroethane, chloroform, PCE, zirconium, trans-1,2-DCE, cobalt, cyanide, 4,6-dinitro6dinitro-2-methylphenol, DRO – aliphatic, DRO – aromatic each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional NSGW COCs: 2,6-dinitrotoluene, nitrobenzene, nitrate, mercury, thallium, 1,1-dimethylhydrazine, hydrazine, 1,2,3-TCP, ORO – aromatic, BEHP, and benzene.
- **CFGW Domestic Use**: Lead, TCE, cis-1,2-DCE, VC, 1,1-dimethylhydrazine, NDMA, chlorotrifluoroethylene, DRO – aliphatic, DRO – aromatic, and formaldehyde were identified as risk assessment COCs for the Alfa/Bravo CFGW, with 1,4-dioxane, trans-1,2-DCE, methylene chloride, 2,6-dinitrotoluene, BEHP, PCE, dibromochloromethane, bromodichloromethane, 1,2-dibromoethane, benzene, o-toluidine, chloroform, zirconium, mercury, and thallium each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional CFGW COCs: 1,3-dinitrobenzene, fluoride, cobalt (dissolved), benzo(a)anthracene, benzo(a)pyrene, hydrazine, pentachlorophenol, 1,1-DCA, 1,2,3-TCP, isopropanol, TCDD TEQ, nitrobenzene, mercury, 1,2,4-trimethylbenzene, 1,2-DCA, 1,3,5-trimethylbenzene, ethylbenzene, m,p-xylenes, naphthalene, o-xylene, and toluene.

- **Vapor Intrusion**: The current vapor intrusion pathway is incomplete based on the lack of a groundwater vapor intrusion source for the unoccupied Alfa/Bravo Control Center building; no other buildings are located at the Alfa/Bravo AIG. The vapor intrusion pathway in the HHRA was completed to assess hypothetical future exposure scenarios. TCE, VC, and cis-1,2-DCE, along with chloroform (which contributed to 0.05% of the total cancer risk estimate and 0.0002% of the total noncancer HI) and PCE (which was detected once in bedrock vapor samples less than 170 feet bgs), are considered vapor intrusion COCs based on bedrock vapor sampling results for the Alfa/Bravo AIG.

3.1.2.2 Alfa/Bravo AIG Ecological Risk Assessment Chemicals of Ecological Concern

The Alfa/Bravo AIG was not included in the risk assessment because no seeps have been identified within or in the vicinity of this AIG; therefore, no pathways for exposure to seeps and springs by ecological receptors exist for the Alfa/Bravo AIG (NASA 2020a).

3.1.2.3 Alfa/Bravo AIG Summary

HHRA COCs for the NSGW, based on the RFI dataset and the 2017 to 2017 samples, include TCE, VC, cis-1,2-DCE, NDMA, chlorotrifluoroethylene, and arsenic, along with 1,4-dioxane, formaldehyde, chromium VI, n-nitroso-di-n-propylamine, 2,3,7,8-TCD' TEQ, 3,3'-dichlorobenzidine, 1,1,2-trichloroethane, chloroform, PCE, zirconium, trans-1,2-DCE, cobalt, cyanide, 4,6-dinitro-2-methylphenol, DRO – aliphatic, DRO – aromatic each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional NSGW COCs: 2,6-dinitrotoluene, nitrobenzene, nitrate, mercury, thallium, 1,1-dimethylhydrazine, hydrazine, 1,2,3 TCP, ORO – aromatic, BEHP, and benzene.

Alfa/Bravo AIG groundwater-related HHRA COCs for the CFGW, based on the RFI dataset and the 2017 to 2017 samples, include lead, TCE, cis-1,2-DCE, VC, 1,1-dimethylhydrazine, NDMA, chlorotrifluoroethylene, DRO – aliphatic, DRO – aromatic, and formaldehyde, along with 1,4-dioxane, trans-1,2-DCE, methylene chloride, 2,6-dinitrotoluene, BEHP, PCE, dibromochloromethane, bromodichloromethane, 1,2-dibromoethane, benzene, o-toluidine, chloroform, zirconium, manganese, mercury, and thallium each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional CFGW COCs: 1,3-dinitrobenzene, fluoride, cobalt (dissolved), benzo(a)anthracene, benzo(a)pyrene, hydrazine, pentachlorophenol, 1,1-DCA, 1,2,3-TCP, isopropanol, TCDD TEQ, nitrobenzene, mercury, 1,2,4-trimethylbenzene, 1,2-DCA, 1,3,5-trimethylbenzene, ethylbenzene, m,p-xylenes, naphthalene, o-xylene, and toluene.

The chlorinated COCs are observed in two main groundwater plumes: one associated with the Alfa Area and one associated with the Bravo Area (Figure 2-12). The cis-1,2-DCE plume has the largest footprint and connects the Alfa and Bravo Areas; however, the extent of commingling between the Alfa and Bravo Area plumes is uncertain. The next largest COC plume is associated with 1,4-dioxane. Most other COCs are contained within the TCE plume footprint (NASA 2020a).

TCE, VC, and cis-1,2-DCE, along with chloroform and PCE contributing to less than 0.05% of the total cancer risk estimate, are considered vapor intrusion COCs based on detections in soil vapor. CFGW COCs associated with the ND-136 and WS-09 sources, and vapor intrusion COCs associated with ND-136 TTA, are addressed in this Phase 1 groundwater CMS. However, other Alfa/Bravo AIG NSGW, CFGW, and vapor intrusion COCs will be assessed in the Phase 2 groundwater CMS.

As discussed in Section 2.3.4.2, no seeps have been identified within, or in the vicinity of, the Alfa/Bravo AIG, so no ecological risk pathways exist for this AIG.

3.1.3 Coca/Delta AIG

3.1.3.1 Coca/Delta AIG Human Health Risk Assessment Chemicals of Concern

The following chemicals were identified as Coca/Delta AIG COCs in the HHRA (NASA 2023a2023 [in progress]) for the indicated medium and exposure pathway:

- **NSGW Domestic Use**: VC, TCE, arsenic, and cis-1,2-DCE were identified as risk assessment COCs for the Coca/Delta NSGW, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: trans-1,2-DCE, formaldehyde and NDMA, 2,3,7,8-TCDD TEQ, 1,4-dioxane, manganese, DRO – aliphatic, and DRO – aromatic. A review of the 2017 to 2022 sampling data resulted in the following additional NSGW COCs: 2,6-dinitrotoluene, mercury, fluoride, nitrate, chlorotrifluoroethylene, ORO – aromatic, PCE, and thallium.
- **CFGW Domestic Use**: Lead, TCE, VC, cis-1,2-DCE, and NDMA were identified as risk assessment COCs for the Coca/Delta CFGW, with the following COCs each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate: formaldehyde, 1,4-dioxane, trans-1,2-DCE, PCE, benzene, naphthalene, phosphorus, manganese, 1,3-dinitrobenzene, lithium, DRO – aliphatic, DRO – aromatic, ORO – aromatic, chlorotrifluoroethylene, and fluoride. A review of the 2017 to 2022 sampling data resulted in the following additional CFGW COCs: 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-nitrotoluene, 1,3,5-trinitro-1,3,5-triazine (RDX), cyanide, thallium, and 1,2,3-TCP.
- **Seeps and Springs**: Based on the RFI dataset of the shallow groundwater collected from seeps downgradient of Coca/Delta (Southern Seep Area) TCE and VC were retained as HHRA COCs based on the day-use recreational exposure scenario. TCE and VC, detected in 62 shallow groundwater samples collected from seeps downgradient of the Coca/Delta AIG (Southern Seep Area), were also retained as COCs based on the samples collected between 2017 to 2022.
- **Vapor Intrusion**: The current vapor intrusion pathway is incomplete; no buildings are located at the Coca/Delta AIG. The vapor intrusion pathway in the HHRA was completed to assess hypothetical future exposure scenarios. TCE, cis-1,2-DCE, and VC were identified as risk assessment COCs for the Coca/Delta AIG based on a residential exposure scenario and bedrock vapor samples.

3.1.3.2 Coca/Delta AIG Ecological Risk Assessment Chemicals of Ecological Concern

No analytes in surface water collected from seeps downgradient of the Coca/Delta AIG (Southern Seep Area) were retained as COECs, and risks to aquatic receptors in receiving water bodies and to birds and mammals that might drink the water are considered low. Chemicals detected in the seeps south of the Coca/Delta AIG represent a combination of contributions from Boeing Area III sources and Coca/Delta AIG sources (NASA 2020a; Boeing 2017). This information is based preferentially on seep water data collected at well clusters, where available. If seep water data were not available, then the shallowest, saturated seep well point data were used (NASA 2021, 2023a).

3.1.3.3 Coca/Delta AIG Summary

VC, TCE, arsenic, and cis-1,2-DCE were identified as risk assessment COCs for the Coca/Delta NSGW, with trans-1,2-DCE, formaldehyde and NDMA, 2,3,7,8-TCDD TEQ, 1,4-dioxane, manganese, DRO – aliphatic, and DRO – aromatic each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional NSGW COCs: 2,6-dinitrotoluene, mercury, fluoride, nitrate, chlorotrifluoroethylene, ORO – aromatic, PCE, and thallium.

Lead, TCE, VC, cis-1,2-DCE, and NDMA were identified as risk assessment COCs for the Coca/Delta CFGW, with formaldehyde, 1,4-dioxane, trans-1,2-DCE, PCE, benzene, naphthalene, phosphorus, manganese, 1,3-dinitrobenzene, lithium, DRO – aliphatic, DRO – aromatic, ORO – aromatic, chlorotrifluoroethylene, and fluoride each contributing to less than 1% of the total cancer risk and total noncancer hazard estimate. A review of the 2017 to 2022 sampling data resulted in the following additional CFGW COCs: 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-nitrotoluene, 1,3,5-trinitro-1,3,5-triazine (RDX), cyanide, thallium, and 1,2,3-TCP.

The chlorinated ethenes identified as COCs are observed in two distinct groundwater plumes: one associated with the Coca Area and one associated with the Delta Area (Figure 2-15). cis-1,2-DCE is the first daughter product of TCE degradation and more mobile than TCE. The cis-1,2-DCE plumes have the largest footprints and extend south of the Burro Flats Fault Zone. The remaining COCs fall within the footprint of the TCE and cis-1,2-DCE plumes (NASA 2020a). TCE, VC, and cis-1,2-DCE are also considered vapor intrusion COCs based on detections in soil vapor and groundwater.

The chlorinated ethenes identified as CFGW COCs associated with the C-6 groundwater and NSGW associated with the Southern Seep Area are addressed in this Phase 1 groundwater CMS. However, other Coca/Delta AIG CFGW, NSGW, and vapor intrusion COCs will be assessed in the Phase 2 groundwater CMS.

No analytes in surface water collected from seeps downgradient of the Coca/Delta AIG were retained as COECs. As discussed in Section 2.3.4.2, GSL exceedances of Coca/Delta AIG COCs TCE and VC were identified in NSGW in seep wells in the Southern Seep Area, potentially along a COC migration pathway originating from Boeing Area III sources and NASA Coca/Delta AIG source areas. However, COC concentrations in seep and spring water itself are below GSLs and, as noted previously, no COECs were identified in seep and spring water (i.e., seep and spring water do not pose unacceptable ecological risk in the Coca/Delta AIG) (NASA 2021). The seeps and seep well clusters in the Southwest Drainage Area in the undeveloped area south of the NASA-administered Area II boundary (namely, SP-890, SP-881, and SP-882) are the locations of primary concern (Figure 2-16) for potential future seep water exposure risk if concentrations increase. Concentrations of these COCs are greatest in SP-890, north of the Burro Flats Fault Zone, with concentrations decreasing down-drainage (with COCs below GSLs a short distance south of the Burro Flats Fault Zone) (NASA 2020a, 2021).

COCs shown in the NASA-administered Area II plume in the Delta Area are complex and difficult to definitively attribute to a source. The plume location and extents shown on Figure 2-15 are for general reference only and do not establish the probable sources. Existing data sets suggest that Boeing Area III sources contribute to the COC plumes in the Delta Area of NASA-administered Area II, in addition to plume sources within the Delta Area itself (NASA 2020a; Boeing 2017). The exact origin, transport direction, extent, and shape of such COC mass contributions from sources within Boeing Area III are not shown and are unknown at this time.

3.2 Media Cleanup Objectives

The previous section highlights a number of COCs for each of the four AIGs. As stated in Section 1, the Phase 1 groundwater CMS will address COCs that contribute the greatest risks in groundwater; specifically, TCE, DCE isomers, and VC. These four constituents can be considered P1 CMS COCs and will be referred to as, simply, COCs, for the remainder of this document. Other AIG-specific COCs will be addressed in the Phase 2 CMS.

The Phase 1 TTAs described in Section 1 represent smaller areas than the full AIG areas for which the COCs were developed. Additionally, because COCs have not been detected in the seep samples north of the former LOX Plant AIG, groundwater MCOs were not developed for this AIG. For the purpose of identifying Phase 1 MCO cleanup concentrations for specific Phase 1 TTAs , the COCs were further evaluated to determine which of these COCs are present at the Phase 1 sites.

Final MCO cleanup criteria have not been defined for NASA SSFL groundwater and the Phase 1 groundwater CMS is using cleanup goals. State Water Resources Control Board Resolution No. 92-49 requires cleanup to background conditions unless the LARWQCB makes a determination of technological or economic infeasibility. Prior to completing the Phase 2 CMS, NASA will prepare a Technical and Economic Feasibility Analysis (TEFA) to support cleanup levels for the Phase 2 CMS. The TEFA will evaluate results of ongoing onsite treatment to support conclusions and recommendations. In the absence of final cleanup levels for this CMS, the CMS will use California MCLs as a target cleanup goal for groundwater for the Phase 1 CMS COCs. California MCLs are protective of human health and are generally considered technically practical. NASA acknowledges that the cleanup levels, proposed in Table 3-1, will be revised as part of the TEFA and Phase 2 CMS to provide final NASA SSFL groundwater MCOs.

- **ND-136 TTA (Alfa Area)** – Phase 1 MCOs were developed for the following COCs at this TTA for the groundwater source area: TCE, cis-1,2-DCE, trans-1,2-DCE, and VC. COCs for the bedrock vapor at this TTA include TCE, cis-1,2-DCE, trans-1,2-DCE and VC. The Phase 1 MCOs for this TTA are listed in Table 3-1.
- **WS-09 TTA (Bravo Area)** – Phase 1 MCOs were developed for the following COCs at this TTA: TCE, cis-1,2-DCE, trans-1,2-DCE, and VC. The Phase 1 MCOs for this TTA are listed in Table 3-1.
- **C-6 TTA (Delta Area)** – Phase 1 MCOs were developed for the following COCs at this TTA: TCE, cis-1,2-DCE, trans-1,2-and VC. The Phase 1 MCOs for this TTA are listed in Table 3-1.
- **Northern Seep Area (B204/ELV AIG)** – Phase 1 MCOs were developed for the following COCs at this Phase 1 seep TTA: TCE, cis-1,2-DCE, and VC. The Phase 1 MCOs for this TTA are listed in Table 3-1.
- **Southern Seep Area** – Phase 1 MCOs were developed for the following COCs at this Phase 1 seep TTA: TCE, cis-1,2-DCE, and VC. The Phase 1 MCOs for this TTA are listed in Table 3-1.

3.3 Overall Cleanup Objectives

The previous section identified COCs for both human and ecological receptors based on the draft final risk assessments completed for SSFL groundwater (NASA 2021, 2023a) and identified COCs that will be addressed in this CMS. The following Phase 1 MCOs were used to identify TTAs for SSFL groundwater:

- Reduce COC concentrations in groundwater to a level that is technically and economically feasible, and apply treatment in a manner that would not prevent potential follow-on actions from achieving Phase 1 MCOs identified in Table 3-1. The values in Table 3-1 are only referenced as they represent cleanup of groundwater to low concentrations. If California MCLs and notification levels are selected as the best water quality which is reasonable, to comply with State Water Quality Control Board Resolution No. 92-49, it should be demonstrated that background water quality cannot be restored and that the Federal and California MCLs and California notification levels are the best water quality that is reasonable, considering the factors in State Water Quality Control Board Resolution No. 92-49, prior to their adoption as MCOs.
- Prevent or minimize the migration of groundwater containing high concentrations of COCs downgradient of the TTAs.
- Implement groundwater treatment in a manner that decreases the time to achieve federal or CA MCLs, provided a technology is available that is considered effective and implementable.
- Clean up and abate the effects of discharges in a manner that will (1) be consistent with the maximum benefit to the people of the state; (2) not unreasonably affect present and anticipated beneficial use of such water; and (3) not result in water quality less than that prescribed in the applicable Basin Plan and applicable Water Quality Control Plans and Policies of the State Water Quality Control Board.
- Clean up groundwater in a reasonable timeframe, if practicable.

- Treat bedrock vapor that decreases the time to achieve federal or MCOs in groundwater (through the migration of bedrock vapor to groundwater pathway).
- Treat groundwater seeps where COCs exceed MCOs (Table 3-1) or represent a risk to human or ecological receptors.
- Use in situ methods to the extent practicable to minimize physical impacts to the environment.
- Recognize the unique biological and cultural significance of the project site through the protection of resources to the extent practicable and consistent with applicable laws and regulations for such resources.
- Remediate the site in an expedient and cost-effective manner and consistent with the application of good science.
- Implement the proposed project in a manner that is compatible with the future use of the property.

These MCOs are useful for identifying, screening, and evaluating groundwater alternatives in this Phase 1 groundwater CMS. NASA acknowledges the primary goal is aquifer restoration and that DTSC determines the cleanup goals. Final MCOs will be developed in the Phase 2 CMS.

3.4 Federal, State and Local Laws

In 2014, NASA completed an FEIS for Proposed Demolition and Environmental Cleanup Activities at SSFL (NASA 2014b), in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended; the implementing regulations issued by the White House's Council on Environmental Quality (*Code of Federal Regulations* [CFR] Title 40, Parts 1500 through 1508); the guidance letter submitted by the Council on Environmental Quality, dated June 19, 2012; and the NASA "Procedures for Implementing the National Environmental Policy Act (NEPA)" (14 CFR 1216.1 through 1216.3). The FEIS presents an overview of the affected environment and the potential environmental consequences associated with the proposed action and the no action alternative. It evaluated a full range of environmental issues, including air quality and greenhouse gas emissions, biological resources, cultural resources, soil, landslide potential, topography, paleontological resources, and water resources (NASA 2014b).

The groundwater cleanup methods to be used were evaluated in accordance with federal, state, and local regulations relevant to each environmental resource area analyzed in the FEIS. The overall environmental impacts related to groundwater cleanup are anticipated to be mostly negligible to minor, with the exception of moderate impacts to groundwater hydrology. However, in the 2014 Record of Decision (ROD) for the FEIS, NASA deferred its decision on groundwater cleanup required to meet the 2007 Consent Order (DTSC 2007) to allow NASA to complete additional groundwater sampling and cleanup technology feasibility and treatability studies. In 2018, NASA issued a ROD, Environmental Impact Statement (EIS) for Proposed Demolition and Environmental Cleanup Activities at SSFL, Groundwater Cleanup (NASA 2018b). The FEIS (NASA 2014b), Appendix B, *Applicable Laws and Regulations,* summarizes the laws and regulations pertaining to the environmental resources in the area. The 2014 FEIS provides information at a high level; the applicable sections of these regulations for the proposed groundwater cleanup remedies will be addressed in this CMS and in the CMI plans that NASA will prepare for groundwater cleanup activities.

The 2018 EIS ROD for Groundwater Cleanup (NASA 2018b) addressed the NEPA process. Various groundwater remediation technologies are discussed and potential best management practices and mitigation measures are identified that NASA will implement to reduce the magnitude of groundwater cleanup impacts.

Key federal, state, and local laws that require additional explanation as they relate to the AIGs and groundwater remediation are discussed in the following sections. Federal, state, and local laws for specific groundwater treatment alternatives are in Section 6, where a detailed analysis of alternatives is presented (specifically the implementability criteria).

National Environmental Policy Act of 1969

NASA addressed NEPA issues in the 2018 EIS ROD for Groundwater Cleanup (NASA 2018b).

California Environmental Quality Act

In 2023, DTSC certified the final Program Environmental Impact Report (DTSC 2023) for remediation of the SSFL facility. The Program Environmental Impact Report provides an assessment of the potentially significant direct, indirect, and cumulative environmental impacts of the remedial activities at SSFL project, including groundwater remediation, and identifies measures to avoid or substantially lessen significant environmental impacts to the extent feasible.

Cultural resources include architectural and archeological resources, as well as Traditional Cultural Properties, cultural landscapes, and Indian Sacred Sites. NASA has prepared an Environmentally Sensitive Area Action Plan (ESAAP) to guide the planning and execution of specific elements of cleanup and remediation with the potential for ground disturbance within archeological sites at the SSFL. The ESAAP has been prepared in fulfillment of Stipulation III.C of NASA's Section 106 Programmatic Agreement (NASA 2014c) as part of compliance with Sections 106 and 110 of the National Historic Preservation Act.

The ESAAP is intended to safeguard cultural resources known to be located within NASA-administered Area II and Area I LOX at the SSFL. Cultural resource environmentally sensitive areas (ESAs) may include built environment resources (buildings and foundations) and prehistoric resources such as rock art, lithic scatters, and habitation areas (middens).

If a ground-disturbing activity is planned within 100 feet of the boundaries of a known archeological site or other historic property, an ESA will be established around the site prior to the start of work. Once the ESA has been delineated, work may begin only with the issuance of a dig permit, the presence of an archeologist, and a Native American monitor, if necessary.

Work plans will be submitted to NASA's Site Management Office in compliance with the ESAAP and must include a detailed map of the areas that will be impacted and a description of the work to be performed, including depth and methods of ground disturbance. Before any work begins, the Site Management Office will issue an excavation permit for ground-disturbing activity. Onsite personnel must complete the NASA site orientation as well as NASA's worker environmental awareness training prior to the start of any work activity.

In the event that cleanup activities uncover any unanticipated archeological discoveries, all work within 30 meters of the location will be suspended and NASA will proceed in accordance with the procedures outlined in Attachments 7 and 8 of the 2014 Programmatic Agreement between NASA, the California State Historic Preservation Officer, and the Santa Ynez Band of Chumash Indians, as well as Sections 6.1.3 to 6.1.7 of NASA's Integrated Resource Management Plan (NASA 2017e).

Biological Resources

Biological resources include federal- and state-listed species, designated critical habitat and other sensitive habitats, and federal- and state-jurisdictional wetlands and waters. NASA prepared a biological assessment report, *Biological Assessment for the Demolition and Cleanup Project at SSFL* (NASA 2013), and received a "not likely to adversely affect" determination from the USFWS in 2014. Similarly, NASA has been coordinating with the U.S. Army Corps of Engineers to minimize project impacts on wetlands and waters of the U.S. and with the California Department of Fish and Wildlife to effectively evaluate and minimize the effects on state-listed rare and sensitive species. Best management practices and mitigation measures to protect biological resources are summarized in the FEIS (NASA 2014b).

Since early 2016, NASA has been engaged with federal and state regulators and other entities at SSFL to develop a process approach that is consistent and adaptable to specific cleanup sites. This process approach looks at potential impacts to biological resources based on the preliminary soil remediation polygons that are based on the detections of COCs and comparison to the Look-up Table values, as dictated by the 2010 AOC requirements (DTSC 2010). A field assessment is then conducted to identify and characterize area of concern exemption areas where sensitive resources are collocated with proposed soil remediation polygons. In concert with the resources agencies, the field assessment is followed by a point-by-point comparison of COC detections within the area of concern exemption areas to ecological risk-based screening levels to adjust the soil remediation polygons to eliminate or minimize actual impacts to biological resources.

NASA has tested this process approach and will continue to use it in the development of future remediation plans. Therefore, it is expected that the individual remediation plans for soil and groundwater can be finalized in a manner that will be protective of existing biological resources at SSFL (NASA 2014b).

Water Quality Protection

The Porter-Cologne Water Quality Act established regional water quality control boards (RWQCBs) throughout the state. RWQCB adopts water quality control plans, or basin plans, that establish water quality objectives to provide reasonable protection of beneficial uses and an implementation program for achieving water quality objectives within the basin plans. The LARWQCB is the public agency with primary responsibility for the protection of ground and surface water quality for all beneficial uses of water within major portions of Los Angeles and Ventura Counties, including the NASA SSFL facility.

The designated beneficial uses of underlying groundwater include the following:

- Municipal and domestic water supply
- Agricultural water supply
- Industrial service supply
- Industrial process supply
- Groundwater recharge

The LARWQCB Basin Plan establishes numerical and narrative water quality objectives for surface and groundwater within the basin. MCLs for organic chemicals are found in *California Code of Regulations* (CCR) Title 22, Section 64444; MCLs for inorganic chemicals are found in 22 CCR 64431.

Stormwater Protection

Site activities would take place in accordance with the statewide General Permit for Stormwater Discharges Associated with Construction Activity (Order No. 2009-0009-DWQ [National Pollutant Discharge Elimination System No. CAS000002]). As required by this permit, NASA would prepare a Stormwater Pollution Prevention Plan and an Environmental Compliance Plan that specified site management activities to protect stormwater runoff and minimize erosion during construction and O&M of the project. NASA also would continue monitoring offsite drainages for increased sediment load and contamination. The Stormwater Pollution Prevention Plan would include the protocol for proper storage and use of hazardous materials, as well as spill response procedures.

These management activities would include construction stormwater best management practices (silt fences, sandbags, straw waddles, and tire washes), dewatering runoff controls, containment for chemical storage areas, and construction equipment decontamination. The effect of remediation activities on the potential to increase surface water and groundwater pollution should be minor, given the regulatory controls in place to protect water quality and the assumption that NASA would adhere to these requirements.

Hazardous Materials and Waste

Waste generated or stored at SSFL is managed as required by the hazardous waste large-quantity generator regulations in 22 CCR 66262. Waste is stored within a secured less-than-90-day storage area at the SPA area until characterized. Upon receiving laboratory analytical results, the waste is transported offsite and disposed of in accordance with hazardous waste management requirements.

Land Use Controls

Each alternative requires LUCs to protect human health until the MCOs are achieved. LUCs include institutional controls (ICs) and engineering controls. ICs include restrictions on the use of the groundwater within an AIG for any purpose and could prohibit the construction of buildings over the AIGs until groundwater MCOs are achieved. Engineering controls include locks on wells to prevent access to groundwater for non-remedial action purposes. Signs may be posted near wells or throughout the AIG areas to prevent groundwater use. In California, LUCs are implemented through Land Use Agreements.

NASA will coordinate LUCs in the Coca/Delta and B204/ELV AIGs with other property owners (Boeing and Brandis-Bardin), as groundwater contamination has potential to migrate onto property not owned by NASA.

Technology-specific Federal, State, and Local Laws

Technology-specific federal, state, and local laws are addressed in Section 6 where the criteria of implementability is addressed.

4. Technology Identification and Screening

This section summarizes the results of the technology evaluations completed by NASA, Boeing, and DOE. Following the summary of the technology evaluations, a list of potential technologies is presented and screened against two criteria: effectiveness and implementability. The technology evaluations completed by NASA, Boeing, and DOE are presented first because they were instrumental in supporting the screening effort. The technologies retained in this section (those that passed the screening) are considered for alternative development in Section 5.

4.1 Summary of Technology Evaluations

The following sections provide a summary of the results of the technology evaluations completed by NASA, Boeing, and DOE. Over the course of past work at SSFL, five technologies have been evaluated in detail by NASA, Boeing, or DOE: BVE, in situ chemical oxidation (ISCO), in situ thermal treatment (ISTT), MNA, and biostimulation.

4.1.1 BVE Study

A BVE pilot study was conducted at HAR-19 in the Bravo Area at SSFL to evaluate the effectiveness and implementability of BVE as a vadose zone remedial technology to remove VOCs from unsaturated bedrock. The technology was tested in the field from August through October 2014 in the Bravo Area and the results are documented in the *Bravo Bedrock Vapor Extraction Treatability Study Summary Report* (Appendix F). An additional test was conducted in the former LOX Plant AIG from May to June 2015 and those results are documented in Appendix A of Appendix A of the NASA Groundwater RFI Report (NASA 2020a). These tests, as well other characterization efforts conducted during the AIG investigations, form the basis of the evaluation of BVE for the CMS for the NASA-administered areas of SSFL.

The BVE technology involves applying a vacuum to fractures in the subsurface above the zone of water saturation to promote the removal of VOCs from connected fractures or the surfaces of bedrock along the sides of the fractures. In the case of SSFL, it is particularly applicable for treating chlorinated ethenes. In contrast to soil vapor extraction (SVE), an analogous technology used in unsaturated soil environments, BVE is effective only when there is significant fracturing in the rock formation and these fractures are largely free of pooled water. Because the induced air flow travels in fractures within the rock matrix, the lateral distance to which vacuum can be expressed is much greater in BVE than in SVE. Correspondingly, the spacing between extraction wells for BVE is expected to be much greater than it would be for SVE in a soil setting of similar size. In terms of cleanup efficiency, the duration of BVE is expected to be longer in a fractured bedrock setting than SVE in a comparable soil setting, because of the potential for long-term release of VOCs from available portions of the rock matrix or the long travel times from extensive fracture flow pathways.

With BVE, the primary geologic challenges involve knowing where moderate or greater aperture fractures are interconnected and where water saturation is absent in these fractures. Additionally, if the fractures dip down into the water table or are located within a few feet of the static water table in the extraction corehole, the vacuum will cause the zone of saturation to rise, thereby blocking further air flow in that zone.

The primary implementation challenges of BVE involve the following:

- Locating extraction coreholes with sufficient fractures and depth of groundwater and in areas with elevated VOCs

- Providing electrical power for the blower to operate in remote, deactivated locations
- Configuring the system to operate cost-effectively for an extended period of time, as the time required to remove VOCs, which may diffuse from the bedrock matrix or arrive from distant sources, may be longer than traditional SVE technology

The Bravo Area BVE field experiment included the following key work elements (Appendix F):

- Modifying an existing corehole for use as an extraction well (HAR-19).
- Collecting rock cores and installing four new multilevel vapor piezometers.
- Configuring existing groundwater wells with screens above the water table for vapor sampling and vacuum monitoring to increase directional coverage.
- Installing pressure transducers in the network of monitoring points.
- Operating a 50-horsepower (hp) blower system for three weekly cycles (weekdays on, weekends off) and one time after a 6-week rebound period.
- Collecting vapor samples from the piezometer network before, during, and following the extraction testing.
- Assembling, summarizing, and evaluating the data.

The former LOX Plant Area BVE field experiment was a component of a mass characterization study, so it included fewer technology-specific elements. The work elements for this study included the following:

- Modifying an existing corehole for use as an extraction well (ND-112). In addition to the wellhead configuration to enable system connection, this modification included installing a packer at depth to prevent off-gassing from the water table.
- Operating a 4-hp blower system for 17 days (weekdays on; weekends and holidays off).
- Collecting frequent measurements of flow, vacuum, and extracted concentration (106 measurement events between May 11, 2015, and June 3, 2015).
- Collecting laboratory samples of the effluent to calibrate the field photoionization detector measurements.
- Assembling, summarizing, and evaluating the data.

The following presents the overall objectives of the Bravo Area BVE field experiment, the assessment of the objectives, and where insight was gained during the former LOX Plant Area BVE test, that information is presented after the Bravo portion:

- **Objective**: Quantify bedrock air removal using standard vapor extraction methods.
  - **Bravo Area Assessment**: The extracted flow consisted of an initial depressurization phase, followed by a steady state flow phase. At HAR-19, the initial flow at 6 inches of mercury (in. Hg) was 110 standard cubic feet per minute (scfm), and over 3 hours, the flow declined and held steady at 65 scfm. Most of the air flow corresponded to two sets of moderate fractures, with the steepness of the fracture dip correlating well with greater flow. A non-negligible fraction (approximately 15%) of flow came from 130 feet of relatively unfractured rock matrix. The maximum practical vacuum and flow were limited by the presence of the water table approximately 7 feet below the lowest fracture set; vacuum greater than approximately 6 in. Hg (82 inches of water [in. H_2O]) did not produce additional flow, because of the submergence of this flow fracture by the upwelling water table.

- **Former LOX Plant Area Assessment**: The flow from ND-112 appeared to originate from a single, moderate, shallow fracture at 39 feet bgs. A vacuum of 12.8 in. Hg produced a flow of about 10 scfm in this well.

- **Objective**: Quantify the volatile organic mass flow rate over time in the BVE well.
  - **Bravo Area Assessment**: The rate of mass removal will depend on the location of centers of VOC mass near to the BVE well. At HAR-19, the arrival of peak concentrations after 2 days of extraction (after weekend shutdowns) suggests that remote sources were being affected. The shift of concentrations from the upper to the lower fracture also suggests that nearby fractures acted as conduits to different sources instead of a single local source. Over the 3-week, weekday-only extraction period, the rate of removal averaged approximately 2.7 pounds per day, for a total of about 30 pounds, with the rate trending upward, likely in response to the arrival of remote vapors. Based on this observation, short-term cycling does not appear to be warranted as a strategy to increase the rate of mass removal in fractured bedrock; however, cycling could be effective to accommodate site requirements (mandate staff be present during operation, with no planned weekend staffing) or to manage energy consumption by operating only during periods of maximum mass removal.
  - **Former LOX Plant Area Assessment**: ND-112 was located nearer to the mapped source in the former LOX Plant area. The total mass removed was approximately 43 pounds and showed a declining rate over time. Intermittent changes in mass flow rate occurred after rainfall events; apparently, the nominal flow pattern from this single fracture created some flow that originated at the ground surface. When this was temporarily blocked by ground saturation, new air flow pathways were required, and these accessed deeper, as-yet-unextracted zones of the source area.

- **Objective**: Quantify the vacuum response in fractures and matrix blocks.
  - **Bravo Area Assessment**: The formation operates as a dual-permeability unit, with high flow and rapid vacuum response in fractures, and low (if any) flow and equal but delayed vacuum response in porous bedrock matrix. Vacuum response showed a directional relationship to bedding plane orientation and a greater relationship to being near an extensive major fracture than to being near the extraction well. Remote vacuum propagation showed some dependence on time, as if progressive moisture removal or bypassing were taking place. In contrast to SVE sites, piezometers apparently screened in or near major fractures detected much higher vacuums than would be expected in soil settings (nearly 50% of wellhead vacuum, 30 feet away; 5% of wellhead vacuum, 376 feet away); where a piezometer was screened in the rock matrix, vacuum response was of a magnitude consistent with fine-to-medium-grained sand but was delayed several days in its establishment.

- **Objective**: Improve the understanding of lithologic and/or structural variations and their impacts on formation advective flow paths under a BVE system.
  - **Bravo Area Assessment**: The observed responses are most appropriately described as a dual-permeability flow system: rapid advection along preferential fracture pathways, and relatively slow advection through less permeable matrix blocks. Bedding planes appeared to influence flow along the bedding direction and impede vacuum and flow across the planes. Major structural features, such as the Alfa Deformation feature, may have a similar effect as bedding planes in impeding vacuum propagation. There is evidence that air flow did occur throughout the entire monitored area, though not at rates equal to where high vacuums were measured.

- **Objective**: Improve the understanding of the diffusive response of VOCs from the rock matrix post-treatment.
  - **Bravo Area Assessment**: The concentrations in vapor phase rapidly declined, and after one weekend, showed some rebound. After the second weekend, there was almost no rebound,

although as extraction occurred, increases in concentrations were observed in the off-gas, probably indicating the arrival of vapors from a remote source (believed to be the Bravo Test Stand area). After the 6-week rebound period, these piezometer concentrations fell, suggesting the newly arrived VOCs had been absorbed into the surrounding rock, which had previously been purged (during weeks one and two) or that the source of the VOC vapor had been depleted. A longer-term test with piezometer monitoring would be necessary to more fully assess this pattern.

The *Bravo Bedrock Vapor Extraction Treatability Study Summary Report* (Appendix F) provides further details on the purpose of the study, scope of work, field methods and system operation, performance monitoring and measured data, data evaluation, and the conclusions.

BVE has been demonstrated as an effective remediation technology where VOCs are present above the water table in the fractured sandstone of SSFL. The usefulness of BVE can be described as two-fold: (1) removal of a current or long-term source for groundwater plume management, and (2) removal of vapor sources that could return to the ground surface. BVE is effective because the induced air flow tends to cover and control the same pathways as those taken by VOC migration. In this way, BVE operates efficiently to intercept and neutralize the vadose zone migration pathway that VOCs may follow downward to groundwater or upward to the ground surface.

Additional BVE study activities at the site include the establishment of a mobile 15-hp blower system with a 70-kilowatt solar panel kW Solar Panel array (mobile BVE system). This blower system is currently being piloted in the ND-136 TTA in the Alfa Area (NASA 2022d), where a bedrock matrix dominated well (NV-003) has achieved about 100 scfm at 6 inches of Hg and has removed approximately 800 pounds of VOCs in eight months of daily (day-time) operation. This system is planned to be expanded to include a fracture-dominated well (ND-162) to compare and extend the VOC removal process. Though matrix dominated, extraction well NV-003 has successfully induced remote vacuum responses on the order of 1 to 2% wellhead vacuum 130 feet away in two ports east and west of the well and has resulted in the reduction of vapor probe concentrations by 95% or more within 300 feet. This is believed to be the result of vacuum propagation in an extensive fault system in the ND-136 TTA of the vacuum that emerges from the bedrock matrix that appears to surround NV-003.

An additional test of the mobile BVE system is planned for the Phase 2 former LOX Plant ND-112 source area, to explore the transfer and set up of the mobile BVE system and its operation in a lower VOC concentration setting (NASA 2023b). This site will also investigate the variability of vapor flow in two new potential BVE wells, drilled in an area documented to have both fractures and to be bedrock matrix dominated (NASA 2022a).

4.1.2 In Situ Chemical Oxidation

The overall purpose of the ISCO field experiment was to evaluate the effectiveness and implementability of using ISCO as a groundwater remedial technology for removing TCE and its daughter products from the saturated bedrock at SSFL (CH2M 2016). Boeing shared the results of the field experiment with NASA, so the results could be used to evaluate ISCO in the CMS for NASA-administered areas of SSFL.

ISCO technology involves delivering an oxidizing agent to the subsurface to promote the oxidation of organic compounds. In the case of SSFL, it is particularly applicable for treating chlorinated ethenes. The Boeing team considered several oxidants for the ISCO field experiment and selected potassium permanganate ($KMnO_4$) because of its persistence in the subsurface for longer periods compared to other oxidants, which could result in increased transport distances through advective flow and greater diffusion into the low-permeability rock matrix. $KMnO_4$ has the additional advantages of reacting directly with contaminants and not requiring an activator and/or catalyst to achieve its full oxidation potential, compared to oxidants such as activated persulfate and catalyzed hydrogen peroxide. Oxidants requiring an activator or catalyst are more challenging in ISCO treatments because the activator or catalyst must be proximal to the oxidant and the contaminant.

Any ISCO application can encounter challenges with natural oxidant demand, subsurface heterogeneities, the mobilization of naturally occurring redox sensitive metals, and contaminant rebound. In addition, each oxidant has unique challenges; the challenge with $KMnO_4$ is the potential for manganese oxidant formation. The Boeing team considered this drawback with $KMnO_4$ less significant than the benefits described previously.

The fieldwork and data collection activities for the ISCO field experiment were conducted from October 2012 through January 2016. The experiment included the following key work elements:

- Modifying an existing monitoring well for use as an injection well.
- Collecting rock cores and installing several new multilevel monitoring wells.
- Conducting tracer testing (using fluorescein dye and bromide) to evaluate the degree of hydraulic connection between the injection well and the monitoring well network.
- Injecting $KMnO_4$, a strong oxidant, into the injection well over seven individual, week-long events.
- Collecting groundwater samples from the monitoring well network before, during, and following the tracer testing and $KMnO_4$ injection events.
- Drilling a post-injection corehole to provide rock samples for evaluating the effectiveness of the oxidant injection.
- Assembling, summarizing, and evaluating the data.

The following describes the overall objectives of the field experiment and the assessment of objectives:

- **Objective**: Evaluate the effectiveness of delivery and distribution of oxidant in the fractured sandstones of the Chatsworth Formation.
  - **Assessment**: There was relatively good distribution of the bromide tracer, which could indicate a good potential for the distribution of the oxidant. However, the overall delivery and distribution of the oxidant was relatively limited. It is likely that the natural oxidant demand (NOD) of the system consumed the oxidant before it could be effectively distributed in the study area. Multiple injections were conducted with relatively minor head rise between the first and final injections, suggesting minor reduction in permeability associated with manganese precipitation.
- **Objective**: Assess the extent of oxidation of TCE and its daughter products in the rock matrix (evaluate the magnitude of contaminant concentration reduction in the rock matrix).
  - **Assessment**: The overall extent of the oxidation of TCE and its daughter products in the rock matrix was limited. Only one post-injection corehole showed evidence of visible permanganate (an indication of oxidant persistence). The percent reduction of contaminants was less than 10%. Permanganate residence time was estimated on the order of 2 to 3 weeks, which is considered relatively short for this oxidant and is an indication of the NOD in the system consuming the oxidant. As a result, diffusion into the rock matrix, where most of the mass resides, was relatively limited. Based on laboratory testing, organic carbon was determined to be the dominant reason for the consumption of the permanganate. The same laboratory testing showed that after a 4-month diffusion study, permanganate penetration into the rock matrix was minimal (approximately 0.1 inch).
- **Objective**: Assess the NOD of the minerals and/or organic compounds in the rock matrix.
  - **Assessment**: The NOD of the Chatsworth Formation rock matrix is significant and results in elevated oxidant consumption and limited diffusion into the rock. Only 6 of the 32 sampling ports

where the tracer bromide was detected showed visible permanganate, which is indicative of a high NOD in the formation and the exertion of NOD on limiting transport of permanganate and penetration into the rock matrix.

- **Objective**: Assess the magnitude and extent of reactive minerals, such as pyrite and magnetite, on the solid surfaces of the rock that may influence the oxidation reaction.
  - **Assessment**: The Chatsworth Formation contains reactive minerals, including pyrite, but these minerals did not appear to significantly influence the NOD. While pyrite is typically reactive in oxidizing environments, laboratory imaging showed pyrite commonly surrounded by organic carbon, which limited the reactions of pyrite with permanganate. In one location, pyrite was more reactive with the permanganate compared to the other testing locations.
- **Objective**: Assess the occurrence and effects of the precipitation of oxidation reaction by-products (particularly solid manganese oxide) in the fracture system, and the occurrence of other by-products (particularly metals) in groundwater.
  - **Assessment**: The multiple ISCO injections resulted in relatively minor manganese precipitation and reduction in permeability in the fracture-dominated flow system. Some locations had elevated manganese concentrations at the end of the monitoring period, potentially posing long-term water quality concerns with respect to manganese. Other metals, such as chromium and selenium, temporarily increased during the injection period but generally declined at the end of the monitoring.

The overall conclusion of the pilot study was that ISCO with $KMnO_4$ is not effective as a remedial technology for impacted groundwater in the Chatsworth Formation. The NOD prevented the effective transport of permanganate into the formation and the penetration of the oxidant into the rock matrix. Where permanganate was visibly evident, the contaminant reduction was less than 10%.

The *Report of Results for the In Situ Chemical Oxidation Field Experiment* (CH2M 2016) provides further details on the purpose of the study, scope of work, pre-injection drilling and testing phase, pre-injection laboratory bench-testing, oxidant and potassium bromide injections, performance monitoring, post-injection corehole drilling and sampling, data evaluation results, and conclusions.

DTSC provided a number of comments on this pilot study in a letter dated March 18, 2019. DTSC questioned the conclusion that NOD was to blame for poor performance because bromide and permanganate detection limits were not comparable. Also, DTSC noted it did not agree with the conclusions of the ISCO pilot study and questioned whether the hydraulic scheme implemented in the experiments maximized fluid flow through the formation. A reinjection scheme may have improved contact between oxidant and treatment zones.

4.1.3 In Situ Thermal Treatment

ISTT comprises a suite of robust and field-proven source area remediation technologies. Available thermal technologies are flexible and adaptable to source area geometries, which allow for implementation where site conditions are constrained, or surface infrastructure preservation is required. Collectively, ISTT methods have been used to remediate a wide array of persistent organic contaminants, such as chlorinated solvents, fuels, heavy organic materials (for example, creosote), and pesticides. The versatility of available heating methods allows for ISTT application under a diverse range of subsurface conditions, treatment depths, and within challenging subsurface lithology, including fractured rock.

The most common forms of ISTT applied in site remediation are electrical resistance heating (ERH), thermal conduction heating (TCH), and steam-enhanced extraction (SEE). In operation, ISTT processes increase subsurface temperature by introducing heat in the form of electrical energy or steam to promote contaminant removal from soil, groundwater, and bedrock. Concurrent extraction of soil vapor and groundwater traditionally accompany heating system operation to capture and recover subsurface contaminants. Given the diverse range of contaminants and subsurface settings under which ISTT has been applied successfully, ISTT was identified as a potential technology for the remediation of COCs in site groundwater.

Although ISTT has been successfully demonstrated for a variety of contaminants and site conditions, as a whole, the application of thermal remediation technologies remains highly site-specific. Within SSFL and specifically Area II, multiple factors, including subsurface lithology, contaminant distribution, and site setting, may strongly influence both the implementability and efficacy of any thermal technology applied for source area remediation. The existence of three different commercially available methods for ISTT implementation adds further complication to assessing the applicability of thermal technologies to remediate contaminant sources on the site. Collectively, these factors impart measurable uncertainty in assessing remediation technologies that may be considered feasible for use at the site. In considering the feasibility of treatment technologies for the remediation of complex sites, pilot testing is frequently applied, and numerous examples of ISTT pilot tests are reported. In the context of multiple confounding constraints (for example, contaminant depth, distribution, lithology, completion schedule, and cost), evaluating the feasibility of ISTT onsite at a pilot scale was deferred in favor of a comprehensive literature review for ISTT applicability in remediation of VOCs from bedrock sites. Findings from the DOE's *White Paper on In Situ Thermal Remediation Technologies for Treatment of Chlorinated Solvents at the Santa Susana Field Laboratory (SSFL)* (CDM Smith 2018) are summarized as follows:

- Among commercially available ISTT technologies, SEE, TCH, and ERH could potentially be applied for the remediation of contaminant source areas in the unsaturated or saturated bedrock zones.
- All commercially available heating methods have been applied successfully for in situ remediation of chlorinated volatile organic compounds (CVOCs).
- Comprehensive evaluation of ISTT applications identified 13 sites where thermal remediation was applied for VOC removal from fractured or competent bedrock and the maximum depth of application was 110 feet. Of the ISTT projects identified in bedrock, ERH and TCH were the predominate heating technologies applied.
- Preference for the ERH and TCH methods in bedrock was noted and attributed to the ability of each technology to overcome bedrock heterogeneity and fracture distribution, which can strongly influence the efficacy of heating and contaminant removal using SEE methods.
- Bedrock type and porosity influence the efficacy of ISTT processes; high-porosity matrices yield better contaminant removal compared to dense, low-porosity rock, as extraction is easier.
- Successful application of ISTT for bedrock remediation requires a comprehensive understanding of the groundwater flow regime in, and immediately surrounding, the TTA. This includes the ability to predict and control the hydraulic gradient under conditions of ISTT operation and evaluate if proper heating will occur in the treatment zone.
- The effectiveness of ISTT in bedrock is predicated on the contaminant storage location (for example, fractures or rock matrix), in addition to the presence and comprehensive understanding of interconnected fractures networks within the treatment zone for recovery of contaminants liberated by heating.
- Investigation findings suggest residual contaminant mass that remains in the fractures is very small compared to contaminated groundwater present within the sandstone matrix. Therefore, diffusion of contaminants from the rock matrix to the fractures where recovery occurs will control the time and extent to which the desired treatment objectives can be fulfilled.

Although implementation of ISTT to contaminant source areas could be considered technically feasible, the potential application of any available heating technology within the site would represent the deepest application of the technology for bedrock remediation ever performed. The maximum fractured rock application depth cited in the DOE's White Paper (CDM Smith 2018) is 110 feet. The treatment depth application at the NASA sources is considerably greater (up to 500 feet or more), as described in Section 4.2 and Appendix D. Intense effort and resources have been applied in developing SCMs that represent observed contamination within the site AIGs and inform the sitewide fate and transport of TCE with the bedrock; as stated within this document and supporting RFIs, local uncertainty of the actual distribution of contaminant sources remains within each AIG.

Overall, the performance of ISTT in bedrock remains critically linked to the ability to achieve three basic conditions in the treatment zone: (1) control groundwater flow, (2) bedrock heating, and (3) extraction of mobilized contaminants. Given the inherent limitations of characterizing the exact geometry of the contaminant source zone, the corresponding fracture network for recovery, and the extreme depths in which ISTT is contemplated, there is little confidence that a system can be designed in a manner that would allow capture of the heat-induced VOC liberated from the matrix, which could lead to contaminants being moved from their current location instead of removed from the TTA. As a result, a case for ISTT application in any of the areas addressed in this Phase 1 groundwater CMS where all three conditions are reasonably satisfied is improbable.

Although ISTT is not likely to be a suitable technology for application at the site, it is recognized that a moderate increase in temperature increases many reaction and biodegradation rates. For example, increasing the groundwater temperature has been shown to increase the rate of many biological processes, including reductive dechlorination and hydrolysis of various chlorinated solvents (Madigan et al. 2012). Thus, it may be feasible to increase groundwater temperature on the order of 10 degrees Celsius (°C) as an ancillary method for enhancing the performance of an in situ bioremediation system.

There are several different configurations that could be considered to heat groundwater to accelerate in situ bioremediation; specifically use of same equipment used for ISTT described previously (ERH, TCH, and SEE), recirculating heated groundwater through the formation, and use of downhole heaters that circulate ethylene glycol, which is heated by solar equipment (as described by Environmental Security Technology Certification Program [ESTCP] project ER20-5028, TISR to Enhance Biotic and Abiotic Reactions and Accelerate Remediation [Divine n.d.]). ISTT technology has not been implemented at the depths required for treatment in groundwater, as referenced previously. The TISR technology is a relatively new sustainable remediation approach that is currently being evaluated as part of an ESTCP project. This technology has not been applied to the depths required for groundwater treatment. For the reasons described here, the ISTT technology and TISR technology were not considered as part of the technology evaluation for this CMS. However, these technologies will be considered in the Phase 2 CMS if they are considered applicable to MCOs. Therefore, the thermal heating component for enhancing EISB will be to deliver heated water in a recirculation look through the TTA.

The benefits of the temperature increase are uncertain and could only be assessed if the rate of back diffusion of contaminants from the rock matrix to the groundwater is known, including how the rate changes with decreasing groundwater concentrations in the fracture and how this dynamic relates to the depletion of mass in the rock matrix. NASA has completed additional back diffusion modeling activities (included in Appendix I) that show increasing the rate of degradation (which could represent biodegradation) in the rock matrix by several factors has limited benefits in accelerating the time to achieve MCOs. The ongoing EISB pilot study will assess how quickly contaminants can be degraded in the groundwater fractures and provide insights into the potential future benefits of the application of heat to the system to accelerate treatment, through a future adaptive management process.

4.1.4 Monitored Natural Attenuation

Natural attenuation refers to the processes by which chemicals released to the environment attenuate without human intervention through a combination of environmental actions, including biological and abiotic degradation, sorption, volatilization, precipitation, transformation, dilution, and dispersion. When used as a formal remedy at a site, the term MNA is used. The regulatory framework through which MNA is evaluated as a potential remedy at a site is described in Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999b), which lists several lines of evidence used to evaluate MNA processes occurring at a site. These lines of evidence typically include:

1. Evaluation of concentration trends (for example, plume stability and declining concentrations)
2. Assessment of geochemical conditions that can be used to demonstrate the types of attenuation processes that may be occurring
3. Field or microcosm studies (for example, microbiological studies) to verify whether particular attenuation processes are occurring

Analysis of these lines of evidence has been conducted at the SSFL AIGs, as summarized in the NASA Groundwater RFI Report (NASA 2020a).

Both laboratory (bench-scale) and field-scale evaluations of natural attenuation processes have been conducted at SSFL. A variety of bench-scale tests to assess the biodegradation processes acting on TCE and its degradation products have been conducted on bedrock and groundwater samples from SSFL by Clemson University on behalf of Boeing. Some of this research has been published in scientific journals, such as *Environmental Science & Technology*. A brief summary of these test results is provided herein.

Darlington and others (2008) presented the results of bench-scale testing designed to evaluate the occurrence of biotic and abiotic degradation of TCE and cis-1,2-DCE within groundwater and sandstone at SSFL. Anaerobic microcosms were constructed using site groundwater and sandstone core samples. ^{14}C-labeled TCE and cis-1,2-DCE were used to allow for careful tracking of degradation products. Microcosm incubation periods of up to 22 months were provided to allow ample time for reactions to proceed to completion. Microcosms were set up using coarse sandstone core samples collected from 161 to 265 meters bgs. Core material was prepared by crushing the rock prior to being placed in the microcosms. Three types of microcosms were used: (1) live, designed to simulate in situ conditions; (2) autoclaved, to assess the extent of abiotic degradation; and (3) water controls, to assess diffusive losses through the microcosm septa.

Evidence of significant reductive dechlorination was observed in many of the live microcosms. Within 150 days of setting up the microcosms, complete reduction of TCE to DCE occurred in 4 of the 12 live microcosms from 161 meters bgs, 1 of the 12 from 222 meters bgs, and 7 of the 12 from 265 meters bgs. In those microcosms in which TCE was degraded to DCE, further dechlorination to VC did not occur. The reasons why the reductive dechlorination process ceased at DCE was not identified. However, one potential reason could be that the appropriate degrading bacteria (for example, *Dehalococcoides*) were not present within the microcosms.

Although biologic reductive dechlorination of DCE was not observed, degradation of DCE was noted to occur, presumably by an unknown abiotic pathway, producing carbon dioxide (CO_2) and non-strippable residue (NSR). Glycolate, formate, and acetate were found to be components of the NSR.

Based on these results, zero order transformation rates for TCE and cis-1,2-DCE were determined to range from 0 to 0.41 micromoles per year (μM/year) and 0 to 1.7 μM/year, respectively. Overall, the test results demonstrated the occurrence of biotic and abiotic attenuation processes in sandstone and groundwater. TCE degraded biotically to DCE and both TCE and DCE degraded abiotically to CO_2 and NSR. DCE was found to degrade abiotically to a greater degree than TCE.

Subsequent research included further bench-scale testing of attenuation processes at SSFL, focusing on anaerobic abiotic transformations of cis-1,2-DCE in sandstone (Darlington et al. 2013). The objectives for these tests were to assess which mineral in the sandstone might be responsible for the abiotic degradation previously observed, evaluate the effect of different sterilization processes, and determine first order degradation rates for DCE transformation under abiotic conditions. As in the previous tests, abiotic degradation of DCE was observed, with the formation of CO_2 and NSR, including glycolate, formate, and acetate. The test results did not identify the mineral responsible for the abiotic degradation but did demonstrate that the mineral was not pyrite. A first order attenuation rate for cis-1,2-DCE for non-sterile samples was determined to be 8.7 per year.

Bench-scale evaluations of TCE and cis-1,2-DCE degradation in solid rock cores were also conducted at Clemson University (Freedman and Yu 2017). These evaluations found that TCE and cis-1,2-DCE degraded within the rock cores but at slower rates than within the previously evaluated crushed rock microcosms. First order attenuation rates in these tests ranged from 0.0095 to 0.019 per year for TCE and from 0.0095 to 0.011 per year for cis-1,2-DCE.

NASA has conducted field-scale evaluations of several MNA lines of evidence for chlorinated solvent COCs in groundwater at SSFL. These evaluations included the assessment of overall plume migration and concentration trends using Mann-Kendall analysis; the evaluation of geochemical and redox conditions within groundwater; and the use of specialized analytical methods, such as compound-specific isotope analysis (CSIA) and molecular biological tools (MBTs) (quantitative polymerase chain reaction methods), to assess the degree to which chloroethene degradation is occurring and identify the presence of microbes potentially responsible for that degradation. The results of these evaluations are presented in the NASA Groundwater RFI Report (NASA 2020a). Based on the evaluation results, it was concluded that, overall, the VOC plume boundaries were not expanding; geochemical conditions in many wells evaluated were adequate for chlorinated solvent biodegradation processes to occur; and various known halorespiring bacteria capable of degrading chloroethenes are present in site groundwater. The detection of known degradation products of TCE, such as cis-12-DCE, VC, and ethene, as well as the isotopic enrichment of TCE and cis-1,2-DCE known to occur during TCE degradation, were further confirmation of natural attenuation occurring at the site. Additional and ongoing plume COC and natural attenuation groundwater sampling is planned by NASA to support Phase 1 remedial design and CMI, the Phase 2 groundwater CMS and CMI, and remedial monitoring network decisions as part of the sitewide groundwater monitoring and future Phase 2 groundwater CMS work and CMI monitoring. As results from future flow and transport groundwater modeling become available, the monitoring well network could be updated.

These evaluations of natural attenuation processes provide compelling evidence that active biodegradation and abiotic processes are acting to attenuate the TCE released at the site. Further evaluation of natural attenuation processes, including additional groundwater monitoring, would be beneficial in improving the overall understanding of the efficacy of natural attenuation in mitigating plume migration.

The criteria for applying MNA as a remedy is well established in regulatory guidance. It involves demonstrating the suitability of MNA through a weight of evidence approach, using multiple lines of evidence, as provided for EPA documents such as OSWER Directive 9200.4-17 (1999). These lines of evidence include temporal and spatial trends in VOC concentrations with emphasis on wells located near the downgradient plume perimeter, evaluation of groundwater geochemistry vis-à-vis attenuation processes known to be effective for degrading VOCs, and additional lines of evidence through field or microcosm studies demonstrating specific degradation processes. More recently, analytical techniques to evaluate changes in carbon or chlorine isotope ratios (compound-specific isotope ratios) or the presence in groundwater of functional genes known to be used by specific dechlorinating microbes have been used to provide evidence for processes to be occurring. NASA will continue to collect and will present data to support each of these lines of evidence regarding the potential for MNA to be an effective process at the site as part of the Phase 2 groundwater CMS after additional MNA sample collection and analysis as part of the Phase 1 CMI and as specified in the forthcoming revised Sitewide Groundwater Sampling and Analysis Plan.

EPA recognizes that uncertainties may exist when implementing an MNA remedy and that those uncertainties can be managed effectively. The EPA guidance document *Performance Monitoring of MNA Remedies for VOCs in Ground Water* (EPA 2004b) provides detailed guidance regarding the design of MNA monitoring strategies and how to plan for and manage uncertainties in MNA programs. The guidance includes a description of situations that may trigger the implementation of contingencies or alternative remedies. Continued evaluation of natural attenuation processes at the site during the development of the overall site remediation approach will provide a greater understanding of site conditions and assist in reducing uncertainties that could impact the design of an MNA remedy at the site.

4.1.5 Enhanced In Situ Bioremediation

In addition to the natural attenuation bench-scale testing conducted at Clemson, bench-scale testing focused on the enhancement of biological degradation processes via biostimulation has been conducted (Freedman and Yu 2017). In the course of that research, additional information on the biological and abiotic degradation pathways for VOCs was generated. Biological conversion of TCE to cis-1,2-DCE appears to be mediated by a species of *Geobacter*. Biostimulation of microcosms containing site groundwater, aquifer material, and sodium lactate initiated complete reductive dechlorination of TCE to ethene; however, complete conversion of DCE and VC to ethene did not occur in later testing using intact rock cores. Conversion of cis-1,2-DCE to VC and ethene, where observed, appears to be mediated by the *Dehalococcoides* species. For the abiotic degradation of TCE and DCE observed in rock cores, first order rate calculations developed using ^{14}C results indicated a rate of 0.049 per year for TCE and 0.044 per year for cis-1,2-DCE, with corresponding half-lives of 14 and 16 years, respectively. These first order rates were estimated to be the most representative of in situ rates of TCE and DCE transformations via pathways other than those occurring with reductive dechlorination. While the bench-scale work found that the *Dehalococcoides* strains identified in these tests were capable of only cometabolically respiring VC, a different *Dehalococcoides* strain, BAV1, which is capable of direct metabolic respiration of DCE and VC, was identified during NASA's field-scale natural attenuation evaluations as being naturally present in SSFL groundwater (refer to Section 4.1.4 for details regarding evaluations conducted to date to assess the applicability of MNA at SSFL).

Overall, extensive bench-scale testing has demonstrated that several biologic and abiotic processes degrade TCE and its daughter products, both in groundwater and within the sandstone rock matrix of the Chatsworth Formation at SSFL. Based on these tests, the addition of fermentable carbon, which will produce electron donors, and specialized bioaugmentation cultures to VOC-impacted groundwater (where the VOCs perform the role of electron acceptor) can be expected to contribute to enhance natural biodegradation processes and help attenuate the VOC plume and source zones.

To better understand the site-specific potential for EISB to be a suitable remedy, NASA is conducting a pilot test of this technology at the ND-136 TTA (NASA 2020d and 2020h). The EISB pilot study started substrate injections and recirculation operations in May 2023 and is anticipated to operate for 18 months under a General Waste Discharge Requirements (WDR) permit (LARWQCB 2021). Reporting is in progress at the time of this document to document startup, operations, and monitoring results.

4.2 Identification of Phase 1 TTAs

As described in Section 1, DTSC and NASA agreed to the following with respect to the components of the Phase 1 groundwater CMS:

- **High TCE Concentration Areas in Groundwater:** The high TCE concentration areas in groundwater were presented in the draft groundwater CMS (NASA 2020g) and were defined as areas in groundwater where TCE concentrations exceeded 10,000 µg/L. These wells were ND-136 in the Alfa Area, WS-09 in the Bravo Area, and C-6 in the Delta Area. These areas will be collectively referred to as the Phase 1 groundwater areas. When it is necessary to refer to each of the areas individually, they are referred to as the ND-136 TTA, the WS-09 TTA, and the C-6 TTA in this report.
- **High TCE Concentration Areas in Soil Vapor:** High TCE concentration areas in soil vapor were defined as soil vapor concentrations that could potentially result in groundwater exceeding concentrations of 10,000 µg/L. ND-136 is the only location where bedrock vapor exceeds this concentration. This location will be referred to as the Phase 1 BVE area. While the ND-112 TTA location was initially considered as an area requiring treatment in the Phase 1 groundwater CMS, sampling completed after the 2015 pilot study showed that concentrations were significantly reduced. Samples collected in 2021 and 2022 confirmed the reduced concentration at this location were still significantly lower that the Phase 1 groundwater CMS bedrock vapor treatment threshold; the highest concentration of TCE was 760,000 µg/m^3 (NASA 2022a). This value is lower than the threshold for bedrock vapor treatment in this Phase 1 CMS. Given this, the LOX location is not further considered for treatment in this Phase 1 CMS and it will be reevaluated in the Phase 2 CMS. NASA submitted a former LOX Plant Area BVE pilot study work plan to DTSC in August 2023 (NASA 2023b) to describe rationale for further study at this location. Results from this study will be incorporated into the Phase 2 groundwater CMS.
- **Seep Areas:** Seeps of discharging groundwater were assessed in the areas north of the B204/ELV AIG, as well as in the southern component of the Coca/Delta AIG. DTSC and NASA agreed to include an evaluation of seep alternatives in the Phase 1 groundwater CMS. These respective areas are referred to as the Phase 1 Northern Seep Area and Southern Seep Area in this report. Seep and seep well clusters have been identified and/or installed in the general vicinity of the B204/ELV AIG associated with the Northern Seep Area, the majority of which occur outside SSFL property boundaries to the north of the AIG (Figure 2-8). Over the period of record, groundwater COCs have been detected at seep OS-08/S-25 and seep well SP-29C (Boeing 2015) and more recently at seep well SP-30D. The Southern Seep Area is defined by wells in the SP-890 cluster and is associated with the Coca/Delta AIG, this cluster is located upgradient of the Burro Flats Fault Zone.

A summary of information related to each TTA (total depth, saturated interval, and COCs targeted) is presented in Table 4-1.

The Phase 1 groundwater CMS focuses on the highest concentration, highest-risk source areas in the NASA SSFL AIGs which is associated with chlorinated ethenes (TCE, DCE isomers, and VC) which drive over 99% of the groundwater risk (NASA 2021). For the purpose of this Phase 1 CMS, TCE, DCE isomers, and VC are considered Phase 1 CMS COCs. For the Phase 2 groundwater CMS, DTSC and NASA agreed to address other areas, AIG-specific COCs, and media within the domain of the NSGW and CFOU.

The goal of treatment at these locations is to reduce contaminant concentrations to the maximum extent practicable with the objective of achieving the MCOs identified in Sections 3.2 and 3.3 and Table 3-1. The practical limits of source reduction are one to four OoM. Work completed by ESTCP (ESTCP 2016) evaluated more than 235 in situ chlorinated VOC remediation projects and found contaminant reduction ranged from one to four OoM. However, the middle 50% of these technologies achieved less contaminant removal.

> "When using the site maximums, the middle 50% of all remediation projects achieved between 0.2 and 1.4 OoM reduction in the site maximum concentration of the parent compound (between 41% and 96% reduction), with the median reduction at about 0.8 OoM (84% reduction). By comparison, when using geomeans for evaluating performance, the middle 50% range of all projects was 0.5 to 2 OoMs (between 71% and 99% reduction), with a median of 1.1 OoMs (91% reduction)." (ESTCP 2016)

In this study, bioremediation, chemical oxidation, and thermal treatment were found to reduce parent median geomean concentrations for the middle 50% of remediation projects by 92% (1.1 OoM) 84% (0.8 OoM), and 95% (1.3 OoM), respectively. The report concluded that "When considering the geomean concentrations for the parent compound, there does appear to be significant differences in the performance…" (ESTCP 2016)….". While chemical oxidation had the worst performance and thermal had the best performance, the results indicated these differences were not statistically significant. It is noted this report focused on parent compounds, and these results do not address daughter products, such as those generated by bioremediation.

The ESTCP cited report did not address groundwater extraction and treatment. However, current performance data for the GETS system indicates contaminant reduction varies at the four NASA operating wells. Over the period between mid-2020 through September 2022, total chloroethene reductions at RD-04, WS-09, and HAR-07 were 93% (1.2 OoM), 98.9% (2 OoM), and 24% (0.1 OoM), respectively. The concentration at RD-41 B increased by 482% (Jacobs 2022, 2023a). All four of these wells have continuously operated through this period, apart from periodic shutdown periods of the GETS system. Subsequent to the GETS shutdown in October 2022, groundwater concentrations have increased to levels approaching pre-treatment levels.

The forecasting of how the in situ treatment technologies will perform, as well as groundwater treatment with the GETS, is further complicated by the uncertainty in the rate of back diffusion of contaminants from the rock matrix to the fractures. While treatment of contaminants in the fractures is expected to be successful, contaminants in the rock matrix will back diffuse into the fractures and recontaminate groundwater in the fractures over time. The rate of back diffusion is uncertain. Results from the continued GETS operations, the EISB pilot study, the BVE pilot study, and future solute transport modeling will help to better inform rates of back diffusion to support future decision making. Preliminary back diffusion modeling has been performed for the site (Appendix I). This work suggests the influence of back diffusion of contaminants from the matrix overwhelm any concentration or mass reduction that may be achieved due to treatment in the fractures.

Given the results highlighted from the 2016 ESTCP report, and the information presented in the Appendix I technical memorandum, the success of treatment at different locations is expected to be variable and it is not possible to accurately forecast how the different treatment technologies will perform in comparison to each other and how performance will vary at different locations. Given the results highlighted from the 2016 ESTCP report, and the information presented in Appendix I, the success of treatment at different locations is expected to be variable and it is not possible to accurately forecast how the different treatment technologies will perform in comparison to each other and how performance will vary at different locations.

Given the previously described information, a 90% concentration reduction could be considered optimistic for each of the treatment technologies. However, this value will be used as a reference point to compare active treatment alternatives to the natural attenuation alternative. Phase 1 groundwater areas were defined based on a TCE concentration greater than 10,000 µg/L in groundwater. This concentration threshold was chosen as it approximates the level of TCE in groundwater at which free-phase TCE could be present based on the 1% rule (EPA 2004a). By treating groundwater with TCE concentrations greater than 10,000 µg/L, the potential for DNAPL to be present is limited, significant mass can be removed from the groundwater system through treatment or extraction, and downgradient mass transport to the rest of the plume is limited.

Based on this information, groundwater TTAs were identified using the decision logic presented on Figure 4-1. Three Phase 1 groundwater areas were defined based on the logic on this figure, which is summarized in Section 4.2. The areas are represented by the 10,000 µg/L TCE plume contours in the Alfa and Bravo Areas (Figure 2-11) and Delta Area (Figure 2-14). Figures 4-2 (ND-136 TTA and WS-09 TTA) and 4-3 (C-6 TTA) show the TTAs for these areas, based on the information on Figures 2-11 and 2-14. The area of each groundwater source TTA is assumed to be 150 feet by 150 feet based on information presented on Figures 2-11 and 2-14. The WS-09 TTA is approximately this dimension on Figure 2-11. The C-6 TTA appears to be more elongated but also less wide on Figure 2-14, with a net area of approximately 22,500 square feet. The ND-136 TTA appears to be smaller based on Figure 2-11, but the depicted area is uncertain. While Figures 2-11 and 2-14 are illustrative of potential TCE plume concentrations, the number of wells to define groundwater concentrations greater than 10,000 µg/L TCE is limited in each TTA, creating uncertainty in the actual TTA footprint. For the purposes of this CMS, it was assumed all three TTAs are 150 feet by 150 feet in areal extent, which is considered reasonable for purposes of comparing corrective action alternatives. Further delineation of the TTAs may be completed in the CMD or CMI phases of work. The TTA for the C-6 location cannot address the full limits of the 10,000 µg/L plume represented on Figure 2-14 due to access restrictions south of the Delta Skim Pond, specifically, rocky terrain and culturally sensitive areas. During the CMI, additional strategies to expand treatment areas and monitoring infrastructure into downgradient areas to the south will be further explored and evaluated for technical feasibility and cost effectiveness. The saturated intervals targeted for treatment and overall depths of treatment for each TTA vary by location and are further discussed in Section 6.1.5 and Appendix D.

NASA installed six groundwater extraction wells in response to DTSC's request for the implementation of the GETS interim measures. The GETS wells started extracting groundwater in mid-2020 after the pipeline was rebuilt from the Woolsey Fire. It operated through October 2022. The system operations were paused due to excessive drawdown of groundwater at the Boeing extraction wells and low mass recovery at NASA extraction wells. The system will return to normal operations when water levels and groundwater concentrations recover and system operation issues are fixed (Jacobs 2023b). GETS well ND-136 is being used for the EISB pilot study (NASA 2020d, 2020h), so performance data on this well is limited. GETS well ND-138A (which replaced WS-09A in the Southern Seep Area) only operates during periods of potential discrete seep water discharge (visible pools) in the Southwestern Drainage, near the SP-890, SP-881, and SP-882 well clusters. Additional information on the NASA extraction well performance is described in the annual and quarterly GETS monitoring reports (CH2M 2023a, 2023b). DTSC has stated that groundwater interim measures "will likely continue until characterization activities are completed, a corrective measures study has been completed, and groundwater final remedy has been selected and implemented" (DTSC 2008).

NASA and DTSC are evaluating, and will continue to evaluate, the effectiveness of the GETS interim measures and determine the future operation of the wells. A summary of the NASA wells included in the GETS interim measures, and a summary of historical data, is presented in Table 4-2, and a layout of the extraction system is presented on Figure 4-4. The locations of the GETS extraction wells and proposed TTAs are also highlighted on Figures 4-2 and 4-3. The information on the GETS extraction wells is provided for informational purposes only and to convey that two of the six GETS extraction wells are sources for high TCE concentration groundwater areas. The performance of the GETS interim measures will also be further evaluated in the Phase 2 CMS.

4.2.1 Phase 1 High Concentration Bedrock Vapor Target Treatment Areas

Some areas of SSFL historically have had high bedrock vapor concentrations. To mitigate the potential for bedrock vapor to impact groundwater and result in high-strength contaminated groundwater, the TTA was defined by bedrock vapors that could result in groundwater TCE concentrations exceeding 10,000 µg/L (Appendix A) and where groundwater concentrations already exceeded 10,000 µg/L.

To address the question of whether bedrock vapor has the potential to result in TCE porewater concentrations greater than 10,000 µg/L, modeling was performed to estimate the level of bedrock vapor that may result in highly contaminated TCE porewater. The results of this model, presented in Appendix A, show that concentrations of TCE greater than 12,000,000 µg/m^3 could result in highly contaminated TCE porewater, using the assumptions provided in Appendix A.

Based on this analysis, one area of bedrock vapor is considered for treatment and coincides with the area of the 10,000 µg/L TCE groundwater plume in the Alfa Area (Figure 2-11). The ND-136 TTA for bedrock vapor at this location is represented on Figure 4-2.

4.2.2 Phase 1 Seep Target Treatment Areas

The following sections discuss the three general seep areas identified in the RFI and the TTAs.

4.2.2.1 Southern Seep Area

As described in the Section 2.3.4.2 seeps subsection, 14 seep areas have been identified in the area of the southern components of the Delta AIG plume. However, only one of these areas is on NASA property, and this location is in the vicinity of the SP-890 well cluster. While this location occasionally has two to three pockets of standing water with dimensions of approximately 5 feet by 5 feet by 4 to 6 inches deep, the standing water is generally observed from mid-spring through late summer. However, in 2019, the seeps and surface water discharge were observed flowing as late as November. Surface water runoff and treated stormwater discharged through Outfall 018 flow through the channel during the winter. The seep area around well cluster SP-890 is currently not included as part of the ongoing manual seep sample collection performed by both NASA and Boeing because of the shallow nature of the drainage channel (the discharge is not naturally contained in bedrock pool facilitating its collection and removal). The depth interval of this TTA is approximately 20 to 45 feet bgs; the rationale for this interval is described in Appendix D. The area of the TTA is uncertain as the amount of upgradient concentration coming from the Boeing site is unknown. The location of the southern seep TTA is presented on Figure 4-3.

4.2.2.2 Northern Seep Area

As discussed in Section 2.3.3.2, 15 seep and seep well clusters have been identified and/or installed in the general vicinity of the B204/ELV AIG associated with the Northern Seep Area, the majority of which occur outside SSFL property boundaries to the north of the AIG (Figure 2-8). Over the period of record, groundwater COCs have been detected at seep OS-08/S-25 and seep well SP-29C (Boeing 2015) and more recently at seep well SP-30D.

Groundwater COCs have not, and are not expected to, reach the B204/ELV AIG-related seeps at concentrations above their GSLs, because of these low and sporadic detections and given the evidence of the lack of plume expansion at the distal edges, as discussed in Section 2.3.2.4 (Appendix B of the NASA Groundwater RFI Report; NASA 2020a).

Routine, long-term groundwater monitoring, augmented by numerical flow and transport modeling, will be fundamental elements of any groundwater remedy at the B204/ELV AIG to assess plume stability, ascertain additional monitoring needs, and identify any unanticipated plume behavior. The ultimate pathway for potential offsite COC migration under current hydraulic conditions is through seep water that emerges to the north of the B204/ELV AIG. However, the existing analytical data indicate that no COCs above GSLs have been detected in the Northern Seep Area. Because plume spatial extents are generally not expanding, with COC detections above GLSs at site monitoring wells being relatively consistent, and the mass of TCE and related daughter products are expected to peak and then decrease as TCE is degraded, no threat of offsite migration of the B204/ELV AIG COC plumes above GSLs has been identified (NASA 2020a). However, as requested by DTSC, contingency remedial action associated with the Northern Seep Area exposure pathway is prudent to assess. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA.

The focus of the Northern Seep Area TTA is to treat or prevent groundwater from migrating from onsite plumes to offsite seep locations. This will be addressed using two different transects (ELV [west of ND-125] and B204 [downgradient of well cluster ND-56]), as presented on Figure 4-5. Each of the transects are approximately 250 feet long and were selected as locations to treat groundwater before it moves farther downgradient. The depth of the B204 transect is 450 feet (150 feet saturated interval) and the depth of the ELV transect is 400 feet (220 saturated interval); the rationale for these depths is included in Appendix D along with associated cross sections. As stated previously, NASA agreed to develop and evaluate alternatives for this area as a contingency measure, in the event that higher concentrations are reported in the future.

4.3 Identification of Phase 1 Treatment Technologies and Screening

As described in Section 4.2, the focus of this groundwater Phase 1 groundwater CMS is on groundwater source areas and seep areas, specifically:

- High TCE concentration areas in groundwater at locations near wells ND-136 (Alfa Area), WS-09 (Bravo Area), and C-6 (Delta Area)
- High TCE concentration areas in bedrock vapor near well ND-136 (Alfa Area)
- Seep areas in NASA-administered areas in the southern Delta plume (Southern Seep Area)
- Seep areas in NASA-administered areas north of the B204/ELV AIG (Northern Seep Area)

The conceptual approach to screening technologies and developing alternatives with retained technologies is represented on Figure 4-6, using the Phase 1 groundwater areas as an example. Technologies that were screened for source areas and seep areas are presented in Sections 4.3.1 and 4.3.2, respectively. These technologies were screened against the criteria of effectiveness and implementability. The full complement of technologies evaluated is presented in Tables 4-3 and 4-4 for source areas and seep areas, respectively.

The following provides a definition of the two screening criteria evaluated for each technology defined in Sections 4.2.1 and 4.2.2:

- Effectiveness – A measure of the technology's ability to remove, treat, or degrade contaminant mass and concentrations. Information presented in Sections 4.1 and 4.2 discuss the challenges associated with a high degree of treatment and achieving OoM reduction with treatment technologies. The ability to achieve MCOs in the near term (e.g., several decades) is uncertain. More data is needed to better estimate time of remediation. Some of this data is expected to come from the implementation and operation of the remedies implemented as a result of the P1 CMS. Other data will be gathered as part of implementing the P2 CMS alternatives and the following adaptive management phase. Given this, the effectiveness criteria have been evaluated in terms of what the best available technology can achieve for general mass removal and contaminant reduction. Over the course of longer time intervals (much longer than what is considered practical for active treatment), MCOs can be achieved.
- Implementability – A measure of the difficulty of implementing the alternative at the TTA. Considerations for these criteria include the availability of service providers to support implementation of the alternative, the ability to successfully permit the alternative for implementation, and the accessibility of the site and site-related support features such as electricity to deploy the alternative at the project site.

The semi-quantitative scoring criteria used for each screening criteria are presented on Exhibit 4-1.

Exhibit 4-1. Semi-Quantitative Scoring Criteria

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Effectiveness	Technology will not be effective at site	Technology has been proven to work at other sites, but there are significant challenges and uncertainties to overcome to achieve desired effectiveness	Technology has been proven to work at other sites, but there are numerous challenges and uncertainties to overcome to achieve desired effectiveness	Technology has been proven to work at other sites, but there are several challenges to overcome to achieve desired effectiveness	Technology is proven to work in conditions similar to the site. High confidence the technology will be effective
	1 Unacceptable	**2 Unlikely to Work**	**3 Equal Plus's and Delta's**	**4 Likely to Work**	**5 High Confidence**
Implementability	Technology is not implementable at site	There is low likelihood that implementation challenges can be overcome	There are numerous implementation challenges and some may be difficult to overcome	There are some challenges to implementation, but they can likely be overcome with effective planning procedures	Minimal implementation challenges expected

4.3.1 Treatment Technologies for Phase 1 Groundwater Areas

This section summarizes the potential source area technologies that could be applied to achieve contaminant concentration reductions, which may reduce the time to achieve MCOs identified in Section 3. The alternative that will ultimately be selected by NASA and DTSC may consist of a combination of technologies, so each technology was evaluated for its potential to be part of a remediation alternative.

The identification of technologies is the first step of the evaluation process used to screen technologies, assemble alternatives, and evaluate the alternatives. The overall process, including the identification of treatment technologies through a detailed evaluation of alternatives, is presented on Figure 4-6. The following technologies were identified for consideration for their contribution to a source remediation alternative:

1) ISTT – Considered for treatment of groundwater areas (refer to Section 4.1.3 for technology description).
2) EISB – Considered for treatment of groundwater (refer to Section 4.1.5 for technology description).

3) Thermally Assisted EISB – Similar to EISB but with the addition of heating the treatment zone to increase subsurface temperatures and accelerate the rate of degradation (refer to the last paragraph of Section 4.1.3 for technology description).
4) ISCO – Considered for treatment of groundwater (refer to Section 4.1.2 for a technology description).
5) Biosparging – Considered for treatment of groundwater. This treatment involves the addition of oxygen, typically compressed air via injection wells, to the groundwater to promote aerobic biological treatment. The treatment is most often applied to petroleum-related contaminants.
6) Air Sparging – Considered for treatment of groundwater. This treatment is similar to biosparging but uses more air. The objective of air sparging is to strip VOCs from the groundwater and allow them to volatilize above the water table. This treatment is often coupled with SVE to recover VOC gases that evolve with air sparging.
7) BVE – Considered for treatment of bedrock vapor (refer to Section 4.1.1 for technology description).
8) Pump and Treat (P&T) – Considered for treatment of groundwater and also used for the interim measure wells. This treatment involves extracting groundwater through groundwater extraction wells and transferring to aboveground treatment processes. For the SSFL, the extracted groundwater would be pumped to the GETS on Boeing's property for treatment or to another ex situ treatment facility that would be constructed in the future.
9) In Situ Fracking – Environmental applications of this technology are applied in unconsolidated media and involve fracturing the geologic formation to create new openings in the media to allow delivery of treatment reagents, such as zero-valent iron, to reach potential contaminants that cannot be accessed through the existing fracture networks.
10) MNA – Considered for treatment of COCs in groundwater (refer to Section 4.1.4 for technology description and criteria for establishing MNA).

Table 4-3 provides an overview of how these technologies would be conceptually deployed and how the technologies were evaluated against the effectiveness and implementability screening criteria. Based on the screening narrative for effectiveness and implementability in Table 4-3, a semi-quantitative score was applied for each criterion and technology, based on the scale in Exhibit ES-1. The results of the technology screening, along with the relative ranking of each technology, are represented in Table 4-3. A graphical summary of the technology screening presented in Table 4-3 is shown on Figure 4-7.

The highest scoring technologies were P&T and BVE. Four other technologies—EISB, thermally assisted EISB, ISCO, and MNA—were also considered viable (Table 4-3 and Figure 4-7). Therefore, the following technologies were retained to be considered for inclusion in the alternatives:

- P&T
- BVE
- EISB
- Thermally assisted EISB
- ISCO
- MNA

After these six technologies were evaluated, there is a noticeable gap in the evaluation scores. The technologies not retained. and the reasons for not retaining them are as follows:

- ISTT was not retained for the following reasons:
  - Phase 1 groundwater areas have treatment zones as deep as 475 feet and are in fractured rock.
  - DOE's White Paper identified 10 ISTT projects implemented in fractured bedrock globally. Each one has encountered challenges that have limited removal efficiency because of high

groundwater flows at depth and the cooling effect these have on the rock and extracted steam. All of these applications were completed at a depth of less than 110 feet. From conversations with vendors, NASA is aware of a new deployment in Europe at a depth of 175 feet; however, the results are not available, and vendors expressed concern about azimuth control with deeper applications (leading to heating elements not able to be kept at design spacing, but some closer to each other, some further away).

- Challenges working at the necessary depths at NASA's sites, including the following:
  - Keeping heating elements spaced as designed; a 1% deviation from vertical when drilling to target treatment depths at the high TCE concentration areas could leave some areas untreated.
  - The heating elements from ground surface to required target treatment depths represent a significant weight on the elements. Heating elements for this depth have not been previously designed.
  - Capturing mobilized COCs that migrate outward faster when heated, beyond the zone of hydraulic control, represents a significant contaminant migration risk, as these volatilized contaminants would then condense outside the treatment zone.
  - Removing deep steam and steam-borne COCs that condense at depth and prevent contaminant recovery is uncertain at the deep depths required for treatment.
  - Power requirements for an ISTT application at each high concentration TTA could exceed 10 megawatts in a remote area.

- Biosparging was not retained because it is considered ineffective for chlorinated ethenes, as it relies on aerobic processes to treat chemicals. Biosparging is typically applied to enhance aerobic treatment in groundwater. Chlorinated ethenes are more effectively treated with anaerobic processes. This technology involves in situ bioremediation of COCs and scored considerably less than EISB, which is also an in situ bioremediation technology. The site does not contain any locations that have what would be considered highly contaminated groundwater with petroleum; no maximum historical concentration of Extractable Fuel Hydrocarbons exceeds 10 mg/L, and more than 85% of maximum historical concentrations are less than 1 mg/L extractable fuel hydrocarbons.
- Air sparging was not retained because it is typically applied in porous media and requires knowledge of where air channels and pathways will migrate so that an effective vacuum extraction system can be installed to capture the chlorinated ethene vapors before they discharge to the atmosphere. Air sparging within a fractured rock system is not advised because of the uncertainty of whether sparged air would migrate up through the bedrock to the vadose zone or become trapped in non-interconnected, branched fracture systems. At best, air sparging moves volatile compounds to a different (and less accessible) spot in the formation. At worst, air in dead-end fractures will be retained by the surface tension of the remaining moisture, through which groundwater will not flow until the air has been reabsorbed (partitioned into solution). Also, air sparging is typically used to "strip" CVOCs from groundwater. While air sparging can be used to add oxygen to water, biosparging, which uses lower air flow, is typically used to add oxygen to make conditions more aerobic, which is counter to EISB strategy. Given the fractured network at the site, confidence in being able to design a system that can safely mitigate VOC off-gas from the air sparging process is low.
- In situ fracking was not retained because environmental applications of this technology are applied in unconsolidated media. Contaminants at NASA SSFL have migrated into the rock matrix via existing fractures. Creating new fractures in the rock matrix is unlikely to access contaminant mass that would be available for recovery and could create new pathways for contaminant migration, which would complicate the current understanding of the SCM.

4.3.2 Treatment Technologies for Seep Areas

This section summarizes the potential seep area technologies that could be applied to achieve the MCOs identified in Section 3. The alternative that will ultimately be selected by NASA and DTSC may consist of a combination of technologies, so each technology was evaluated for its potential to be part of a remediation alternative.

The following technologies were assessed for their contribution to a source remediation alternative:

- Permeable Reactive Barrier (PRB) for Seep Water – This treatment specifically focuses on treating groundwater in areas where seeps show contamination. It uses flow-through media, such as zero-valent iron or carbon, to treat groundwater before the groundwater expresses as a seep.
- EISB Barrier Treatment Zone – Considered for treatment of groundwater in areas upgradient of seeps. EISB involves the addition of a carbon substrate as a food source for indigenous bacteria to grow and degrade chlorinated ethenes and other organic compounds through the process of enhanced reductive dechlorination (ERD) or other anaerobic biological degradation pathways. In some instances, it may be necessary to augment treatment sites with specific bacteria if the indigenous bacteria are not capable of providing the type of microbial reductive processes required to treat COCs. Numerous EISB carbon sources and delivery approaches can be considered. This technology is functionally equivalent to the EISB technology discussed as part of the high concentration TCE areas. The name of this technology was changed, however, to differentiate between the objective of the technology applied to seeps (mitigate downgradient contaminant mass migration) versus source zone treatment applied to high concentration TCE areas.
- Phytoremediation of Seep Water – This treatment involves planting trees to prevent seeps from “daylighting” or to provide incremental mass removal. Existing trees can be used, or new trees planted. Several tree species, some of which currently exist in the Delta Area seep, have been successfully used for cis-1,2-DCE treatment in the root zone (rhizosphere) and are known to create or foster dehalogenase enzymes. This technology is not applicable to the Northern Seep Area because the depth to groundwater is too great for tree roots to access.
- Constructed Treatment Wetlands – The areas where seeps are expressed would be redesigned to install aerobic and/or anaerobic constructed wetlands. Seep water would migrate through the wetlands and contaminants would be removed. Periodic harvesting of plants may be required to keep wetland viable. This technology is not applicable to the Northern Seep Area because of the depth of groundwater.
- Hydraulic Control of Seep Water (Groundwater Extraction and Treatment of Seep Water) – This treatment involves extracting groundwater at a location that can prevent seeps from “daylighting.” Extracted groundwater is treated at the GETS or other ex situ treatment system. This technology is functionally equivalent to the P&T technology discussed as part of the high concentration TCE areas. The name of this technology was changed, however, to differentiate between the objective of the technology applied to seeps (mitigate downgradient contaminant mass migration) versus source zone treatment applied to high concentration TCE areas.
- Fine Bubble Diffused Aeration – This treatment involves using fine bubble aeration to strip VOCs from pooled seep water. This technology would be applied at the location of the seep and treated water would remain in place.
- MNA – Concentrations in expressed seeps are expected to be low and reduce through the process of natural attenuation and potential upgradient treatment. This technology involves evaluating concentrations over time and monitoring geochemical and other parameters in groundwater. If concentrations increase to a level that would warrant active treatment, another technology could be implemented.

Table 4-4 provides an overview of how the technology described in Section 4.3.2 would be conceptually deployed and how the technology was evaluated against the effectiveness and implementability screening criteria. Based on the screening narrative presented for effectiveness and implementability in Table 4-4, a semi-quantitative score was applied for each criteria and technology, based on the scale presented in Exhibit 4-1. The results of the technology screening, along with the relative ranking of each technology, are represented in Table 4-4. A graphical summary of the technology screening presented in Table 4-4 is shown on Figure 4-8.

Because of their relatively higher scores (Table 4-4 and Figure 4-8), the following technologies were retained to be considered for inclusion in the alternatives:

- EISB barrier treatment zone
- Hydraulic control of seep water
- MNA

The following technologies were not retained:

- PRB for seep water treatment was not retained as it would be an environmentally disruptive technology in an environmentally sensitive Southern Seep Area. Installation of a PRB would require extensive drilling and/or trenching, which would likely be impractical in the culturally sensitive area where the PRB would need to be located. Installation of an effective PRB would also require detailed knowledge of subsurface flows, which are not completely understood. There is little confidence that a PRB system can be designed in a manner that would capture contaminants, given the unpredictable groundwater flow. It is not practical do deploy this technology in the Northern Seep Area due to the depth challenges.
- Phytoremediation (not applicable to Northern Seep Area) of seep water was not retained, as it would involve planting of hundreds of non-indigenous trees in the culturally sensitive area of the Southern Seep Area, making this technology environmentally disruptive during planting activities. The use of non-indigenous trees in a culturally sensitive area may also be a concern.
- A constructed treatment wetland (not applicable to Northern Seep Area) was not retained as it would involve significant earthwork to build the technology, which would have negative impacts to the culturally sensitive area in the Southern Seep Area. Earthwork would include the drainage area where seep occurs. Additionally, stream bed alteration permits would likely be required, and they are difficult to get approved for a culturally sensitive area. The wetland plants that are successful in promoting aerobic and anaerobic treatment are not indigenous to the culturally sensitive TTA. Plants would require water year-round, but the seeps are present only during the wet season. Consequently, the constructed treatment wetland would likely not survive the dry season.
- Fine bubble diffused aeration (not applicable to the Northern Seep Area) was not retained as its application to the shallow seep pools would significantly limit its effectiveness. Fine bubble diffused aeration is a physicochemical stripping process that requires contact time and water column mixing. These requirements necessitate standing water over the fine bubble diffusers, which is not attainable in the shallow seep pools where the technology would be implemented.

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5. Development of Alternatives – Sources

For the next step of the evaluation process, the technologies retained in Section 4 were used to develop Phase 1 alternatives. The alternatives represent technology combinations, as shown on Figure 4-6 (refer to "Assembled Alternatives"). Each alternative is described in this section.

Alternatives for Phase 1 groundwater and bedrock vapor and seep areas, are presented as separate groups and each group is evaluated separately.

The alternatives presented for the Phase 1 groundwater TTAs and the seep TTAs are evaluated as if one alternative is applied to all the TTAs in a specific type of TTA (i.e., source groundwater or seep). For example, Alternative 2a (described in a following subsection) is evaluated assuming this alternative is implemented at the three source TTAs. However, the evaluation of alternatives presented in this report also supports using different alternatives at different specific TTAs. For example, NASA and DTSC may choose to implement Alternative 2a as the ND-136 TTA and Alternative 3 at the WS-09 TTA, and the information contained in this report can support this decision. It is not practical to address every alternative combination at each of the TTAs as an inordinate number of alternative combinations would require evaluation.

5.1 Phase 1 High TCE Concentration Area Alternatives

The alternatives described in this section are considered the best combinations of the retained technologies that could result in the most promising alternatives to achieve the cleanup objectives for the sources COC sources (groundwater and bedrock vapor):

- Alternative 1: MNA and LUCs. This alternative relies on natural attenuation, which has been demonstrated to be successful in some locations at SSFL (Section 2), and LUCs to prevent access to groundwater and limit future site use until MCOs are achieved. LUCs include ICs and engineering controls.
- Alternative 2a: Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs. This alternative has the technology components of Alternative 1 with the addition of BVE treatment at well ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TTA) using EISB technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- Alternative 2b: Groundwater treatment with EISB and thermal heating, followed by MNA for groundwater, BVE for soil vapor, and LUCs. These are the same treatment technologies described in Alternative 2a with the addition of heating the water prior to injection to facilitate faster microbial degradation.
- Alternative 3: Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs. This alternative has the technology components of Alternative 1 but also includes BVE treatment at ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TTA) using P&T technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- Alternative 4: Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs. This alternative has the technology components of Alternative 1 but also includes BVE treatment at well ND-136 (Alfa Area) and treatment of groundwater (ND-136 TTA, WS-09 TTA, and C-6 TT) using ISCO technology. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.

The following rationale was used in developing the alternatives:

- All alternatives will use MNA and LUCs. MNA has been shown to be effective for managing groundwater after the active treatment elements of the alternatives have reached their practical limitations. LUCs are included in all alternatives because ICs and engineering controls will be required to prevent contact with COCs.
- BVE is a technology component of Alternatives 2a, 2b, 3, and 4 and will be used at locations where bedrock vapor concentrations have the potential to mix with infiltrating water and result in pore water TCE concentrations greater than 10,000 µg/L (ND-136 TTA).
- P&T technology is included in Alternative 3 and may be used to treat groundwater where TCE concentrations exceed 10,000 µg/L (Figures 4-2 and 4-3). P&T technology is already being deployed as part of the GETS interim measures.
- EISB technology is included in Alternatives 2a and 2b and may be used to treat groundwater where TCE concentrations exceed 10,000 µg/L (Figures 4-2 and 4-3).
- Thermally assisted EISB is included in Alternative 2b. This alternative is identical to Alternative 2a with the exception of heating the recirculated water prior to injection to accelerate the rate of biodegradation.
- ISCO is included in Alternative 4 and would be used to treat groundwater where TCE concentrations exceed 10,000 µg/L (Figures 4-2 and 4-3).

5.2 Phase 1 Seep Alternatives

The following alternatives are considered the best combinations of the retained technologies that could result in the most promising alternatives to achieve the cleanup objectives for the seeps. These alternatives have an "SP" in the alternative name to differentiate them from the alternative names for the high concentration TCE source TTAs. These alternatives apply to the Southern Seep Area and the Northern Seep Area; as stated in Section 4.2.3.3, the alternatives for the Northern Seep Area should be considered contingency alternatives should they need to be applied in the future. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA.

- **Alternative SP-1: MNA and LUCs.** This alternative relies on natural attenuation, which has been demonstrated to be successful in some locations at SSFL (Section 2), and LUCs to prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative SP-2: Hydraulic Control of Seep Water, MNA, and LUCs**. This alternative is similar to Alternative 3 (for the high TCE concentration groundwater TTAs) in that contaminated groundwater is extracted and treated at the GETS. Instead of targeting source areas, this technology is deployed to intercept contaminated groundwater before it expresses as seeps. This alternative includes MNA, which would be used after hydraulic control has achieved its practical application limits. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.
- **Alternative SP-3: EISB, MNA, and LUCs**. This alternative is similar to Alternative 2a (for the high TCE concentration groundwater TTAs) in that EISB is used to enhance degradation of contaminants in the subsurface. However, instead of applying the EISB technology in a source area, EISB would be deployed upgradient of where contaminated groundwater is expressing as seep water. This deployment is expected to treat contaminated groundwater prior to it expressing as seeps. This alternative includes MNA, which would be used after EISB has achieved its practical application. LUCs are also a component of this alternative and will prevent access to groundwater and limit future site use until MCOs are achieved.

The following rationale was used in developing the alternatives:

- All alternatives will use MNA and LUCs. MNA will be used to reduce contaminant concentrations with Alternative SP-1 and be used after the practical limitations of the hydraulic control and EISB technologies have been achieved with Alternatives SP-2 and SP-3, respectively.
- Hydraulic control technology is included in Alternative SP-2 to reduce contaminant concentrations in groundwater before it can migrate offsite and express as seeps.
- EISB technology is included in Alternative SP-3 to intercept contaminated groundwater before it can migrate offsite and express as seeps.

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6. Detailed Analysis of Alternatives

Each Phase 1 groundwater CMS alternative developed in Section 5 represents a combination of individual technologies. The following sections provide the details for implementing the technologies for each alternative. In the descriptions of these technologies, which are assembled into different combinations to create CMS groundwater and bedrock vapor source Alternatives 1, 2a, 2b, 3, and 4 and seep area Alternatives SP-1, SP-2, and SP-3, some conceptual details regarding equipment, materials, and design variables are based on information available at the time the Phase 1 groundwater CMS was prepared. As part of the normal CMD phase of work, this information will be revisited, and likely revised, during the design process. In this Phase 1 groundwater CMS, any design details are presented for conceptual purposes only. More accurate information will be developed as part of the CMD and implementation phases of the project.

In addition to the technologies included in the alternatives, LUCs (Section 6.1.3) are a component of all source area treatment alternatives and adaptive site management (Section 6.1.9) can be applied to all the technologies. The time period for remediation is also a consideration for all the source area treatment alternatives and is discussed in Section 6.1.1.

6.1 Technology Components of Alternatives

The technology components that make up the overall source and seep area alternatives are described in the following sections.

6.1.1 Estimate of Time Period for Remediation

One important component of each alternative is the amount of time it takes to achieve MCOs. This information will help frame the time period for achieving MCOs and highlights the degree of benefit associated with active treatment.

To help address the amount of time for remediation for each alternative, one-dimensional groundwater modeling was performed (Appendix B) to roughly estimate the time it takes to reduce TCE concentrations in each of the high TCE groundwater concentration TTAs addressed by this CMS. The one-dimensional model is based on the change in plume lengths over time, using assumptions based on active treatment and natural attenuation progress. It is acknowledged this modeling approach simplifies the matrix-diffusion process. However, as agreed upon between NASA and DTSC, the modeling work documented in Appendix B meets the intended purpose to support Phase 1 groundwater CMS-level alternative comparisons of remediation timeframes. Additional AIG- and plume-specific groundwater flow and transport modeling is being performed for the NASA site to support Phase 1 CMI and Phase 2 CMS/CMI work and incorporates a more robust transport formulation that better simulates the matrix-diffusion process (NASA 2022b, 2023c).

This analysis was completed for the groundwater sites to provide a range of potential MNA and active treatment timeframes. The estimates for MNA assume the use of only natural attenuation processes (refer to Section 6.1.2 for MNA discussion). The one-dimensional modeling results are summarized in Appendix B and Table 6-1. Based on the results, the length of time for natural attenuation to achieve MCLs in each source area TTA is approximately 190, 360, and 270 years for ND-136, WS-09, and C-6, respectively. As described in Section 4.2, achieving a 90% mass reduction with treatment could be considered optimistic. Modeling results presented in Appendix B (Table B-3) estimate the time to achieve one, two, and three OoM reductions (i.e., 90%, 99%, and 99.9% reduction) of TCE, considering both natural attenuation and active treatment. Employing active treatment with Alternatives 2a, 2b, 3, and 4, which may accomplish an initial one OoM reduction, would change the time to achieve TCE MCLs of each source area TTA to 140, 275, and 215 years for ND-136, WS-09, and C-6, respectively. The reduction in time for each source area TTA is 50, 85, and 55 years for ND-136, WS-09, and C-6, respectively (refer to Table 6-1).

When comparing the length of time of remediation between natural attenuation and the active treatment alternatives, the length of time to achieve a one OoM reduction is reduced at the ND-136 TTA, WS-09A, and C-6 TTA by 47, 85, and 50 years (Table B-3 in Appendix B), respectively, assuming a one OoM reduction can be achieved with each active treatment technology in 10 years. The time to achieve additional second and third OoM reduction in the post active treatment phase is approximately 57, 95, and 60 years respectively for each TTA, comparable to orders of magnitude reduction for the natural attenuation alternative.

The time of operation for the active treatment components of Alternatives 2a, 2b, 3, and 4 were all assumed to be 10 years. All four alternatives rely on treating or removing contaminant mass flowing in bedrock groundwater fractures. Given the uncertainties in rates of back diffusion from the rock matrix, groundwater velocities, and treatment effectiveness of each alternative, it is not possible to distinguish different treatment times for each of the four active treatment alternatives. The 10-year active treatment is an assumption based on application of the treatment technologies at other complex sites. The treatment time assumption is used for the purposes of developing a cost estimate for implementation of each alternative. However, as part of the adaptive management component of each alternative, if treatment continues to be effective after 10 years, treatment will continue until a time where it becomes technically or economically infeasible.

A number of uncertainties are associated with the modeling, such as the following:

- Model addressed only TCE and not the daughter products.
- Baseline (starting) concentration for the model could change depending on when the alternative is implemented.
- One-dimensional groundwater modeling presented in Appendix B and summarized in Table 6-1 does not differentiate between Alternatives 2a, 2b, 3, and 4 regarding the amount of time for remediation because it is not possible to estimate different treatment efficiencies (mass removal and time) for each active treatment alternative. For the purposes of this CMS, it was assumed that all active treatment components for groundwater would perform equally and operate for 10 years (as described above), with the potential for operating longer if practicable. The results presented in Table 6-1 are based on a time of remediation estimate for the entire Alfa, Bravo, and Delta TCE plumes. While the focus of this Phase 1 groundwater CMS is the source areas of these three plumes, the results presented in Table 6-1 are still valid for the purposes of estimating cleanup time because the source areas would likely be the last areas of the plume to achieve MCOs.
- As described in Section 4.2, a 90% concentration reduction could be considered optimistic for active treatment. While it is possible that greater than 90% removal may be achieved in one or more of the source areas, decreasing the overall time of remediation for alternatives with active treatment as a component, it is equally likely that less than 90% reduction may be achieved with active treatment, which could extend the time to achieve concentration reduction.

NASA acknowledges the additional uncertainties with regard to the accuracy of the one-dimensional groundwater model presented in Appendix B. Additionally, NASA understands a number of papers question the benefits of source treatment in a fractured rock environment. For example, Pierce and others (2018) concluded that the removal of sources does not impact the dimensions of a plume in a back-diffusion-limited environment. However, NASA recognizes a benefit to removing isolated high concentration areas of TCE and the possibility that removal of such mass may potentially reduce the amount of time necessary for remediation. NASA believes the modeling conclusions are valuable in providing a context for the time it may take to remediate groundwater plumes and represent a potential reduction in remediation time with active treatment of Phase 1 groundwater areas. Further work at NASA, such as additional plume-specific flow and transport modeling (NASA 2022b, 2023c), and the observations on plume response to the GETS interim measure operations and EISB pilot studies will help NASA and DTSC better understand the benefits or limitations of treatment in the context of time and costs that can be incorporated in the Phase 2 CMS and adaptive management.

Given these uncertainties, the values summarized in Table 6-1 were used as remediation time estimates for high TCE concentration TTAs to compare the different alternatives. In general, NASA believes these time estimates are optimistic and the actual amount of time could be much longer. However, as a basis for comparing the different alternatives, the values in Table 6-1 are considered appropriate.

A time period for remediation in the Northern and Southern Seep Areas was not estimated. The Northern Seep Area alternatives were developed as a contingency. The Southern Seep Area is downgradient of the NASA Delta AIG plume and the Boeing Area III plume. For the purposes of this CMS, it was assumed the active treatment components of these alternatives would be 10 years, but this time frame could potentially be longer.

6.1.2 MNA

MNA is a component of all source and seep area alternatives. MNA refers to the reliance on natural attenuation to achieve site-specific MCOs. Natural attenuation includes a variety of physical, chemical, and biological processes that work without human intervention to reduce the mass, toxicity, volume, and concentrations of groundwater COCs. For the COCs at SSFL, these processes typically include dispersion, dilution, adsorption, and absorption. Additional processes applicable to organic chemicals include aerobic and anaerobic biodegradation, volatilization, and abiotic degradation. The following text provides an overview of how MNA would be implemented at SSFL. An assessment of the AIG-specific MNA processes contributing to limited COC plume expansion is presented in the NASA Groundwater RFI Report (NASA 2020a) and summarized in Section 2.3. This discussion is applicable to the Phase 1 groundwater and seep TTAs.

Monitoring is an important element of MNA that is conducted to track the progress of remediation, evaluate whether potential receptors are impacted by the migration of contamination, and confirm that natural processes acting to attenuate contamination continue to do so in an effective manner. MNA must be implemented within a well-understood SCM, in which the nature of the original COC releases and relevant contamination migration pathways are sufficiently characterized. When properly implemented, MNA is an effective and safe remedy and is recognized as an important element in the remediation of most sites impacted by chlorinated solvents.

The regulatory framework for implementing MNA is well established. For Superfund and RCRA sites, OSWER Directive 9200.4-17P describes EPA's overall policy regarding the use of MNA for site remediation (EPA 1999b). In addition, EPA presents a technical approach for evaluating the suitability of MNA for a site in its well-known document, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (EPA 1998).

Since the publication of the 1998 technical protocol document, significant scientific advances in the understanding of attenuation mechanisms have occurred and new tools for understanding the nature of attenuation processes have become available. For example, in addition to the well-known anaerobic reductive dechlorination process, cometabolic aerobic degradation (Alvarez-Cohen and Speital 1998) and abiotic degradation (He et al. 2015) have been found to contribute to the degradation of many chlorinated compounds. New analytical tools, including CSIA (Hunkeler et al. 2008) and MBTs (Kavanaugh and Deeb 2011), have also emerged for evaluating the degree to which degradation is occurring and which microbes are responsible for observed COC transformations.

CSIA relies on the use of gas chromatography/ion ratio mass spectrometry to measure the ratio of specific isotopes present in the target compound. Ratio measurement of ^{12}C to ^{13}C or ^{35}Cl to ^{37}Cl can provide input into the processes affecting chlorinated solvent degradation. Changes in isotope ratios as COCs migrate along a flow path have been found to be associated with specific degradation pathways, because the chlorine-carbon bond energy for heavier isotopes is greater than that of lighter isotopes. Biodegradation can be confirmed because, as degradation favors the lighter isotopes, the remaining contamination is enriched with heavier isotopes. MBTs rely on the analysis of various nucleic acids that are associated with specific bacteria genes and can demonstrate the type and species of bacteria present, their populations, and specific enzyme activity. Together, these new tools have greatly advanced the understanding of natural attenuation processes that occur at sites impacted with VOCs.

At SSFL, available data, including geochemistry, CSIA, and MBT analyses, suggest that a variety of processes may be contributing to natural attenuation, including anaerobic biodegradation, aerobic cometabolic degradation, and abiotic degradation, as well as dilution, dispersion, adsorption, absorption, and volatilization (NASA 2020a). Additional plume COC and natural attenuation parameter information is planned to support the Phase 2 groundwater CMS, and an updated plume stability and attenuation evaluation will also be included in that document. In addition, because of the geologic setting, diffusion of contamination into the rock matrix as VOC-contaminated groundwater migrates through bedrock fractures contributes to the retardation of COC transport, providing a complementary process to natural attenuation processes and allowing more time for natural attenuation processes to act upon the COCs as they migrate. A detailed evaluation of natural attenuation processes is provided in the NASA Groundwater RFI Report (NASA 2020a).

The natural attenuation of chlorinated ethenes, such as TCE and its daughter products, is well-understood and is not detailed in this section.

MNA would be implemented by periodic monitoring of groundwater at select monitoring wells in the vicinity of the TTAs. A variety of chemical and microbiological analyses would be performed on groundwater samples to further develop the previously established lines of evidence for natural attenuation, as discussed further in this section. A sitewide comprehensive MNA evaluation (separate from the Phase 1 CMS/CMI), updated from the NASA Groundwater RFI Report (NASA 2020a) analysis, will be performed prior to the completion of the Phase 2 groundwater CMS to support Phase 2 groundwater CMS remedial decisions.

For the purpose of developing the MNA alternative or as a component of an alternative, the wells near the TTAs will include an MNA well network, as presented in Tables 6-2 through 6-6 for the Northern Seep Area, ND-136, WS-09, C-6, and Southern Seep Area TTAs, respectively. The wells specified in these tables were identified as reasonable for monitoring MNA and other alternatives implemented in the TTAs. Additional and ongoing plume COC and natural attenuation groundwater sampling is planned by NASA to support Phase 1 remedial design and CMI, the Phase 2 groundwater CMS and CMI, and remedial decisions as part of the sitewide groundwater monitoring and future Phase 2 groundwater CMS work and CMI monitoring. Also, future groundwater flow and transport modeling is planned to support remedial monitoring network decisions.

As new information becomes available, the monitoring well network identified in Tables 6-2 through 6-6 (one table for each of the areas addressed by this Phase 1 CMS) will be updated, in consultation with DTSC.

Each well or well interval would be analyzed periodically (for example, yearly during initial monitoring) for groundwater constituents listed in Table 3-1 to assess the progress of constituent degradation, plume attenuation, and stability characteristics, using methods such as time versus concentration plots or

Mann-Kendall statistical analysis. Additionally, select geochemical analyses, such as dissolved iron and other metals, select anions, and other indicator parameters such as methane or total organic carbon, would also be conducted periodically on groundwater samples to assess the geochemical and redox conditions of the groundwater. Analysis for nucleic acid-based indicators, such as specific bacterial functional genes for dechlorinating enzymes, or CSIA may also be periodically conducted. These analyses would provide greater diagnostic information regarding specific microbes involved in degrading the COCs and provide confirmatory data to support other lines of natural attenuation, such as abiotic and cometabolic degradation. In addition to these analyses, field data such as depth to static groundwater levels would be collected from additional monitoring wells to support the development of potentiometric surface maps to confirm the stability of groundwater flow directions and appropriateness of locations chosen for MNA performance monitoring.

The type of MNA data collected and the manner in which the data will be used will be documented as part of the design for the selected alternative to evaluate if the proper data are being collected to support the effectiveness of MNA through multiple lines of evidence. Additionally, the design will address the decision-making process used to assess the performance of the MNA component of an alternative. If the results of those decisions indicate that MNA is not performing as planned, additional testing or mitigation measures will be warranted. The adaptive site management process (Section 6.1.9) will be used to update the monitoring network to reflect changes that may be necessary, such as increasing or decreasing well network, sampling frequency, or target analytes.

Currently, NASA is performing routine groundwater sampling and analysis for sitewide groundwater quality and the PCP monitoring programs. The natural attenuation monitoring discussed in this CMS may be redundant with some of these activities. These redundancies will be resolved during the CMD or CMI phase of work.

6.1.3 Land Use Control Component

Each alternative requires LUCs to protect human health until the overall cleanup objectives are achieved. LUCs include ICs and engineering controls. ICs include restrictions on groundwater use within the TTA for any purpose and may include a prohibition on constructing buildings over the AIGs until groundwater corrective action objectives are achieved. Engineering controls include locks on wells to prevent access to groundwater for non-remedial action purposes. Signs may be posted near wells or throughout the AIG areas to prevent groundwater use.

The details of the LUC requirements will be documented in a LUC plan, which will be included as part of the design and implementation of each alternative. In addition to delineating the specific ICs and engineering controls to be implemented with the alternative, the plan will specify the monitoring frequency for each LUC, how to address deficiencies, and how to document LUC compliance over the lifetime of the alternative, until MCOs are achieved.

LUCs will be implemented with the DTSC-selected remedy for each TTA and continue until MCOs have been achieved. NASA will coordinate with Boeing and Brandis-Bardin property owners on the implementation of LUCs in the seep areas where groundwater contamination has migrated off NASA-administered property in the Northern and Southern Seep Areas.

The application of LUCs will be the same for all alternatives in this CMS. The only difference in the execution of this technology component is the length of time that LUCs will be necessary, which is based on the time it takes to achieve MCOs. The length of time for LUCs to remain in effect is the same as that estimated for MNA (Table 6-1).

6.1.4 Bedrock Vapor Extraction Component

BVE is a component of Alternatives 2a, 2b, 3, and 4 for vadose zone source treatment, and the TTAs for BVE application are represented on Figure 4-2 (ND-136 TTA). The technology may operate concurrently with the groundwater treatment components of the alternatives. There may be benefits to concurrent treatment including simplifying treatment operations management. NASA is currently performing a pilot study in the ND-136 TTA where EISB and BVE are operating concurrently. The information from this pilot study will help determine if there are benefits to concurrent operations.

For cost estimating purposes, it is assumed the total length of time for operating the BVE technology will be 5 years. This assumption is based on the premise that extraction of vapor from fractures will be mostly complete after this time. However, over time, vapor concentrations may diffuse back into fractures previously remediated and require additional BVE applications in the future.

BVE is a recently developed concept with applicability at SSFL. It works in a similar manner to SVE, with the following main differences:

- Subsurface vapor flow is almost entirely within interconnected fracture channels, instead of being through the rock matrix.
- Vacuum and flow propagate to greater distances (or hardly at all, if no fractures are present).
- Extracted concentrations are expected to persist for a longer time, given the extensive surface area of rock that would be swept by the flow, if VOCs present are in the rock matrix and continue to diffuse outward. However, the focus of this technology is this Phase 1 groundwater CMS is to remove mass at high concentration areas, as described in Section 4.2.2.
- Contaminant removal occurs in this dual-domain setting by diffusion of vapor from the rock matrix to adjacent fractures and advection under vacuum through the fractures. As with SVE, the rate and sequence of remediation depends on the relative location of the well, the centroid of COC mass, and the origin of recharge air.

BVE is effective in removing VOCs from the vadose zone, provided that substantial and interconnected fracture networks are present. In contrast to SVE, BVE offers the possibility of using fewer wells to affect a larger area and a longer operating period. The effectiveness of BVE is two-fold: (1) by providing ventilation of interconnected fractures, pathways in the rock matrix used by VOCs to migrate are treated, and (2) upward pathways for possible surface emission are pneumatically vented so BVE can intercept and remove VOCs in the rock that could be traveling downward to groundwater or upward toward the surface.

BVE has been tested at Bravo Area well HAR-19 (autumn 2014) as documented in Appendix F and former LOX Plant AIG well ND-112 (spring 2015) as documented in the NASA Groundwater RFI Report (NASA 2020a). Both wells were also scanned by downhole optical geophysics, and a general pattern of well flow, vacuum, fracture presence, and VOC uptake were discerned. These two wells extracted 50 scfm at 4 in. Hg (Bravo area well HAR-19) and 10 scfm at 13 in. Hg (former LOX Plant AIG well ND-112), respectively, removing approximately 10 pounds (HAR-19) and 12 pounds (ND-112) of VOCs per week, respectively.

For this CMS, locations with the following characteristics were identified as BVE TTAs:

- Locations that could potentially result in porewater TCE concentrations of greater than 10,000 µg/L (or TCE concentration of approximately 12,00,000 µg/m^3 in vapor; refer to Appendix A for basis) in areas where groundwater already exceeds 10,000 µg/L
- Evidence of air flow supporting fractures above the water table
- Ample depth to groundwater (greater than 50 feet)

Well ND-136 (Alfa Area) was the only well that met this criteria for the most recently available vapor data. A BVE pilot study is currently being performed in the ND-136 TTA (NASA 2022d) at BVE well NV-003 with a mobile 15-hp blower system with a 70-kilowatt solar panel array (mobile BVE system). The bedrock matrix dominated well (NV-003) has achieved about 100 scfm at 6 inches of Hg and has removed approximately 800 pounds of VOCs in eight months of daily (day-time) operation. This system is planned to be expanded to include a fracture-dominated well (ND-162) to compare and extend the VOC removal process. Depending on the results of the Alfa Area BVE pilot study, the treatment could be expanded and/or extended at the ND-136 TTA.

The Bravo Area BVE pilot test established the possible sufficiency of a single extraction well. At any given site, the prospect of BVE will be assessed during remedial design in terms of known fracture depth and aperture at the proposed well. It is anticipated that if fracture air flow during implementation is not sufficiently extensive or is not effective in producing a sustained VOC capture (like at NV-003), the installation of additional BVE wells may be needed in an iterative manner. Two additional multilevel vapor monitoring wells were installed and monitored to document active soil vapor concentration decline for the Alfa Area BVE pilot study. Existing dry or partially saturated piezometers were also converted to vapor monitoring wells (NASA 2022e). The vapor monitoring data will be used to verify the target treatment threshold for source BVE is being addressed in the TTA.

6.1.5 Pump and Treat and Hydraulic Control

This section provides a generalized discussion of the technical applicability of groundwater P&T at the NASA SSFL site, as well as generalized P&T conceptual design considerations.

P&T is the active component of Alternative 3 for the source areas. The hydraulic control technology that was developed for Alternative SP-3 for the seep areas is functionally equivalent to P&T. However, the goal of P&T is to remove contaminant mass at high concentration areas, whereas the goal of hydraulic control is to prevent downgradient plume migration. Aside from this distinction, the engineering details and technical components of P&T (for high concentration TCE groundwater areas) and hydraulic control (for seep areas) are identical.

The groundwater TTAs for the P&T technology are represented on Figure 4-2 (ND-136 TTA and WS-09 TTA) and Figure 4-3 (C-6 TTA) and would be applied in each of the three groundwater source areas. The hydraulic control areas for the Northern Seep Area and Southern Seep Area are represented on Figure 4-5 and Figure 4-3, respectively.

Groundwater extraction wells have already been installed at ND-136 (Alfa Area), WS-09 (Bravo Area), and ND-138A (Delta Area in the Southern Seep Area) as part of the GETS interim measures. Furthermore, extraction wells at RD-04 (Bravo Area), RD-41B (Coca Area), and HAR-07 (Delta Area) are included in the GETS interim measure extraction network. As the latter three wells are not part of the TTAs in this Phase 1 groundwater CMS, they are not discussed further in this document but will be considered in the Phase 2 groundwater CMS.

6.1.5.1 Pump and Treat Technical Overview

P&T involves the physical removal of groundwater and dissolved/entrained COCs from the aquifer system, followed by ex situ treatment and discharge. P&T incorporates a series of groundwater extraction wells designed either to capture underflow through a specific volume of aquifer or induce sufficient drawdown to create a hydraulic gradient toward the well. P&T can be implemented to promote hydraulic capture at any accessible point within a groundwater COC plume (that is, both source area and/or distal plume). Groundwater remediation can be accelerated through physical removal of COCs from the aquifer system, as well as by flushing relatively cleaner groundwater (through pumping) from upgradient areas through the TTA, although this is challenging as its effectiveness will be governed by the rate of back diffusions from the rock matrix, which is currently unknown. As described in the NASA Groundwater RFI Report (NASA 2020a), the current SCM for the COC system at SSFL shows the majority of contamination has diffused into the permeable sandstone matrix, while interconnected fracture networks provide the primary transport pathways. Flushing the fracture networks, and to a lesser degree the rock matrix, with groundwater that has relatively lower concentrations of contamination will also promote back diffusion of COCs from the matrix (refer to Appendix I for preliminary back diffusion modeling results).

P&T has been implemented at SSFL previously. Several groundwater extraction wells were active at the site between the mid-1980s through the early 2000s, with the primary goal of inducing a hydraulic gradient towards the central portion of the site, western Area I, and Area II (Groundwater Resources Consultants 2000). Operation of wells created a groundwater depression within the Sage Member of Areas I and II (refer to Figure 6-26 of MWH 2009a). Groundwater extraction during the mid-1980s through the early 2000s created a drawdown (during pumping) and recovery (following cessation of pumping) signal within the CFGW system (Sage Member) up to several thousand feet from the groundwater extraction wells (MWH 2009a). This suggests the potential for a large P&T radius of influence within the Sage Member and hydraulically connected HSUs. Although operated through the early 2000s, the estimated TCE mass removal from the eight groundwater extraction and treatment systems operating at SSFL ranged from 80 to 250 pounds per year between 1987 and 1996 (GRC 1996, 2000). An analysis of the data from the 1999 annual groundwater monitoring report (GRC 2000) showed that in 1999, approximately 850,000 gallons of extracted groundwater recovered 1 pound of total VOCs. Approximately 101 pounds of total VOCs were recovered with the extraction of over 85 million gallons that year.

Additionally, six existing wells within NASA-administered Area II are associated with the GETS interim measure treatment system at SSFL (MWH 2009b; CH2M 2015). Two of these extraction wells are located at groundwater source area TTAs in the Alfa Area (ND-136) and Bravo Area (WS-09). Another well is located in the Southern Seep Area TTA in the Delta Area (ND-138A, which replaced previous GETS well WS-09A). Initially, wells RD-49A and HAR-20 were included in the GETS interim measure treatment system. However, after the 2018 Woolsey Fire, which required reconstruction of most of the GETS extraction and conveyance system at NASA, NASA requested that RD-49A and HAR-20 be removed based on recent groundwater concentrations and replaced with ND-136. This change in extraction wells was approved in a letter from LARWQCB to DTSC in 2019 (Appendix C).

While groundwater extraction may be beneficial from a hydraulic containment perspective, experience at a wide number of sites, including SSFL, has shown that its relatively ineffective in the removal of contaminant mass. An evaluation of the SCM and fate and transport of contaminants in groundwater at SSFL concluded the following: "The most common advection-based technology is pump-and-treat (mass removal by advection), which has already been used at SSFL and showed insignificant contaminant mass removal capability. This mass removal is insignificant because the rate at which contaminant mass diffuses out of the matrix blocks into the flowing groundwater was insufficient relative to what is needed for P&T methods to be effective." (SSFL Groundwater Advisory Panel et al. 2009). While the previous goal for operating the extraction wells was hydraulic containment, the rationale DTSC used to select the interim measure wells was a concentration exceeding 1,000 µg/L. Based on the RFI data, hydraulic containment for the purposes of achieving plume containment and/or stability is not warranted because the plume boundaries are not currently expanding. However, the implementation of P&T within high concentration plume cores may provide benefit in the prevention of continued migration of groundwater containing high concentration of COPCs into downgradient areas, which may facilitate reduction in plume extents. Additional information on GETS interim measure P&T effectiveness will continue to be assessed as part of the NASA GETS performance monitoring, and these data will be used in the Phase 2 CMS and CMI to evaluate the benefits of including source area P&T actions within future groundwater remedial strategies.

6.1.5.2 Pump and Treat Conceptual Design

The conceptual layout for the source area P&T extraction wells was designed to target areas of TCE concentrations greater than 10,000 µg/L in three individual groundwater source area TTAs and two seep TTAs. The TTAs for the high TCE groundwater concentration source areas are limited to approximately 150-foot by 150-foot areas centered at wells ND-136 (Alfa Area), WS-09 (Bravo Area), and C-6 (Delta Area) (Figures 4-2 and 4-3); the rationale for the dimensions of the source groundwater TTAs are defined in Section 4.2.1. The goal of the P&T assessment is to design a system capable of capturing the groundwater underflow through each of the TTAs and removing mass from the TTAs.

The goal of the seep area hydraulic control extraction wells is to prevent downgradient contaminant transport into areas where groundwater can be expressed as seeps. The locations of the seep extraction wells are presented on Figures 4-3 and 4-5. As the goal of seep management is hydraulic control, the goal of seep extraction wells is to minimize downgradient contaminant migration instead of mass recovery, which is the focus of treatment in the source areas.

Calculation of the pumping rate necessary to capture underflow through each of the TTAs was performed using Darcy's Law (Equation 1):

$$Q = K \times i \times A$$

Where:

Q = Groundwater flow (cubic length per time [L^3/t])
K = horizontal hydraulic conductivity (L/t)
I = horizontal hydraulic gradient (L/L)
A = TTA of the aquifer (L^2)

Darcy's Law is applicable to steady state, laminar flow, of an incompressible fluid with constant properties (that is, temperature, density, viscosity, etc.) through a homogenous porous media of constant cross-sectional area. Although the aquifer system at SSFL does not conform to these simplifying assumptions, this technique was considered appropriate for remedy screening relative to other technologies. When developing groundwater extraction rates based on underflow calculations, it is standard practice to at least double the estimated underflow flow rate so that the P&T system effectively captures the full width of the flow field moving beneath the TTA. Accordingly, and because the aquifer system at SSFL is a fractured bedrock system instead of an equivalent porous medium, and the groundwater flow is moving primarily through bedrock fractures of unknown orientation, connectivity, and aperture, an additional safety factor of 2 was applied. Table 6-7 presents the estimated rate for each of the TTAs along with assumed aquifer properties.

Site-specific assumptions are included in the data presented in Table 6-7; the treatment intervals for extraction at high concentration areas are as follows (refer to Appendix D for further information):

- ND-136 (Alfa Area) – about 475 feet deep, about 200 feet saturated
- WS-09 (Bravo Area) – about 400 feet deep, about 150 feet saturated
- C-6 (Delta Area) – about 500 feet deep, about 400 feet saturated
- Southern Seep Area (ND-138A) – about 45 feet deep, about 25 feet saturated
- Northern Seep Area (B204 Area) – about 450 feet deep, about 150 feet saturated
- Northern Seep Area (ELV Area) – about 400 feet deep, about 220 feet saturated

Hydraulic gradients were estimated from the third quarter 2016 CFGW (Sage Member) groundwater elevation contour map presented on Figure 4-16 of the draft NASA Groundwater RFI Report

(NASA 2020a). Horizontal hydraulic gradients will likely change in response to future groundwater extraction and/or reinjection at SSFL.

Horizontal hydraulic conductivity for the TTAs at the Alfa/Bravo AIG represents the geometric mean of estimates from the time-draw-up analysis of data collected during the 72-hour constant rate injection aquifer test (Appendix C of the NASA Groundwater RFI Report; NASA 2020a).

The groundwater extraction rate assumed for the C-6 TTA is based on the sustainable flow rate from well ND-169 during aquifer testing within the TTA conducted in 2022.

Hydraulic containment at the Southern Seep Area (ND-138A) in the Burro Flats Fault Zone area would be accomplished by a single extraction well, as is currently being performed. The extraction well is located north of the NASA-administered Area II boundary upgradient of SP-890, as shown on Figure 4-3. Preliminary modeling performed using the SSFL mountain-scale groundwater flow model indicates that operation of ND-138A at 5 to 10 gpm is capable of providing hydraulic capture of the Delta Area plume in the SP-890 seep well cluster area. The more recently developed plume scale groundwater flow and transport model of the Coca/Delta AIG (NASA 2022b) was used to further evaluate the rate of groundwater extraction that would be required from well ND-138A to hydraulically capture contaminated groundwater in the vicinity of the SP-890 seep cluster. The results of these model simulations, provided in Appendix H, suggest that an extraction rate of 5 gpm from well ND-138A will reduce contaminated groundwater discharge to the Southern Seep Area by more than 99%. In addition, the Delta Skim Pond NASA source area, associated with the Southern Seep Area distal plume, will be treated as part of the Phase 1 CMI.

Hydraulic containment at the B204/ELV AIG plumes associated with the Northern Seep Area would be accomplished by installing three extraction wells. The extraction wells would be installed in the vicinity of RD-56 (one well) and ND-125 (two wells), as shown on Figure 4-5.

In addition to the treatment of high concentration TCE areas, this technology involves the GETS interim measure extraction wells installed as part of the 2009 order requiring interim action. These wells are identified in Table 4-1 and on Figures 4-2 and 4-3. These wells have already been installed, equipped with extraction well infrastructure, and connected to the GETS. Their total combined flow rate has been estimated as 29 gpm.

Based on the estimated pumping rates presented in Table 6-7, a single groundwater extraction well would be needed to capture groundwater underflow through each of the source area TTAs and the Southern Seep Area. Well WS-09 is currently planned to operate as an extraction well as part of the GETS (MWH 2009b; CH2M 2015), with a target flow rate of 17 gpm, a higher rate than the estimate in Table 6-7. As such, dedicated pump and groundwater extraction conveyance is in place at this location and no further construction/action is necessary. ND-136 is equipped with a pump that can operate at 30 gpm (to support the EISB pilot study) and is planned to operate at 10 gpm (the planned extraction rate), so no further construction is required at this location. ND-138A is equipped with a pump currently operating at 10 gpm, which is the planned extraction rate, so no further construction is required for this location. Because a dedicated monitoring well is in place at C-6 (with a planned flow of 6.6 gpm), a new groundwater extraction well is needed at this TTA. Once drilled and constructed, the well will be equipped with pumps, drop pipe, and groundwater conveyance consistent with current GETS wells (CH2M 2015). Likewise, three new extraction wells, as depicted on Figure 4-5, will be constructed at the Northern Seep Area, if necessary. In the B204/ELV Area, contaminated groundwater will be conveyed from three extraction wells at a maximum combined flow rate of 3.2 gpm.

These flows represent an increase in flow to the GETS, considering these wells would be in addition to the six extraction wells (ND-136, WS-09, RD-04, RD-41B, HAR-07, and ND-138A [WS-09A replacement]) already planned for connection and operating as of the GETS interim measure treatment system. However, the flows can be adjusted, with DTSC approval, so as to not exceed the overall operating flow of the GETS, including the Boeing component.

P&T (high TCE groundwater TTAs) and hydraulic control (seep TTAs) performance monitoring will include monitoring groundwater levels in the extraction and surrounding observation wells to evaluate changes in the groundwater elevations as a result of groundwater pumping. Groundwater quality sampling will be performed in the extraction and downgradient monitoring wells to evaluate changes in COC concentrations over time.

Each new extraction well will consist of the following components, similar to existing extraction wells ND-136, WS-09, and ND-138A:

- Below-grade well vault and piping
- Electric submersible pump with level controller
- Flow meter with totalizer and a pressure indicator
- Dedicated sample collection valve

The extracted groundwater will be conveyed by double-contained high-density polyethylene piping conveyance pipelines ranging in size from 1 by 3 inches to 4 by 8 inches. New conveyance piping will be located within or alongside existing roadways (if in the area, and where feasible) and may be placed above or below ground. Air pressure relief and system bypass valves will be located along the conveyance pipeline as necessary.

Electrical power for the system extraction wells will be supplied from existing overhead power lines and transformers in the vicinity of each extraction well; new electrical distribution will need to be installed as part of the C-6 TTA and Northern Seep Area systems. Distribution power will be conveyed to the individual wellheads in conduit below-grade. Individual extraction wells will be operated using a programmable level controller with capacity for automatic pump shutdown if the groundwater level falls below desired levels. A radio telemetry system will allow remote communication (if possible based on signal strength), data acquisition, and control of the extraction wells using a central control network integrated into ex situ treatment equipment operations. In the event of treatment system shut down, the main control panel can cascade command operations to the remote well locations to shut down the extraction pumps.

6.1.5.3 Treatment System Description

Extracted groundwater is conveyed from several extraction wells to a common, jointly operated groundwater treatment system within a 4,000-square-foot pre-engineered steel building in Area I. A process flow diagram showing the system components is presented on Figure 6-1.

The Area I GETS was previously constructed by Boeing for the purpose of treating extracted groundwater from a limited number of wells; water from well installation, development, and decontamination; and pump test water generated during SSFL field activities. Groundwater extracted as part of interim measures in other areas of SSFL will be combined with groundwater extracted from the AIGs, as described previously, for joint treatment using the upgraded GETS process equipment detailed later in this section. Treated groundwater is discharged to well WS-05 in Area I under a WDR permit issued by the LARWQCB (MWH 2016).

Following influent flow equalization in a carbon steel storage tank, extracted groundwater is pumped through particulate filter vessels to remove suspended solids. Next, an oxidation/filtration system, with low concentration sodium hypochlorite (chlorine) dosing, removes iron and manganese, which are collected in a backwash tank. Water is then conveyed through two liquid-phase granular activated carbon (LGAC) vessels primarily for removal of residual chlorine from the oxidation/filtration system and secondarily for removal of VOCs. Next, water is conveyed through two ion exchange vessels for removal of perchlorate, which is present in some groundwater extracted from Area I. Water is then directed to an advanced oxidation process treatment system, with hydrogen peroxide dosing, for removal of 1,4-dioxane, NDMA, and VC. Next, water is conveyed through two final LGAC vessels for VOC polishing and then into a carbon steel tank for treated effluent storage. Finally, the treated effluent is directed through a set of bag filters to reduce turbidity prior to discharge by underground conveyance piping to WS-05. A flow totalizer installed after the final bag filters and prior to WS-05 discharge provides continuous measurement of the total volume of water treated by the GETS for reporting under the WDR permit.

When necessary, waste products such as saturated (spent) media in the LGAC and ion exchange vessels and iron/manganese sludge from the oxidation/filtration system are disposed of at an authorized offsite, licensed facility. The conveyance of the extracted groundwater from additional wells to GETS will be coordinated with Boeing. If capacity issues occur, it may be possible to take some of the extraction wells offline if they are no longer needed. Additionally, the system may be operating below design flows and able to receive additional flow from wells at high concentration areas or the seep areas.

For cost estimating purposes, it was assumed the P&T system would operate for 10 years to reduce concentrations of TCE in the TTAs. It has been assumed that the practical limit of P&T benefits will be realized in 10 years, and additional treatment time would provide limited incremental benefits. However, NASA and DTSC may agree to operate the system longer if beneficial removal is still achieved at 10 years. Estimating the length of time the P&T system will operate is difficult because it this depends on a number of factors, including mass recovered, concentrations recovered, how concentrations change over time, and a subjective interpretation of the benefits being realized (e.g., is it beneficial to continue to operate the system, is the estimated concentration reduction greater than that which can be accomplished with natural attenuation). If high concentrations return to the TTAs in the future, it may be necessary to treat these areas longer or reactivate the system after deactivation.

If this technology is selected, operations of the technology will be guided by an adaptive site management approach defined in the CMI. This could include technology optimization, transitioning to another technology, or ceasing active treatment operations.

For cost estimating purposes for the seep areas, it was assumed the hydraulic control system would operate for 10 years. The seep areas are located farthest from the source areas and would be expected to achieve MCOs sooner than the source areas once the plumes contract due to natural attenuation or potential source treatment in the area. For example, treatment at the high concentration area near C-6 could minimize contaminant mass transport downgradient, resulting in plume contraction. However, it may be necessary to operate seep hydraulic control systems longer or reactivate them after deactivation if concentrations in the TTA rebound. As was presented for the source areas, if this technology is selected, operations of the technology will be guided by an adaptive site management approach defined in the CMI. This could include technology optimization, transitioning to another technology, or ceasing active treatment operations.

6.1.6 EISB Component

This section provides a generalized discussion of the technical applicability of EISB at SSFL, as well as generalized EISB conceptual design considerations. EISB is a component of Alternative 2a for the source area groundwater represented on Figures 4-2 and 4-3 as well as Alternative SP-3 for the Northern and Southern Seep Areas.

EISB involves the addition of various reagents or amendments such as electron donor compounds (that is, an organic carbon amendment), nutrients, pH buffers, and bioaugmentation cultures to the aquifer to accelerate biodegradation of chlorinated solvents. The optimal degradation pathway for many chlorinated solvents is via reductive dechlorination, an anaerobic process in which chlorine atoms are sequentially removed from the parent compound.

For TCE, the reductive dechlorination process has been shown to proceed along the following pathway:

TCE -> 1,2-DCE (primarily cis-1,2-DCE) -> VC -> ethene

EISB approaches can support other degradation pathways within the treatment zone (for example, abiotic degradation) or at the fringes of the treatment zone (for example, aerobic cometabolism). Abiotic and biotic transformation of CVOCs have been studied in a fractured sandstone matrix in southern California under conditions consistent with the NASA SSFL site (Darlington et al. 2008, 2013). These studies have demonstrated that abiotic and biotic transformation processes are responsible for attenuation of CVOCs within the sandstone matrix. Data collected during the SSFL groundwater monitoring and draft NASA Groundwater RFI Report preparation (NASA 2020a) show that degradation of TCE and its daughter products is occurring as groundwater migrates through the bedrock fractures due to various natural processes. The lines of evidence include the following:

- Presence of geochemical conditions favorable for reductive dechlorination in portions of the aquifer
- Presence of reductive dechlorination daughter products (cis-1,2-DCE, VC, and ethene) in groundwater
- Increases in the ratio of daughter products to TCE as migration proceeds downgradient in some portions of the site
- Presence of obligate halorespiring bacteria known to participate in TCE reductive dechlorination as well as bacteria known to induce cometabolic aerobic TCE degradation
- Enrichment of the ^{13}C to ^{12}C ratio, an indicator of TCE degradation

Because these naturally occurring abiotic and biotic degradation processes have been confirmed, enhancing these processes with EISB is expected to successfully reduce COC concentrations further in the TTAs. Another potential degradation pathway that can be enhanced involves dissolved gases generated during EISB (for example, methane) or that may be present as a result of natural geologic conditions; when present in the anaerobic/aerobic transition zone at the fringe of an EISB TTA, methane has the potential to support cometabolic degradation of TCE and DCE.

EISB is an appropriate source area technology because it accelerates mass removal through the following mechanisms:

- Enhanced dissolution and/or desorption of DNAPL and/or sorbed-phase contaminant mass (ITRC 2008)
- Biological, abiotic, or cometabolic degradation of dissolved-phase contaminants to less harmful compounds (ITRC 2008; Brown et al. 2009; Suthersan et al. 2011)

EISB enhances dissolution and desorption of nonaqueous phase contaminants to the aqueous phase where they can be more readily degraded (ITRC 2008), resulting in accelerated remediation time frames compared to traditional technologies, such as P&T, that do not enhance dissolution and desorption to the same degree as an EISB approach.

EISB is most commonly implemented by biostimulation, which involves the subsurface injection of organic carbon amendments, such as lactate or EVO. The EISB pilot test proposed by NASA will evaluate whether EVO, a widely used treatment reagent for EISB, can successfully achieve biostimulation at the site. Data from bench-scale studies being conducted by Clemson University will also be considered in evaluating potential reagents to use.

For sites where appropriate dechlorinating bacteria are not present, bioaugmentation may be performed to supplement native bacterial populations. At SSFL, a diverse population of halorespiring bacteria has been shown to be present. Therefore, bioaugmentation may not be necessary.

The injection of amendments is typically achieved via injection wells arranged in grids or rows. However, the injection of fluid in fractured bedrock settings is challenging for several reasons. It can lead to exaggerated or non-uniform displacement of groundwater near the injection area, which has the potential to mobilize elevated levels of contamination to areas outside the TTA (ITRC 2008). Dilution of contaminant concentrations within the injection zone can also occur, which may bias monitoring results (ITRC 2008). In addition, the fractures in which contaminated groundwater is migrating may not be intercepted by the injection wells, limiting their effectiveness for COC treatment.

One way to overcome these limitations is to employ groundwater recirculation within the TTA. Recirculation of injected reagents would provide better distribution of treatment reagents and allow the groundwater flow to be directed by the recirculation system design, instead of relying on natural groundwater gradients to transport the treatment reagents. Therefore, for the implementation of EISB within fractured bedrock settings, reagent delivery methods different from the conventional injection well approach should be considered.

An alternative approach to consider for groundwater recirculation is subgrade biogeochemical reactor (SBGR) technology (Gamlin and Downey 2017; Gamlin et al. 2017). The SBGR technology involves the following:

- Construction of the SBGR includes excavation of a void space for the reactor, which is then filled with a mixture of rounded gravel for structural stability, as well as composted bark mulch and iron amendments coated with vegetable oil to support ERD. An infiltration pipe and geotextile are installed over the top of the SBGR treatment media at approximately 4 feet bgs for infiltration of contaminated groundwater through the SBGR. The top of the SBGR is then filled with clean soil to the ground surface. This technology requires approximately 20 feet of overburden to emplace the reactor. If rock is encountered, it would be removed (for example, blasting) to achieve the desired design configuration for treatment.
- Each SBGR is connected to one extraction well, as the source of contaminated water to be infiltrated through the reactor.
- Treated water from the bottom of the SBGR is then conveyed to two SBGR infiltration columns that extend to the water table to allow the treated water to be returned to the aquifer.
- Treated water containing elevated dissolved organic carbon is then recirculated through the aquifer or fractures for in situ treatment of the groundwater plume. As groundwater flows towards the extraction wells, a recirculation treatment cell is created.

A variety of biotic and abiotic processes occur within the SBGR that lower CVOC concentrations in groundwater and amend the groundwater with dissolved organic carbon for additional in situ treatment. Groundwater recirculation under an SBGR approach can also limit mobilization of groundwater outside the TTA. Additionally, given sufficient hydraulic conductivity, this approach can support better distribution of in situ amendments that help counteract treatment limitations associated with aquifer and fracture heterogeneity. Other EISB configurations could also work at the SSFL site. However, the main focus of this section is EISB as a technology; the specific means and methods to achieve EISB goals will be addressed in the remedial design phase.

While any of the previously mentioned configurations could be deployed, for the purposes of this CMS, it was assumed that recirculation would be employed at the high TCE concentration TTAs because greater treatment would be needed to address the sources and that direct injection would be used at the seep TTAs because concentrations at those locations are very low.

6.1.6.1 EISB Conceptual Design

The dimensions (total depth, area, targeted saturated interval) of each TTA are presented in Table 6-7. Further details regarding these dimensions are presented in Appendix D.

The plan view layout and process flow diagram for the high TCE groundwater concentration TTAs, using the ND-136 TTA, based on the pilot test (NASA 2020d), are presented on Figures 6-2 and 6-3. The general layout for the EISB system is three injection wells, one extraction well, and monitoring wells. The injection wells are installed on the upgradient side of the TTA and the extraction well is installed on the downgradient side of the TTA (NASA 2020h). Information from the ND-136 TTA pilot study would be used to expand or extent the EISB treatment.

For the seep areas, EISB will be applied using well ND-138A, which is screened from approximately 20 to 45 feet. Only one injection well was selected for this area; additional wells could be added, if necessary. For the Northern Seep Area, two transects consisting of five injection wells, each, near RD-56 and ND-125 (B204/ELV AIG) as shown on Figure 4-5 (note, only the transects are shown; individual injection wells are not shown), will be used to deliver the biostimulation and bioaugmentation reagents to the subsurface to a depth of approximately 400 feet (220 feet saturated) for the ELV transect and to 450 feet (150 feet saturated) for the B204 transect.

The treatment reagents will be defined in the CMI plan. For the purposes of this Phase 1 groundwater CMS, it was assumed the carbon source would be EVO with nutrient and bioaugmentation additions. Bicarbonate may be added for pH buffering, and a bioaugmentation culture may be added as well, to increase the concentration of halorespiring microbes that facilitate reductive dechlorination to ethene. The carbon substrate is typically injected as a 2 to 5% solution. For SSFL, it was assumed total addressable porosity was 2% of the TTA volume to account for flow in both the primary and secondary porosity features in the TTA. The CMD will refine the assumed porosity based on the EISB pilot test results.

The treatment reagents may be gravity drained or pumped into the formation. Dilution water for injectate to deliver the reagents will be formation water from the site. Once the reagents have been injected, the recirculation wells will be turned on periodically to facilitate optimal delivery of the treatment reagents. Injection wells will be open coreholes. The target treatment intervals for each of the TTAs are described in Appendix D.

Whether the fractures in the injection and recirculation wells align precisely with this interval will be assessed with geophysical surveys and rate of flow tests, with tracer tests if needed to evaluate fracture interconnectivity.

EISB performance monitoring will complement the MNA sampling program. Additional sampling beyond the MNA program will be performed at each TTA. Process treatment samples will be collected and analyzed periodically for VOCs and a variety of geochemical indicators, including total organic carbon, dissolved gases, volatile fatty acids, functional genes of various relevant microbes using the quantitative polymerase chain reaction method QuantArray Chlor, and CSIA.

The operating duration of the EISB portion of the remedy is assumed to be 10 years to reduce concentrations of TCE in the source area TTAs. This assumption is based on the premise that extraction and recirculation of groundwater from fractures will be mostly complete after this time and additional treatment time for applications would provide minimal incremental benefits. It is difficult to estimate the length of time the EISB system will operate because it depends on a number of factors, including how concentrations change over time and subjective interpretation of benefits being realized (e.g., is it beneficial to continue to operate the system, is the estimated additional concentration reduction greater than that which can be accomplished with natural attenuation). Over time, TCE within the rock matrix may diffuse back into fractures previously remediated and require additional treatment.

If this technology is selected, operations of the technology will be guided by an adaptive site management approach defined in the CMI. This could include technology optimization, transitioning to another technology, or ceasing active treatment operations.

For cost estimating purposes for the seep areas, it was assumed the EISB portion of the remedy would operate for 10 years. The seep areas are located farthest from the source areas and would be expected to achieve MCOs sooner than the source areas once the plume contracts due to natural attenuation or potential source treatment in the area. For example, treatment at the high concentration area near C-6 could minimize contaminant mass transport downgradient, resulting in plume contraction. However, it may be necessary to operate the EISB system longer or reactivate the EISB seep system if concentrations in the seep TTAs rebound. As was presented for the source areas, if this technology is selected, operations of the technology will be guided by an adaptive site management approach defined in the CMI. This could include technology optimization, transitioning to another technology, or ceasing active treatment operations.

6.1.7 Thermally Assisted EISB

This technology is a component of Alternative 2b and is the same as that described in Section 6.1.6, with the addition of heating the water before it is reinjected into the injection wells. This technology applies only to the high TCE concentration TTAs, as the benefits of heating for low concentration groundwater in the seep areas is likely to be low and therefore not included in the seep treatment options.

As stated in Section 4.1.3, increasing the groundwater temperature has been shown to increase the rate of many biological processes, including reductive dechlorination and hydrolysis of various chlorinated solvents (Madigan et al. 2012). Thus, it may be feasible to increase groundwater temperature on the order of 10°C as an ancillary method for enhancing the performance of an in situ bioremediation system. The most practical approach for achieving this objective is to pass groundwater through a hot water heater prior to injecting it.

An onsite electric-powered steam boiler would be used to heat the water. The electricity to power the boiler may be provided by solar or line power. The temperature to heat recirculated water in the EISB system to facilitate a 10°C temperature rise at the fracture locations is uncertain. For the purpose of this CMS, it was assumed water would be injected at 145°C. Additionally, six open coreholes will be added to the EISB configuration described in Section 6.1.6 to monitor temperature through the TTA using fiber optic sensors. Data will be collected using an optical data acquisition system.

The challenges to achieving that target temperature increase of 10°C at the fracture locations are significant, as follows:

- Hot water may rise in the injection well, resulting in stratification of heated water. Thus, the ability to achieve the desired temperature increase at each fracture may be difficult.
- Once the heated water enters the fracture, the distance the heat can propagate in the fracture would be difficult to estimate and monitor. Much of the heat may be transferred primarily to the rock matrix close to the injection point.
- If the water is overheated, it could cause significant negative impacts to the microbes required to facilitate contaminant biodegradation.
- If the water is underheated, the benefit of using heated water would not be achieved.

Significant field testing and monitoring would be required to optimize the delivery of heated water. The practical benefits of heating water are uncertain. If it is assumed the rate of biodegradation within groundwater could be increased by a factor of 2 under ideal, uniformly heated conditions, then the results could be the accelerated treatment of contaminants in the fracture and a faster rate of back diffusion from the rock matrix close to the heated fractures. However, the rate of traditional EISB without added heat could potentially accomplish the same outcome, depending on how fast the water is moving through the fracture and the rate of back diffusion from the rock matrix (refer to Appendix I for preliminary back diffusion modeling results).

6.1.8 In Situ Chemical Oxidation

The dimensions (total depth, area, targeted saturated interval) of each TTA are presented in Table 6-7. Further details regarding these dimensions are presented in Appendix D.

ISCO chemically converts hazardous contaminants to nonhazardous or less toxic compounds that are inert, more stable, or less mobile. Oxidants have been able to rapidly and completely destroy many toxic organic chemicals through chemical reactions. ISCO is a component of Alternative 4 for source treatment only (and is not included in seep area technology alternatives). ISCO would primarily consist of injecting a chemical oxidant into the TTA to treat the COCs. The COCs would be converted into innocuous compounds commonly found in nature, such as CO_2, water, and inorganic chloride.

The oxidants that may be applicable to the site include permanganate and persulfate, which have been used for the remediation of chlorinated solvents like the chlorinated ethenes at SSFL. Permanganate is commonly available in two forms: $KMnO_4$, a crystalline solid that is typically mixed with water onsite to form a solution, and a liquid sodium permanganate. Compared to other oxidants, permanganate is relatively more stable and persistent in the subsurface; as a result, it can migrate by diffusive processes. Persulfate typically must be activated in the field by applying heat, a metal catalyst such as iron ethylenediaminetetraacetate, or a base such as sodium hydroxide to increase pH. For persulfate to be effective in field applications, the activator must be distributed and transported with the persulfate. Natural mineral activation of persulfate by ambient groundwater minerals, including iron, could potentially activate the persulfate.

One limitation of ISCO is that each aquifer formation has a unique NOD that consumes the oxidation. This reduces the amount of oxidant available for treating the target contaminants. At sites with high NOD, ISCO may be a relatively ineffective process, with most of the oxidant being consumed by natural demand. In addition, the use of ISCO has been shown to mobilize redox sensitive metals such as chromium and arsenic, in many cases causing these metals to exceed their respective groundwater criteria, such as drinking water standards. Although these metal mobilizations are typically temporary and decline once the oxidant is spent, it may increase the monitoring costs and may raise public concerns about causing potentially permanent or extended impact to the aquifer.

As with EISB, different configurations can be used for oxidant delivery. Direct injection and recirculation are two practical options for SSFL. Boeing pilot tested direct injection at SSFL. For the purposes of this CMS, injection of oxidant was assumed to be accomplished using a recirculation well network. The oxidant would be injected into the subsurface and then enter the fractures, spreading laterally into the aquifer formation. The oxidant would mix and react with the COCs within the surrounding groundwater. After the initial injection period, an evaluation could be conducted to determine if additional injections are necessary.

Parameters specific to the performance of ISCO would be monitored, such as oxidant concentrations, metals that may be solubilized because of highly oxidative conditions (for example, arsenic, barium, cadmium, chromium, lead, or selenium), pH, oxidation reduction potential, dissolved oxygen, and general chemistry.

It is difficult to estimate the length of time the ISCO system will operate, as it depends on a number of factors, including concentration reductions and subjective interpretation of the benefits being realized (e.g., is it beneficial to continue to operate the system, is the estimated concentration reduction greater than that which can be accomplished with natural attenuation). The operating duration of the ISCO portion of the remedy is assumed to be 10 years to reduce concentrations of TCE in the source area TTAs. This assumption is based on the premise that the ISCO technology will have accomplished what it can at TTAs, and additional applications would provide minimal incremental benefits. Over time, groundwater concentrations may diffuse back into fractures previously remediated and require additional groundwater treatment.

If this technology is selected, operations of the technology will be guided by an adaptive site management approach defined in the CMI. This could include technology optimization, transitioning to another technology, or ceasing active treatment operations.

6.1.8.1 ISCO Conceptual Design

The layout of the ISCO recirculation system and the process flow diagram would be similar to the ones described for EISB (Section 6.1.6). The injection wells will be used to deliver the oxidant to the subsurface to a depth of approximately 270 to 475 feet bgs, depending on the target treatment depths at the specific TTA.

The treatment reagents will be defined in the CMI plan. For the purposes of this CMS, it was assumed that a 2 to 3% sodium permanganate solution would be used as the treatment reagent and dose, based on experience from the SSFL ISCO pilot study. For SSFL, it was assumed a total addressable porosity was 1% of the TTA volume to account for flow in both the primary and secondary porosity features in the TTA and interval; this is likely a conservative estimate and may significantly overestimate the amount of oxidant required. The CMD will define a high confidence design porosity on which to base treatment reagent needs.

The treatment reagents may be gravity drained or pumped into the formation. Dilution water for treatment will be formation water from the site. Once the reagents have been injected, the recirculation wells will be turned on periodically to facilitate optimal delivery of the treatment reagents. Injection wells will be open coreholes. The target treatment intervals for each of the TTAs are described in Appendix D.

Whether the fractures in the injection and recirculation wells align precisely with this interval will be assessed with geophysical surveys and flow rate tests, with tracer tests conducted, if necessary, to evaluate fracture interconnectivity. ISCO performance monitoring will complement the MNA sampling program.

6.1.9 Adaptive Site Management

As defined by the Interstate Technology & Regulatory Council (ITRC) (2017), the term "adaptive site management" refers to "…a comprehensive, flexible, and iterative process that can be used to manage the remediation process." The National Research Council (NRC) (2003) coined the term "adaptive site management" referring to "a comprehensive and flexible approach… for dealing with difficult-to-remediate hazardous waste sites over the long term" or where "…current technologies have proved to be ineffective in reaching site objectives for many types of contamination." Adaptive site management can be used to make decisions in response to remedy performance while considering changes in site conditions, the CSM, technology performance, and technological advances over time."

The ITRC (2017) further states:

> NRC recommends adaptive site management at complex Superfund sites, noting that "adaptive management is not synonymous with 'trial and error'" (NRC 2005). The adaptive site management process is instead a means to "…learn from, test, assess, and modify or improve remedies with the goal of meeting long-term objectives" (NRC 2007).

EPA also has similar guidance related to adaptive site management, which is described in the *Groundwater Remedy Completion Strategy* (EPA 2014b).

Adaptive site management applies to all elements of each alternative. For example, it can be used to modify (increase or decrease) the monitoring well network or assess whether MCOs are being met. It can also be used to define the criteria used to transition from active remediation to monitoring.

The active treatment components described previously include BVE, P&T/hydraulic control, EISB/EISB barrier treatment zone, thermally assisted EISB, and ISCO. There is no agreed-upon guidance on how best to determine when to shut down active treatment components; therefore, the decision to shut down components is typically addressed on a site-by-site basis.

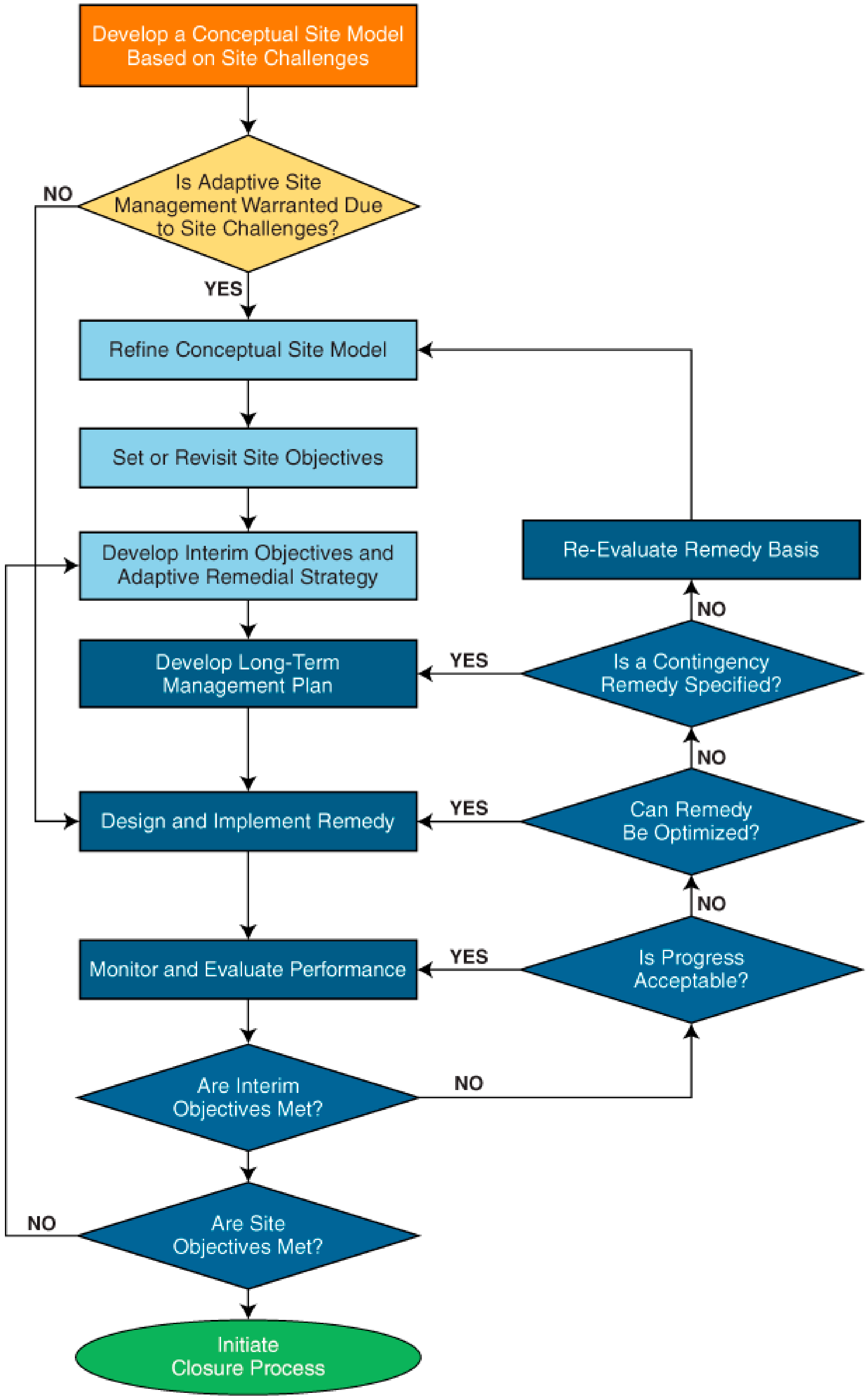
To properly define the parameters for determining when to shut down active treatment components, performance metrics for each active treatment technology must be established. These metrics could include the following:

- Mass removed, or concentration reduction, per year, per TTA location
- Total mass removed, or concentration reduction, relative to total contaminant mass, or concentration, present (if total mass present can be estimated with reasonable confidence)
- Mass removed, or concentration reduction, per unit volume of media (for example, groundwater, bedrock vapor) treated
- Rate of change of mass removal, or concentration reduction, over time
- Progress of planned mass removed, or concentration reduced, at specific milestones compared to total estimate of mass removed, or concentration reduction, at planned milestone
- Trajectory of mass removed, or concentration reduced, over planned time of remediation
- Comparison of performance against shutdown parameters

ITRC proposed the following flowchart for implementing adaptive site management (Exhibit 6-1).

Exhibit 6-1. Flowchart for Adaptive Site Management

Corrective Measures Study, SSFL, Ventura County, California



Typically, a decision to shut down an active treatment component is based on weight of evidence using the metrics listed previously. In some instances, optimization through adaptive site management is the first step in determining whether system performance can be improved. Performance can include different operating conditions (for example, pulsed, as opposed to continuous, operation). Once optimization approaches have been exhausted and the weight of evidence shows the limits of the technology have been reached, the system is shut down temporarily. After a period of time (for example, 6 months or a year), the wells in the TTA can be sampled to determine if contaminants have rebounded in a manner that supports continued operation or if the performance metrics support a permanent shutdown.

The shutdown metrics and process are typically overviewed in the CMD, or the CMI, and documented in greater detail in the O&M plan.

Adaptive site management will be used in the selected alternative to assess the performance of the selected alternative. If the alternative is not performing as planned, the project stakeholders can determine another course of action, including modifying the system operating parameters, changing the remedy, or recognizing that contemporary treatment technology is limited in its ability to remove mass or reduce concentrations at one or more of the TTAs.

The components of adaptive site management, as they relate to the selected alternative, will be detailed in the CMD and include a site-specific adaptive site management flow chart to update Exhibit 6-1.

6.1.10 Performance Monitoring and Optimization

Performance monitoring and optimization will be a part of all alternatives. The detailed requirements of this component of alternatives will not be defined until the CMI is complete. The costs for these activities are represented in the O&M section of each alternative cost.

6.2 Detailed Analysis of Alternatives – Criteria

The detailed analysis of the alternatives followed EPA guidance entitled "Final Remedy Selection for Results-Based RCRA Corrective Action" (EPA 2000a). The CMS guidance specifies three performance criteria an alternative is required to achieve. In addition to the performance criteria, EPA has identified seven balancing criteria. Each criterion is described in the following sections.

6.2.1 Protect Human Health and the Environment (Performance Criteria)

Protecting human health and the environment is the general mandate from the RCRA statute; therefore, it is appropriate to include this goal as the first performance standard for final RCRA corrective action remedies. This standard also serves to allow remedies to include protective activities, such as providing an alternative drinking water supply, that would not necessarily be needed to achieve the other two standards.

6.2.2 Achieve Media Cleanup Objectives (Performance Criteria)

The performance criterion requires achieving MCOs appropriate to the assumptions regarding current and reasonably anticipated land uses and current and potential beneficial uses of water resources. The cleanup objectives should address media cleanup levels (chemical concentrations), points of compliance (where cleanup levels should be achieved), and remediation time frames (time needed to implement the remedy and achieve cleanup levels at the point of compliance).

6.2.3 Remediate the Sources of Releases (Performance Criteria)

This performance criteria requires remediation of the source to eliminate or reduce further releases of hazardous wastes or hazardous constituents that may pose a threat to human health and the environment and requires the use of treatment to address principal threat waste, unless alternative approaches are approved by the overseeing regulator. In this context, "source" includes both the location of the original release and the locations where significant mass of contaminants may have migrated. Although EPA expects facilities to use treatment technologies to address principal threat waste, they also expect that containment technologies and LUCs can be used to address waste that pose relatively low long-term threats.

6.2.4 Long-term Effectiveness (Balancing Criteria)

Decision makers should evaluate remedies based on the long-term reliability and effectiveness they afford, along with the degree of certainty that they will remain protective of human health and the environment. Additional considerations include the magnitude of risks that will remain at a site from untreated hazardous wastes, hazardous wastes, hazardous constituents, and treatment residuals, and the reliability of any containment systems and LUCs. A remedial option should include a description of the approaches that facilities will use to assess long-term performance and effectiveness. The time period for this criterion starts after the remedy has been implemented and determined to operate properly and successfully through the time at which MCOs are achieved.

6.2.5 Toxicity, Mobility, and Volume Reduction (Balancing Criteria)

Decision makers should evaluate remedies based on the degree to which they employ treatment, including treatment of principal threats, that reduces the toxicity, mobility, or volume of hazardous wastes and hazardous constituents, considering, as appropriate, the treatment processes to be used and the amount of hazardous waste and hazardous constituents that will be treated, the degree to which treatment is irreversible, and the types of treatment residuals that will be produced.

6.2.6 Short-term Effectiveness (Balancing Criteria)

Decision makers should evaluate remedies based on the short-term effectiveness and short-term risks that remedies pose, along with the amount of time it will take for remedy design, construction, and implementation. This criterion includes the protection of workers, community, and environmental impacts. Environmental impacts were assessed using DTSC's Green Remediation Evaluation Matrix.

6.2.7 Implementability (Balancing Criteria)

Decision makers should evaluate remedies based on the ease or difficulty of remedy implementation, considering as appropriate the technical feasibility of constructing, operating, and monitoring the remedy; the administrative feasibility of coordinating with, and obtaining necessary approvals and permits from, other agencies; and the availability of services and materials, including the capacity and location of needed treatment, storage, and disposal services.

6.2.8 Cost (Balancing Criteria)

Decision makers should evaluate remedies based on capital and O&M costs and the net present value of the capital and O&M costs. EPA recommends a discount rate of 7%. However, this guidance was last updated in a 1993 (OSWER Directive No. 9355.3-20) and primarily applies to private site cleanups. "For

Federal facility sites being cleaned up using Superfund authority, it is generally appropriate to apply the real discount rates found in Appendix C of Office of Management and Budget Circular A-94 (U.S. Government 2020). These rates, which are also used in the President's annual budget submission to Congress, are based on interest rates from Treasury notes and bonds" (EPA 2000b). While this statement references Superfund, the same logic is appropriate for RCRA cleanups at federal facilities. The most current Office of Management and Budget A-94 Circular (year ending 2020) recommends a 30-year discount rate of 0.4%. A table of past year rates shows the discount rate for 30 years ranges between 5.4% in 1979 and 0.4% in 2020 (U.S. Government 2020). Using the most recent discount rate puts more emphasis on the lowest discount rate since tracking of the metric began in 1979. To factor in potentially higher discount rates in the future and recognizing that the cleanup of groundwater at SSFL will likely take many years, a 2% discount rate was used for net present value calculations.

For the groundwater TTAs, given the estimated length of time to achieve MCOs for the three alternatives (Table 6-1), the long-term costs are considered highly uncertain. The assumptions used in the cost estimates (Appendix G) are based on current treatment and monitoring technology and do not consider likely future innovations in environmental science and engineering that will likely reduce the long-term monitoring costs, such as automated and in situ analysis of groundwater instead of mobilizing sampling crews to collect groundwater samples and having the samples analyzed at remote laboratories. There is higher confidence in the capital costs and O&M costs for the first 30 years of operation. These costs are considered conceptual only; it is typical to apply a plus 50% and minus 30% to conceptual costs to represent uncertainty related to conceptual estimates. There is less confidence in the costs estimated for the time period after 30 years and it would not be appropriate to establish a cost confidence range for these costs. Additionally, reliable discount rates are not available for time periods beyond 30 years. Therefore, costs are extended through year 30. While not representing the full life-cycle costs of the alternatives, it does provide a reasonable basis for cost comparison. Additionally, as MNA is the only technology extended beyond year 30, the comparison of costs beyond 30 years would not help differentiate cost differences.

For the seep alternatives, a total of 10 years of operation and monitoring was assumed. This time was considered a basis for comparing alternatives. The Northern Seep Area alternatives were developed as a contingency. If monitoring or treatment is needed, it is uncertain if the operating time would be a short- or long-term basis. This same logic applies to the Southern Seep Area. The alternatives in the Southern Seep Area were developed based on concentrations in NSGW. Future operation of ND-138A may demonstrate the need for short- or long-term operation.

All alternative costs are detailed in Appendix G.

6.2.9 Community Acceptance (Balancing Criteria)

Decision makers should evaluate remedies based on the degree to which they are acceptable to the interested community. This criterion will be factored in after public review and will not be included in the detailed evaluation of alternatives.

6.2.10 State Acceptance (Balancing Criteria)

Decision makers should evaluate remedies based on the degree to which they are acceptable to the state in which the subject facility is located. This criterion will be factored in after regulatory review and will not be included in the detailed evaluation of alternatives.

6.2.11 Adaptive Site Management

Adaptive site management was added as a criterion to conceptually demonstrate how its principles could be applied over the course of the remedy. This criterion is not a RCRA criteria and was not scored in the following sections.

6.3 Detailed and Comparative Analysis of Alternatives

Table 6-8 presents the detailed and comparative analysis of the Phase 1 groundwater alternatives. Table 6-9 presents the detailed and comparative analysis of the Phase 1 seep water alternatives.

The alternatives presented for the Phase 1 groundwater and seep water sites are evaluated as if one alternative is applied to all the TTAs in a specific type of TTA (i.e., groundwater or seep). For example, Alternative 2a is evaluated assuming this alternative is implemented at all three source groundwater TTAs. However, the evaluation of alternatives presented in this report also supports using different alternatives at specific TTAs. For example, NASA and DTSC may choose to implement Alternative 2a at the ND-136 TTA and Alternative 3 at the WS-09 TTA, and the information contained in this report can support that kind of decision. It is not practical to address every alternative combination at each of the TTAs, as an inordinate number of alternative combinations would require evaluation.

The alternatives that were evaluated for the Phase 1 groundwater are:

- Alternative 1 – MNA and LUCs
- Alternative 2a – Groundwater treatment using EISB followed by MNA, BVE for soil vapor and LUCs
- Alternative 2b – Groundwater treatment using EISB with thermal heating, followed by MNA for groundwater, BVE for soil vapor and LUCs
- Alternative 3 – Groundwater treatment using P&T, followed by MNA, BVE for soil vapor and LUCs
- Alternative 4 – Groundwater treatment using ISCO, followed by MNA, BVE for soil vapor and LUCs

The alternatives that were evaluated for the Phase 1 seep areas are:

- Alternative SP-1 – MNA and LUCs
- Alternative SP-3 – EISB of Seep Water, MNA, and LUCs
- Alternative SP-2 – Hydraulic Control of Seep Water, MNA and LUCs
- Alternative SP-3 – EISB of Seep Water, MNA, and LUCs

An overview of each TTA is presented in Table 4-1.

Scores are provided within each criterion discussed in Tables 6-8 and 6-9. These groundwater alternative scores are summarized on Figure 6-4, Figure 6-5a (graphical scoring summary for ND-136 and WS-09 TTA) and Figure 6-5b (scoring summary for C-6 TTA). The seep alternatives scores are summaries on Figure 6-6 and graphically summarized on Figure 6-7.

All the balancing criteria have sub-criteria. An average value of the sub-criteria is used to represent the score for the parent criteria, which is used in the total overall score and the bar chart summary presented on Figures 6-4 through 6-7. The scoring definitions are presented on Exhibit 4-1.

Capital, O&M, and net present value (NPV) costs for groundwater and seep alternatives are summarized in Tables 6-10 and 6-11, respectively.

7. Recommended Alternatives

This section provides an overview of the detailed and comparative analysis of the alternatives evaluated for Phase 1 groundwater (Section 7.1) and seep water alternatives (Section 7.2). Each section describes the rationale for the preferred alternative.

The alternatives evaluated were evaluated as if one alternative is applied to all the TTAs in a specific type of TTA (i.e., groundwater or seep). For example, Alternative 2a is evaluated assuming this alternative is implemented at all three source groundwater TTAs. However, the evaluation of alternatives presented in this report also supports using different alternatives at specific TTAs. For example, NASA and DTSC may choose to implement Alternative 2a at the ND-136 TTA and Alternative 3 at the WS-09 TTA, and the information contained in this report can support that kind of decision. It is not practical to address every alternative combination at each of the TTAs, as an inordinate number of alternative combinations would require evaluation.

7.1 Overview of Groundwater Alternatives and Recommendation for Preferred Alternative

Section 6 presented a detailed and comparative analysis of alternatives. The alternatives evaluated are:

- Alternative 1 – MNA and LUCs
- Alternative 2a – Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs
- Alternative 2b – Groundwater treatment using EISB with thermal heating, followed by MNA for groundwater, BVE for soil vapor, and LUCs
- Alternative 3 – Groundwater treatment using P&T, followed by MNA, BVE for soil vapor, and LUCs
- Alternative 4 – Groundwater treatment using ISCO, followed by MNA, BVE for soil vapor, and LUCs

A summary of scoring for the groundwater alternatives is presented on Figures 6-5 and 6-6. Costs for the five alternatives are summarized on Table 6-10.

7.1.1 Overall Relative Comparison of Groundwater Alternatives Against Performance Criteria

All alternatives were considered reasonably protective of human health and the environment. Alternative 1 does not employ active treatment. However, the TTAs are located well within the NASA-administered areas and LUCs can prevent pathways to human health. No ecological risks were identified for the TTAs.

Uncertainty surrounds the amount of contaminant reduction that active treatment can achieve. As discussed in Section 4.2, median concentration reductions for a groundwater treatment area are anticipated to be approximately 91%. Considering the complexities of the hydrogeology at the site and the amount of contaminant mass in the rock matrix, this level of concentration reduction would be challenging. Higher levels of concentration reduction (greater than 99.99%) would be required to achieve MCOs. Alternative 1 scored the lowest for this criterion because it does not employ active treatment. While the rest of the alternatives do employ active treatment, it is uncertain if and when MCOs can be achieved. Alternative 4 was scored lower than the other active treatment alternatives because of concerns about limited oxidant persistence and its effect on treatment.

All active treatment alternatives were comparable in addressing the sources of the releases. Alternative 1 does not control the source of release through treatment and was scored lower for this criterion.

7.1.2 Overall Relative Comparison of Groundwater Alternatives Against Balancing Criteria

For long-term effectiveness, all four active treatment alternatives scored similarly. While the sub-category criteria varied slightly among the four alternatives, the average score of the three sub-criteria that make up long-term effectiveness varied between 4 and 5 for the four active treatment alternatives, with Alternatives 2a, 2b, and 3 scoring the highest. Alternative 1 scored the lowest for this criterion due to lack of active treatment.

For reduction of toxicity, mobility, and volume, there was a greater separation of scores. Alternative 1 scored the lowest across the six sub-criteria. Alternatives 2a, 2b, and 3 scored comparably, with Alternative 3 scoring slightly higher, mainly because it removes contaminants and does not have treatment by-products. Alternative 4 scored the lowest of the active treatment alternatives because of concerns related to oxidant persistence and the ability of the ISCO technology to reduce contaminant concentrations.

For short-term effectiveness, Alternative 1 scored the highest because of its lesser impact on the community, workers, and the environment. It is not uncommon for low infrastructure alternatives to score high with this criterion because it has the least amount of activity that could affect the community and workers and minimal impacts on the environment. Alternatives 2a, 2b, and 4 scored comparably. Alternative 3 scored the lowest because of the potential increase in worker risk associated with the mechanical and treatment components of the alternative and the environmental impacts related to energy and material usage.

For implementability, all alternatives scored relatively high. Alternative 1 scored the lowest because of the expected administrative challenge of it being an acceptable alternative to regulators. The other four alternatives scored nearly the same.

The capital costs for Alternatives 2a, 2b, and 4 are the highest (and thus scored the lowest), with costs ranging between approximately $11.4 and $14.6 million. Capital costs for Alternative 3 were relatively low because much of the infrastructure for this alternative is already in place. Alternative 1 had the lowest capital costs because the monitoring network is already in place.

For O&M costs, all five alternatives have similar monitoring costs. The same network and frequency of monitoring applies to all the alternatives. Alternatives 2a and 3 had comparable O&M costs, as did Alternatives 2b and 4. Alternative 1 had the lowest O&M costs because active treatment is not employed.

7.1.3 Recommended Alternative for Groundwater

Overall, Alternatives 2a and 3 scored the highest, and Alternative 2b scored slightly lower. Alternative 4 scored the lowest of the active treatment alternatives and Alternative 1 scored the lowest overall. Given the limited differentiation between Alternatives 2a and 3, both alternatives are considered acceptable and appropriate for implementation at the source areas. Infrastructure for Alternative 3 currently exists at the ND-136 and WS-09 areas. A new extraction well and conveyance line is being designed for implementation at the C-6 area to provide more groundwater flow to the GETS system, which will increase the treatment system's operational flexibility. Infrastructure for Alternative 2a currently exists at the ND-136 area due the ongoing operation of the EISB pilot study. Based on this information, NASA recommends the following:

- Alternative 3 is the recommended alternative for the WS-09 TTA because infrastructure for this alternative is currently in operation at this location.
- Alternative 3 is the recommended alternative for the C-6 TTA. As noted in the detailed analysis, the location of the Delta Skim Pond may limit well installation locations for Alternatives 2a, 2b, and 4. This TTA is located very close to the GETS conveyance pipeline so infrastructure for Alternative 3 is nearby.
- Alternative 2a is the recommended alternative for the ND-136 TTA. While this location has infrastructure for both Alternatives 2a and 3, Alternative 2a was selected to provide another treatment alternative that was not reliant on GETS operations. However, if the EISB pilot test results are evaluated to be less optimal than Alternative 3, Alternative 3 may be implemented in the future as the TTA already has infrastructure for this alternative in place.

7.2 Comparative Analysis of Alternatives for Seep Areas

Section 6 presented an evaluation of each alternative compared with RCRA criteria. This section provides a comparative analysis of the alternatives reported in Sections 6.8 through 6.10:

- Alternative SP-1 – MNA and LUCs
- Alternative SP-2 – Hydraulic Control of Seep Water, MNA, and LUCs
- Alternative SP-3 – EISB of Seep Water, MNA, and LUCs

A summary of scoring for the groundwater alternatives is presented on Figures 6-7 and 6-8. Costs for the five alternatives are summarized on Table 6-11.

7.2.1 Overall Relative Comparison of Alternatives Against Performance Criteria for Seep TTAs

Alternatives SP-1 and SP-2 were considered protective of human health and the environment because concentrations are below MCOs in seep water and no unacceptable risks to humans or ecological receptors were identified. Alternative SP-3 scored lower because of the potential concern related to mobilization of naturally occurring metals with EISB reducing conditions that could daylight in seeps and negatively impact ecological receptors.

The confidence in the ability to treat COCs in groundwater that could express as seep water is relatively low with all three alternatives. In the Northern Seep Area, Alternative SP-3 is unlikely to accomplish treatment goals because halorespiring bacteria require elevated concentrations of chlorinated ethenes to create a critical mass of microbes that can degrade the contaminants and these concentrations do not exist in the Northern Seep Area. Alternative SP-2 scored the highest with respect to attaining MCOs because it was considered more effective in removing groundwater contaminants before they could migrate downgradient.

The control of sources criterion was not evaluated for the seep alternatives; sources that are upgradient of seeps will be addressed in the Phase 2 groundwater CMS.

7.2.2 Overall Relative Comparison of Alternatives Against Balancing Criteria for Source Area Treatment Alternatives

For long-term effectiveness, Alternative SP-2 scored the highest because there is greater confidence in the effectiveness of hydraulic containment, though Alternative SP-3 scored only slightly lower. The main difference in these two alternatives is Alternative SP-2 removes contaminants, whereas Alternative SP-3 treats the contaminants in situ, thereby creating daughter products, which could be managed with proper operation. Alternative SP-1 scored lower than the other two alternatives. The difference in scoring for Alternative SP-1 for the Northern and Southern Seep Areas is MNA, which is considered more reliable in the Northern Seep Area because the concentrations are already low, compared to the Southern Seep Area where concentrations in shallow groundwater are above GSLs.

For reduction of toxicity, mobility, and volume, Alternative SP-1 scored the lowest across the six sub-criteria evaluated. Alternatives SP-2 and SP-3 had comparable scores, with Alternative SP-2 scoring higher because of marginally better scores for toxicity, mobility, volume, and types of treatment residuals.

For short-term effectiveness, all three alternatives scored the same for community protection. Alternative SP-2 scored the lowest for this criterion because of a greater environmental footprint and risks to workers. Alternative SP-3 was scored between Alternatives SP-1 and SP-2 because the treatment technology has less worker risk and a smaller environmental footprint than Alternative SP-2.

For implementability, all three alternatives received a score of 5 in each sub-criterion category, with the exception of Alternative SP-1 in the Southern Seep Area, which is unlikely to be acceptable by regulators.

The capital costs for Alternatives SP-1, SP-2, and SP-3 for the Southern Seep Area were low, less than $250,000. The monitoring network is already in place for the seep TTAs. The extraction well for Alternative SP-2 is already in place and operating. Well ND-138A will be used for injection of EISB (ND-138A would be repurposed as an EISB injection well) for Alternative SP-3. The capital costs for Alternatives SP-2 and SP-3 ($3.8 million and $6.4 million, respectively) in the Northern Seep Area were both high because of the need to implement a groundwater extraction network for Alternative SP-2 and an EISB injection well network for Alternative SP-3.

The O&M monitoring costs for the seep alternatives are comparable because the monitoring well network and sampling frequency are the same. The O&M costs for Alternative SP-3 in the Southern Seep Area are the lowest of the active treatment alternatives, because the only cost beyond annual sampling is periodic injection of EISB treatment reagents into two injection wells.

The O&M life-cycle costs for Alternatives SP-1 and SP-3 in the Southern Seep Area are less than $710,000. The higher O&M costs for Alternative SP-2 are related to GETS costs, with O&M life-cycle costs in the Northern Seep Area estimated at approximately $2 million and in the Southern Seep Area at $2.2 million. The costs are higher for the Southern Seep Area because of the higher pumping rate from well ND-138A, which is about three times greater than the combined pumping rate from the three extraction wells in the Northern Seep Area. For Alternative SP-3, the Northern Seep Area life-cycle O&M costs are much higher than the Southern Seep Area ($2.2 million versus $709,000) because the

10 injection wells require 10 times the EISB treatment reagent as that required for the same alternative in the Southern Seep Area.

7.2.3 Recommended Alternative for Northern Seep and Southern Seep Area

As stated in numerous sections of this CMS (Sections 3.1.2.3, 4.2.3, 5.2, 6.1.1, and 6.2.8, and in Table 6-9), at the request of DTSC, alternatives were developed for the Northern Seep Area as a contingency. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA. DTSC and NASA agreed that enough information is available to evaluate alternatives for the Phase 1 groundwater CMS TTAs and could result in accelerating the implementation of groundwater actions while NASA completes additional work on the Phase 2 groundwater CMS. Given the nature of the need for implementing a continency remedial action in the Northern Seep Area will be dictated by future offsite contamination being reported, it is premature to select a recommended alternative for the Northern Seep Area. The recommended alternative for this area can be better made by DTSC and NASA after the need for remedial action is defined and the characteristics of the contamination are better known. For this reason, it is not appropriate to recommend a seep alternative for the Northern Seep Area at this time.

For the Southern Seep Area, Alternative SP-2 scored the highest, followed by Alternative SP-3; Alternative SP-1 scored the lowest. Alternative SP-2 was rated superior to Alternative SP-3 for protection of human health and the environment, attaining medial cleanup objectives, long-term effectiveness, and reduction in toxicity, mobility, and volume. Alternative SP-3 was rated better for short-term effectiveness and costs. The two leading alternatives were considered comparable for implementability. Given this and considering the infrastructure for Alternative SP-2 is already in place in the Southern Seep Area, Alternative SP-2 is the preferred alternative for the Southern Seep Area.

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Tables

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Table 2-1. Summary of Hydrostratigraphic Units in NASA-administered Area I and Area II
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Hydrostratigraphic Unit	Aquifer	Aquitard
Alluvium/Overburden	X	
Upper Chatsworth Formation, Shale 3		X
Upper Chatsworth Formation, Sandstone 2, Upper Burro Flats Member	X	
Upper Chatsworth Formation, Sandstone 2, ELV Member		X
Upper Chatsworth Formation, Sandstone 2, Lower Burro Flats Member	X	
Upper Chatsworth Formation, Sandstone 2, SPA Member		X
Upper Chatsworth Formation, Sandstone 2, Silvernale Member	X	
Upper Chatsworth Formation, Shale 2, Upper Member (siltstone)		X
Upper Chatsworth Formation, Shale 2, Intermediate Sandstone	X	
Upper Chatsworth Formation, Shale 2, Lower Member (siltstone)		X
Upper Chatsworth Formation, Sandstone 1, Sage Member	X	
Upper Chatsworth Formation, Sandstone 1, Upper and Lower Bravo Beds		X

ELV = Expendable Launch Vehicle

SPA = Storage Propellant Area

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Table 2-2. SSFL Source Area Information

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

AIG	AIG Area	Source Area Name	Phase 1 CMS TTA	Source Area (ft^2)	Approximate Depth to CFGW[a] (feet)	Soil TCE Concentration Max (µg/kg)	Soil TCE Concentration Date	Vapor TCE Concentrations Max (µg/m^3)	Vapor TCE Concentration Date	Rock Core TCE Concentrations Max (µg/kg)	Rock Core TCE Concentrations Max (µg/kg) Date	Groundwater TCE Concentrations[b] Max (µg/L)	Groundwater TCE Concentrations[c] Max Date	Estimated TCE Source Area Mass[d] - Vadose Zone (lb)	Estimated TCE Source Area Mass[e] - Saturated Zone (lb)
Former LOX Plant	Former LOX Plant	LOX-SA-1	No	9,940	110	140,000 J	6/12/2008	14,000,000 (760,000 after BVE)	3/5/2015 (2/21/22)	11,000	1/21/2015	2,300	2/9/2016	53	560 - 590 (CFGW)
B204/ELV	ELV	BE-SA-1	No	11,250	210	3,000 J	10/15/1997	3,200,000 J	7/16/1997	11	11/20/2014	150	10/14/2010	55	13 (NSGW) 37 - 60 (CFGW)
B204/ELV	ELV	BE-SA-4	No	17,260	160	5 U	12/4/1997	610,000	3/12/2015	6,647	1/29/2001	1,300	11/18/2015	55	13 (NSGW) 37 - 60 (CFGW)
B204/ELV	ELV	BE-PSA-5	No	16,330	175	6.4	3/24/1993	38,000	6/2/1997	--	--	--	--	55	13 (NSGW) 37 - 60 (CFGW)
B204/ELV	B204	BE-SA-3	No	25,410	180	1.14 U	12/4/2008	410,000	5/13/2015	180	4/9/2015	970	2/9/1993	165	26 (CFGW)
B204/ELV	AP/STP	BE-PSA-2A[f]	No	7,640	60	1.19 U	6/12/2008	4,800	6/10/1997	--	--	--	--	<0.5	68 - 86 (CFGW)
B204/ELV	AP/STP	BE-SA-2B	No	15,930	50	0.92 J	2/27/2007	120,000	3/7/2007	14	6/13/2008	87 J	4/28/2011	<0.5	68 - 86 (CFGW)
B204/ELV	AP/STP	BE-SA-2C[g]	No	27,840	50	6 U	11/2/2010	272,000	7/26/2006	422 J	11/8/2000	2,900	2/4/1987	<0.5	68 - 86 (CFGW)
Alfa/Bravo	Alfa	Alfa Skim Pond	No	11,370	200 - Sage > UBB	725 U	11/24/1997	--	--	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	AB-SA-3A	Yes	47,800	120 - Shale 2 280 - Sage < UBB	1,820,000 J	10/13/1997	65,000,000 J	7/7/1997	9,800	8/19/2015	49,000	5/19/2010	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	AB-PSA-3B	No	17,960	275 - Sage > UBB	980	11/19/2008	38,000	12/9/2008	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	AB-PSA-3C	No	23,060	130 - Shale 2 285 - Sage > UBB	20,000 J	12/12/1997	7,270,000	8/16/1993	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	AB-PSA-3D	No	45,620	140 - Shale 2 295 - Sage > UBB	440 J	10/14/1997	7,000	6/17/1997	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	AB-PSA-3E	No	9,080	145 - Shale 2 300 - Sage > UBB	1.05 U	11/13/2008	430	12/10/2008	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Alfa	Alfa Retention Pond	No	8,700	225 - Sage > UBB	30 U	10/16/1997	--	--	--	--	--	--	18,700	115 (NSGW) 2560 - 6660 (CFGW)
Alfa/Bravo	Bravo	Bravo Skim Pond	No	25,430	200 - Sage > UBB 205 - Sage < UBB	29,000 U	11/6/1997	400,000	9/12/2014	730	4/2/2015	3,500	9/10/1989	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	Alfa/Bravo Skim Pond[c]	No	13,700	35 - Shale 2 195 - Sage . UBB	500 U	6/3/1987	--	--	--	--	--	--	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-SA-4A	No	4,720	260 - Sage < UBB	540 J	10/27/1997	1,620,000	8/27/1993	140	8/14/2015	46	2/4/2016	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-PSA-4B	No	21,530	260 - Sage < UBB	7.2	3/5/2012	327,000	8/18/1993	--	--	--	--	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-PSA-4C	No	12,560	205 - Sage > UBB 210 - Sage < UBB	5 U	7/7/1993	2,980	5/3/2001	--	--	--	--	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-PSA-4D	No	9,770	220 - Sage < UBB	18 J	11/3/1997	869,000	5/3/2001	--	--	--	--	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-PSA-4E	No	8,100	225 - Sage < UBB	1.7 J	3/20/2012	96,500	5/3/2001	--	--	--	--	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	Bravo	AB-PSA-5	Yes	7,300	255 - Sage < UBB	8.29	11/13/2008	8,700	7/17/1997	--	--	30,000	2/19/2016	350	5 (NSGW) 21640 - 22640 (CFGW)
Alfa/Bravo	SPA	AB-PSA-1A	No	10,890	50 - Shale 2	30 U	6/2/1987	22,000 J	6/10/1997	--	--	190	6/6/1988	<1	<1
Alfa/Bravo	SPA	AB-PSA-1B	No	15,130	50 - Shale 2	5 U	5/1/2001	28,000 J	6/10/1997	--	--	4	8/28/1987	<1	<1
Alfa/Bravo	SPA	AB-PSA-2	No	11,500	40 - Shale 2	500 U	6/10/1987	9,000	7/11/1997	--	--	31	4/27/2011	<1	<1
Coca/Delta	Coca	Coca Skim Pond	No	16,490	180	17 U	10/15/1997	--	--	--	--	--	--	100	1230 - 3860 (CFGW)
Coca/Delta	Coca	CD-SA-4	No	122,670	180	50,000 J	11/6/2000	7,100,000 J	9/30/1999	1,680	11/21/2000	630	5/11/2016	100	1230 - 3860 (CFGW)
Coca/Delta	Delta	Delta Skim Pond	Yes	28,220	100	84,000	6/2/1987	190,000	2/12/2015	670,705	3/1/2001	150,000	6/20/2016	745	6830 - 342500 (CFGW)
Coca/Delta	Delta	CD-SA-1A	No	7,790	85	2 U	6/28/1993	2,400,000	2/13/2015	--	--	61,000	5/7/1997	745	6830 - 342500 (CFGW)

Table 2-2. SSFL Source Area Information

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

AIG	AIG Area	Source Area Name	Phase 1 CMS TTA	Source Area (ft^2)	Approximate Depth to CFGW[a] (feet)	Soil TCE Concentration Max (µg/kg)	Soil TCE Concentration Date	Vapor TCE Concentrations Max ($\mu g/m^3$)	Vapor TCE Concentration Date	Rock Core TCE Concentrations Max (µg/kg)	Rock Core TCE Concentrations Max (µg/kg) Date	Groundwater TCE Concentrations[b] Max (µg/L)	Groundwater TCE Concentrations[c] Max Date	Estimated TCE Source Area Mass[d] - Vadose Zone (lb)	Estimated TCE Source Area Mass[e] - Saturated Zone (lb)
Coca/Delta	Delta	CD-PSA-1B	No	67,790	100	6	6/28/1993	31,000 J	6/17/1997	--	--	--	--	745	6830 - 342500 (CFGW)
Coca/Delta	Delta	CD-PSA-3	No	11,640	150	3.2	7/19/2012	10,000	7/26/2012	23	3/9/2015	0.37 U	5/13/2016	745	6830 - 342500 (CFGW)
Coca/Delta	R-2 Ponds	CD-PSA-2	No	33,100	30	8.8 U	5/14/2009	--	--	--	--	--	--	10	6830 - 342500 (CFGW)

Note: Data set associated with the NASA Groundwater RFI Report (NASA 2020a) and includes data through October 2016.

[a] From Baseline groundwater sampling events for each AIG (3Q15 through 1Q16).

[b] Excludes packered groundwater samples.

[c] These mass estimates are uncertain and could vary by an order of magnitude; therefore, they should be considered approximate values to provide context for the relative mass present (not absolute values). Additional mass estimate evaluations may be needed as part of the remedial design process

[d] Calculated mass ranges are based on use of depth discrete sample data versus traditional groundwater sample data, as described in Appendixes A through D of the NASA Groundwater RFI Report (NASA 2020a).

[e] SWMU/AOC status is "Inactive RFI."

[f] SWMU/AOC status is "standby."

[g] SWMU/AOC status is "closed."

-- = no data
µg/kg = microgram(s) per kilogram
µg/L = microgram(s) per liter
$\mu g/m^3$ = microgram(s) per cubic meter
AIG = area of impacted groundwater
AOC = area of concern
AP = ash pile
B204 = Building 204
CFGW = Chatsworth Formation groundwater
ELV = Expendable Launch Vehicle
ft^2 = square foot (feet)
lb = pound(s)
NSGW = near-surface groundwater
RFI = RCRA facility investigation
SWMU = solid waste management unit
TCE = trichloroethene
TTA = target treatment area

Table 3-1. Media Cleanup Objectives for Phase 1 Groundwater and Seep Water

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Chemical Analyte	Value (µg/L)[a]	Source	B204/ELV AIG Northern Seep Area[a]	Southern Seep Area	ND-136 TTA	WS-09 TTA	C-6 TTA
Trichloroethene	5	Federal MCL	x	x	x	x	x
cis-1,2-Dichloroethene	6	CA MCL	x	x	x	x	x
trans-1,2-Dichloroethene	10	CA MCL	x	x	x	x	x
Vinyl Chloride	0.5	CA MCL	x	x	x	x	x

[a] No exceedances of P1 CMS MCOs reported.

µg/L = microgram(s) per liter

AIG = Area of Impacted Groundwater

B204/ELV = Building 204 and Expendable Launch Vehicle

CA = California

MCL = maximum contaminant level

MCO = media cleanup objective

TTA = target treatment area

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Table 4-1. Overview of P1 CMS Target Treatment Area Saturated Thickness and Historical Contaminant Concentrations

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Target Treatment Area	AIG	Total Well Depth (feet bgs)	DTW (Q3 2023; feet toc)	Water Column Height (feet)	TCE (2015 to July 2023) (µg/L)	cis-1,2-DCE (2015 to July 2023) (µg/L)	VC (2015 to July 2023) (µg/L)
ND-136	Alfa	553.5	256.42	298	3800-18000	6200-16000	40-430
WS-09	Bravo	800	242.35	560	190-30000	45-2900	0.36-53
C-6	Delta	885	80.32	805	74-150000	15000-45000	190-3400
Southern Seep Area (ND-138A)	Delta	45	25.76	18.96	0.59 - 0.68	<0.48	<0.3
Northern Seep Area (transect near ND-124; Port 4, other ports dry)	B204	554	179.54	374.46	<0.37	<0.48	<0.4
Northern Seep Area (transect near RD-51C)	ELV	602	191.4	410.6	<0.37	<0.48	<0.1 - 0.39

µg/L - microgram(s) per liter

AIG = area of impacted groundwater

Alfa = Alfa Area

B204 = Building 204

bgs = below ground surface

Bravo = Bravo Area

Delta = Delta Skim Pond

DCE = dichloroethene

DTW = depth to water

ELV = Expendable Launch Vehicle

TCE = trichloroethene

VC = vinyl chloride

Table 4-2. Summary of Data at Interim Measure Wells (January 2011 through September 2022)

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Potentially Relevant Chemical	Statistic	Units	HAR-07	ND-136[a]	ND-138A	RD-04	RD-41B	WS-09
TCE	Sample Count	N/A	47	45	12	27	33	28
TCE	Minimum Concentration	µg/L	38 J	20	0.75	0.52	ND	190
TCE	Maximum Concentration	µg/L	8400	18000	750	2200	1300	30000
TCE	Average Concentration[b]	µg/L	2458	6692	199	381	287	11321
cis-1,2-DCE	Sample Count	N/A	47	45	12	28	33	29
cis-1,2-DCE	Minimum Concentration	µg/L	420	76	1.3	ND	480	45
cis-1,2-DCE	Maximum Concentration	µg/L	6900 J	24000	590	250	3500	2900
cis-1,2-DCE	Average Concentration[b]	µg/L	2309	10536	233	105	1516	1032
trans-1,2-DCE	Sample Count	N/A	47	44	12	7	33	15
trans-1,2-DCE	Minimum Concentration	µg/L	ND	3.7	ND	28	16	ND
trans-1,2-DCE	Maximum Concentration	µg/L	380 J	1300	20	16	140	72
trans-1,2-DCE	Average Concentration[b]	µg/L	126	260	7.2	2.7	69	29
VC	Sample Count	N/A	47	44	12	28	33	29
VC	Minimum Concentration	µg/L	ND	2.2	ND	ND	4	ND
VC	Maximum Concentration	µg/L	240	4600	2.3	3.2	250 J	53
VC	Average Concentration[b]	µg/L	42	765	0.77	1.1	42.4	8.3

[a] Statistics represent data collected from four distinct FLUTe ports that were formerly installed in ND-136. The FLUTe well was removed from ND-136 in late 2019.

[b] Averages exclude nondetect results.

J = Estimated concentration.

µg/L = microgram(s) per liter

DCE = dichloroethene

FLUTe = Flexible Liner Underground Technology

N/A = not applicable

ND = not detected

VC = vinyl chloride

Table 4-3. Treatment of Groundwater, Technology Screening, and Ranking
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
ISTT	Thermal electrodes or heater wells are installed in the target treatment area, nominally on 15-foot centers. The electrode or heater well heats the subsurface allowing VOCs in the groundwater and rock to be volatilized. The volatilized VOCs are captured with a vapor extraction system.	Technology is effective in remediating high concentrations in limited areas; effective in treating stored mass in rock matrix as well as groundwater in fractures; expected to reach target treatment objectives quickly and minimizes long-term impacts related to back diffusion. High probability that all volatilized VOCs will not be captured, resulting in a redistribution of VOCs while some VOCs may be recovered by vapor extraction. The amounts of VOCs recovered versus redistributed is uncertain but represents a risk to technology effectiveness. Upgradient groundwater likely to re-contaminate TTA and potentially result in matrix diffusion of contaminants back into rock. Rating = (2) Unlikely to be effective with potential to move mass to unrecoverable areas and potential for recontamination after treatment	Technology has depth limitations and is not appropriate for larger source volumes; access challenges due to need for high density subsurface components and line power supply. Rating = (1) Access challenges prevent placement of heater wells in optimal locations (e.g., sloping ground, cultural areas); technology has not been attempted to depths required at TTA (deepest reported implementation reported in Section 4.1.3 is 110 feet, which is much shallower than what is required for source areas)	2	1	3	7
EISB	Extraction and injection wells are installed and biological treatment amendments are injected into the wells, where they would be released into the subsurface where they could facilitate biological activity to reduce contaminant concentrations. Extraction wells are paired with extraction wells to facilitate recirculation which will optimize reagent delivery. Testing would be required to identify the optimal treatment interval for reagent injection. Could also be implemented using only injection wells.	Primarily focuses on water in fractures. The effectiveness of treatment is driven by ability of reagents to be delivered to the right zones where contaminants are migrating. Reapplication of reagents will be necessary, as total organic carbon concentrations decrease in the TTA. Rating = (4) Delivery challenges in the subsurface but can potentially be overcome with testing and evaluation.	Technology can be easily deployed in the Alfa and Bravo areas. The technology can also be physically deployed in Delta source area, however, construction would have to comply with the post closure permit, which may create challenges to implementation. There is some degree of physical constraints for installing injection and extraction wells at all three locations. Rating = (4) Generally implementable though some specific challenges related to access.	4	4	8	3
Thermally Enhanced EISB	Same as EISB with the addition of inline heating to increase temperatures of injected fluids by 10°C.	Similar to EISB, this technology focuses on water in fractures. The rate of contaminant reduction can be increased with elevated temperatures; however, the rate of back-diffusion out of the rock matrix is not expected to significantly change by adding heat. Heating the water would increase the operating costs Rating = (4) Same rating as EISB; addition of heat can increase rate of treatment but is unlikely to change rate of back-diffusion out of formation.	Same as EISB Rating = (4) Addition of heat does complicate implementation but these challenges can likely be overcome.	4	4	8	3

Table 4-3. Treatment of Groundwater, Technology Screening, and Ranking
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
ISCO	Extraction and injection wells are installed and chemical oxidants are injected into the wells, where they would be released into the subsurface where they can oxidize chlorinated ethenes. Extraction wells are paired with injection wells to facilitate recirculation which will optimize reagent delivery. Testing would be required to identify the optimal interval for reagent re-injection. Could also be implemented using only injection wells.	Technology applicable to remediating high concentrations in limited areas; primarily focuses on water in fractures; extremely challenging to implement in fractured rock due to uncertainty in delivery of reagents and targeting of treatment area; will not significantly penetrate into rock matrix and some smaller fractures; considered comparable to EISB but limited by quick reagent utilization (less time to act on contaminants) and requirement for frequent injections of oxidant). Additionally, dosing with oxidants often leaves behind treatment reagent constituents. In the case of potassium permanganate (the most likely oxidant to be considered at SSFL given its longevity), manganese is expected to persist in the target treatment zone, but eventually decrease over time. Rating = (3) Typically, ISCO treatment reagents persist for shorter period of time compared to biological treatment reagents and thus require more frequent application.	Technology can be easily deployed in the Alfa and Bravo areas. The technology can also be physically deployed in Delta source area, however, construction would have to comply with the post closure permit, which may create challenges to implementation. There is some degree of physical constraints for installing injection and extraction wells at all three locations. Rating = (4) Likely to be implementable.	3	4	7	5
Biosparging	Air is sparged through injection wells to facilitate aerobic degradation of contaminants.	Air can be delivered to fractures to facilitate aerobic contaminant reduction. Not applicable to TCE in source areas. Ability to achieve distribution of air in fractures is uncertain. Rating = (1) Technology not effective for TCE.	Technology can be easily deployed in the Alfa and Bravo areas. The technology can also be physically deployed in Delta source area, however, construction would have to comply with the post closure permit, which may create challenges to implementation. There is some degree of physical constraints for installing injection and extraction wells at all three locations. Rating = (4) Technology can be implemented provides access challenges can be addressed.	1	4	5	6
Air sparging	Air is sparged through injection wells to facilitate stripping of contaminants from groundwater to air where it can be recovered with vapor extraction.	Typically applied in porous media; inability to predict where VOC vapors migrate is a significant challenge; will require vapor extraction to capture vapors; will only treat water in fractures that air bubbles can contact and will not address mass stored in rock. Like ISTT, high potential to mobilize mass from location to another. Rating = (1) Unable to confidently recover volatilized chlorinated ethenes.	Can be implemented, with same constraints as described for ISCO, EISB, and Biosparging. Likelihood regulators would not endorse a technology that would not confidently recover contaminants. Rating = (2) Unlikely to be acceptable to regulatory agencies.	1	2	3	7
BVE	Extraction wells are installed in the vadose zone and designed to recover vapor contaminants in high concentration fractures. Recovered air is recovered and treated through off-gas treatment processes.	Applicable to source areas in the bedrock located in the unsaturated zone. NASA pilot studies showed this technology can be successful in reducing VOC concentrations in the target treatment area, which will likely result in limiting continued migration of bedrock vapor to groundwater. Rating = (5) Proven to be effective in site pilot studies.	Easily implemented; extraction wells need to be installed and off-gas treatment process is required; drilling sites would need to be accessible by drill rig type equipment and support vehicles. Rating= (4) Proven to be implementable at SSFL, provided access issues can be addressed.	5	4	9	1

Table 4-3. Treatment of Groundwater, Technology Screening, and Ranking

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
Pump and Treat	Groundwater extraction wells are installed in the TTA and extract contaminated groundwater, which is transmitted to the GETS systems for treatment and discharged through an onsite injection well.	Technology applicable to remediating high concentrations; primarily focuses on water in fractures; does not address mass in rock; extremely challenging to implement in fractured rock due to uncertainty capture zone confidence. Rating = (4) Technology likely to be effective provided sustained mass recovery can be maintained.	Easily implemented; extraction wells need to be installed and treatment process required to treat extracted groundwater prior to it being discharged; drilling sites would need to be accessible by drill rig type equipment and support vehicles. Rating = (5) Proven to be implementable at SSFL.	4	5	9	1
In Situ Fracturing	Fracturing is implemented in targeted intervals to create more permeable zones to allow access to contaminants in stored rock.	Environmental fracturing typically applied to low permeability formations such as clay or saprolite, not applied to rock. New fractures would likely create unintended contaminant migration paths. Rating = (1) Fracturing for environmental applications is not applicable for target depths.	Implementation challenging and optics of "fracturing" likely would be unacceptable to public. Rating = (1) Numerous technical challenges to implementability.	1	1	2	9
MNA	This technology can be considered a stand-alone technology or used in combination with other technologies. Contaminants are allowed to degrade naturally.	MNA can be a solution for source areas, though the time to achieve remedial action objectives could be several hundred years. This technology can also be used as a component of a treatment train, concurrently with or after active treatment occurs in a source area. Lines of evidence for assessing MNA (e.g., monitoring well locations and target analytes) will need to demonstrate that MNA is occurring. Rating = (4) Rating is for MNA after treatment. MNA only alternative could be considered as a comparison to active treatment remedies.	Easy to implement and requires only monitoring. As a stand-alone remedy, MNA may not be acceptable to regulatory agencies. However, it is appropriate to consider MNA for the plumes concurrently with or after active treatment is completed. Monitoring can be easily implemented at the site. The need for additional MNA wells to support remedial monitoring for NASA AIG plumes will be evaluated in the Phase 2 groundwater CMS and the CMI design. Rating = (4) Rating is for MNA after active treatment (low rating if considered without active treatment)	4	4	8	3

Notes:

°C = degree(s) Celsius
BVE = bedrock vapor extraction
COC = chemical of concern
Eff = effectiveness
EISB = enhanced in situ bioremediation
GETS = groundwater extraction and treatment system
IC = institutional control
Imp = implementability
ISCO = in situ chemical oxidation
ISTT = in situ thermal treatment
LUC = land use control
MNA = monitored natural attenuation
NASA = National Aeronautics and Space Administration
O&M = operation and maintenance
PRB = permeable reactive barrier
SSFL = Santa Susana Field Laboratory
SVE = soil vapor extraction
TCE = trichloroethene
TTA = target treatment area
VOC = volatile organic compound

Table 4-4. Treatment of Seeps, Technology Screening, and Ranking
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
PRB for Seep Water	A trench is installed upgradient of where the seeps are expressed. The PRB would include sand and zero valent iron. The dimensions of the PRB will vary by TTTA and could be 300 ft long by up to 400 ft deep. A rock trencher can be used to install a depth to approximately 40 ft. To install the PRB deeper, dynamite or large diameter augers would be necessary.	Primarily focuses on water in fractures; installation of flow-through media to treat contaminants in groundwater before it expresses as a seep. Treatment media would be effective for chlorinated ethenes but less ineffective for 1,4-dioxane. Requires knowledge of groundwater flow and ability to locate PRB. The location faults in this area adds complexity to understanding how groundwater contaminants migrate. Rating = (2) Very unlikely PRB can be effectively placed and media can be identified to remove all contaminants.	Environmentally disruptive technology as it requires extensive drilling and/or trenching; likely impractical in the culturally sensitive area where PRB would need to be located. Generally not applicable where treatment depths of greater than one hundred feet are required. Rating = (1) Negative impacts to culturally sensitive area would be unacceptable.	4	1	5	3
EISB Barrier Treatment Zone	Injection wells are installed upgradient of where seeps are expressed. Biological treatment amendments would be injected into the wells, where they would be released into the subsurface where they could facilitate biological activity to reduce contaminant concentrations. Periodic injections would be required as the substrate concentrations are diminished, until a point of time when upgradient groundwater does not require further treatment. Downgradient extraction wells could also be utilized to facilitate recirculation and residence of the amendments in the target treatment area. Testing would be required to identify the optimal treatment interval for reagent injection.	Primarily focuses on water in fractures. The effectiveness of treatment is driven by ability of reagents to be delivered to the right zones where contaminants are passing before they are expressed as seeps. The location of faults adds complexity to understanding how groundwater contaminants migrate. The migration of contaminants is uncertain in this area. Recirculation can be utilized, if necessary, to keep the amendments in the target treatment area. Rating = (3) May be able to distribute amendments but some areas may not be adequately addressed; may be able to identify amendments that can address both chlorinated ethenes and 1,4-dioxane.	This technology is disruptive as it requires drilling in a culturally sensitive area in the southern seep area and continued operations of upgradient and downgradient extraction wells and reapplication of treatment amendments. Additionally, it will be challenging to deliver the right dosage of biological treatment reagents so they are utilized in the subsurface and not expressed in the seeps (this can be accomplished using testing to incrementally increase concentrations). May result in mobilizing of redox sensitive metals that can be expressed in seeps and result in risks to ecological receptors. Rating = (3) Some negative impacts of culturally sensitive area due to well installation. Potential for amendments to daylight in drainage. Potential for mobilized redox sensitive metals to impact ecological receptors.	4	3	7	2
Phytoremediation of Seep Water	Trees are planted in the target treatment area. The trees can be inoculated with a culture that allow them to better withstand environmental contamination. Another configuration of phytoremediation involves construction of tree well systems, which promote deeper root growth. Trees can also be used to facilitate hydraulic control through their evapotranspiration capability.	Use of inoculated trees (existing or new) provides an additional incremental benefit for mass removal. Hundreds of trees are typically planted. These trees are typically not indigenous to the area. Where phytoremediation has been deployed, it is generally effective in limiting shallow contaminant migration. The technology is proven to be effective in reducing chlorinated ethenes and 1,4-dioxane concentrations. The likelihood of the trees being able to prevent seeps at the surface is dependent on the rain intensity, length, and ability to of trees to transpire water. It is likely that some seeps will still occur even with a mature phytoremediation system, but the seeps would likely disappear quicker. Rating = (3) Phytoremediation proven to provide hydraulic containment though there is some uncertainty about what conditions the system could be effective for with respect to different precipitation events. This technology would not be applicable in the northern	While phytoremediation is a green technology, it is environmentally disruptive during planting activities. Additionally, there would be significant impacts to culturally sensitive areas. The use of non-indigenous trees in a culturally sensitive area may also be a concern. Permitting may be required if it is determined that the streambed would be altered. Rating = (1) Negative impacts due to planting of hundreds of non-indigenous trees in culturally sensitive area. Depth to groundwater in northern seep area too deep for this technology to be considered.	4	1	5	4

Table 4-4. Treatment of Seeps, Technology Screening, and Ranking
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
Constructed Treatment Wetlands	The areas where seeps are expressed would be redesigned to install aerobic and/or anaerobic constructed wetlands. Seep water would migrate through the wetlands and contaminants would be removed. Periodic harvesting of plants may be required to keep wetland viable.	The use of constructed wetlands would be effective removing contaminants; however, operation in the semi-arid environment would involve periods of prolonged dryness, so supplemental would be required to keep the wetland plants viable so they are available during the season where seeps are expressed. Rating = (4) Technology likely to be effective in treating contaminants. Not applicable to northern seep area due to depth of groundwater.	Implementation of the wetland would involve significant disruption of the southern seep area drainage area where seeps occur. This negatively impact the culturally sensitive area. Additionally, stream bed alteration permits would be required. The wetland plants that are successful in promoting aerobic and anaerobic treatment are not indigenous to the culturally sensitive target treatment area. Plants would require water year round. Rating = (1) Significant earthwork required to build technology has negative impacts to culturally sensitive area.	4	1	5	4
Hydraulic Control of Seep Water	Groundwater upgradient of the seep area would be pumped and treated at the GETS. One or more wells may be required to prevent seep expression during the rainy season. The pumping could be intermittent and only operated when there is a potential for rain.	Groundwater would be extracted and treated in the GETS or other ex situ treatment system. The number of wells required to prevent seep expression is uncertain. Information available so far indicates a nearby extraction well ND-138A can control groundwater levels at the SP-890 cluster in the southern seep area. Rating = (4) Very likely pumping of groundwater near the seep can control seeps in southern seep area; much greater uncertainty in the northern seep area.	ND-138A has already been installed and is currently operating. Testing will be required to identify the right balance between preventing seeps without changing the local ecosystem. Additional wells may have a more negative impact on the culturally sensitive area. Greater implementation challenges in the norther seep area due to need to install conveyance piping and affect a larger area. Rating = (3) A single well is not problematic. However additional wells could have negative impacts on culturally sensitive area.	4	3	7	2
Fine Bubble Diffused Aeration (FBDA)	FBDA's are placed in low spots where seeps collect. The aerators are manually turned on and will strip VOCs from water. The FBDA's can be manually moved around to different locations or the site can be contoured to focus seeps into general areas. Air diffusers can be powered by a blower run on a generator.	Periodic maintenance of diffusers are required to prevent air holes from being clogged. Effective for VOCs. Depths of seep pools are likely too shallow for this technology to be effective as FBDA equipment is designed for fully submerged applications, which is unlikely in the areas where seeps are expressed. Rating = (1) Some small "puddles" would not be addressed. But vast majority of seep water could likely be managed with this technology. The shallow depths of water pools prevents effective utilization of this technology.	Technology is implementable. However, the locations of seeps on NASA's sites are minimal and water drains into the subsurface quickly after a rain event. It is uncertain if the technology can be implemented in a timeframe to have meaningful impact. Rating assumes manual deployment of aerators and site grading would not be performed. Air permitting may be required though mass transfer is expected to be low. Rating = (3) Technology not implementable in northern seep area	1	3	4	7

Table 4-4. Treatment of Seeps, Technology Screening, and Ranking
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Treatment	Conceptual Deployment	Effectiveness (Eff)	Implementability (Imp)	Eff	Imp	Total	Rank
MNA	This technology can be considered a stand-alone technology or used in combination with other technologies. Contaminants are allowed to degrade naturally.	This technology can also be used as a component of a treatment train, concurrently with or after active treatment occurs, and also alone. Lines of evidence for assessing MNA (e.g., monitoring well locations and target analytes) will need to demonstrate that MNA is occurring. Rating = (3) MNA, as a stand alone remedy, is more promising in the northern seep area since concentrations are already very low. For the southern area, concentrations are higher (though generally less than 100 ppb) but will not likely be reduced until upgradient concentrations are reduced.	Easy to implement and requires only monitoring. Monitoring can be easily implemented at the site. The need for additional MNA wells to support remedial monitoring for NASA AIG plumes will be evaluated in the Phase 2 groundwater CMS and the CMI design. Rating = (5)	3	5	8	1

BVE = bedrock vapor extraction
COC = chemical of concern
Eff = effectiveness
EISB = enhanced in situ bioremediation
GETS = groundwater extraction and treatment system
IC = institutional control
Imp = implementability
ISCO = in situ chemical oxidation
ISTT = in situ thermal treatment
LUC = land use control
MNA = monitored natural attenuation
NASA = National Aeronautics and Space Administration
O&M = operation and maintenance
ppb = part(s) per billion
PRB = permeable reactive barrier
SSFL = Santa Susana Field Laboratory
SVE = soil vapor extraction
TTA = target treatment area
VOC = volatile organic compound

Table 6-1. Remediation Time Estimates for Different Alternatives and Target Treatment Areas

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Scenario	Only Natural Attenuation (Alternative 1) (years)	Treatment of TTAs followed by Natural Attenuation (years) (Alternatives 2a, 2b, 3, and 4)	Reduction in Time to Achieve TCE MCLs
ND-136 TTA (Alfa Area)	190	140	50 years (26%)
WS-09 TTA (Bravo Area)	360	275	85 years (24%)
C-6 TTA (Delta Area)	270	215	55 years (20%)

TTA = target treatment area

MCL = maximum contaminant level

Table 6-2. Wells for MNA Sampling in Northern Seep Area – B204/ELV AIG (B204 and ELV Transect Seep Monitoring Areas)

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Well	Location
ND-123 (multilevel well, 4 ports) – ELV Transect in Northern Seep Area	Downgradient of ELV source areas
ND-127 – ELV Transect in Northern Seep Area	ELV plume, downgradient of ELV
PZ-144 – ELV Transect in Northern Seep Area	ELV plume, downgradient of ELV
RD-56A (multilevel multi well, ports 2 and 3) – B204 Transect in Northern Seep Area	B204 plume centerline, downgradient
ND-122 (multilevel well, port 2) – B204 Transect in in Northern Seep Area	B204 plume centerline, downgradient
ND-124 (multilevel well, port 4) – B204 Transect in Northern Seep Area	B204 plume centerline, downgradient
RD-68A and RD-68B	Downgradient wells from B204 and ELV
SP-29 cluster (3 levels) – B204 Transect in Northern Seep Area	B204, downgradient
SP-33 cluster (3 levels) – ELV Transect in Northern Seep Area	ELV, downgradient

Note: Well locations shown on Figure 2-9.

B204 = Building 204

ELV = Expendable Launch Vehicle

Table 6-3. Wells for MNA Sampling – ND-136 Target Treatment Area

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Well	Location
ND-136	Source Area, currently configured as groundwater extraction well
C-5 (multilevel well, ports 2, 4, and 6)	Downgradient of Alfa Area source area
New Alfa source well ND-160 (multilevel well, 6 ports)	Alfa Area source area
Three new EISB Pilot Study Area multilevel monitoring wells (ND-163, ND-165, ND-167; 5 ports each)	Alfa Area source area and downgradient
ND-137A and ND-137B	Downgradient of Alfa Area source area
RD-49B and RD-49C	Downgradient of Alfa Area source area
PZ-154	Alfa Area potential source area NSGW well

Note: Well locations shown on Figures 2-12.

EISB = enhanced in situ bioremediation

NSGW = near-surface groundwater

Table 6-4. Wells for MNA Sampling – WS-09 Target Treatment Area

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Well	Location
WS-09	Source area, currently configured as groundwater extraction well
ND-168 (multilevel well, 5 ports)	Source area, adjacent to WS-09
ND-132 (multilevel well, 5 ports)	Bravo Area plume, downgradient
ND-133 (multilevel well, 4 ports)	Bravo Area plume, downgradient
ND-134 (multilevel well, 4 ports)	Bravo Area plume, downgradient
ND-135 (multilevel well, 4 ports)	Bravo Area plume, downgradient
RD-04	Groundwater extraction well

Note: Well locations shown on Figure 2-12.

Table 6-5. Wells for MNA Sampling – C-6 Target Treatment Area

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Well	Location
C-6	Coca/Delta Skim Pond source area
HAR-07	Side gradient, Coca/Delta Skim Pond source area
ND-169	Coca/Delta Skim Pond source area
HAR-08	Side gradient, Coca/Delta Skim Pond source area
Also includes wells monitored for Southern Seep Area (Table 6-6)	Downgradient plume of Delta Area

Note: Well locations shown on Figure 2-15.

Table 6-6. Wells for MNA Sampling – Southern Seep Area

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Well	Location
ND-138A and ND-138B	Upgradient of Southern Seep Area, within the Area II/III plume
WS-09A	Upgradient of Southern Seep Area
SP-882G	Downgradient portion of Area II/Area III plume, downgradient of fault
SP-881C	Downgradient portion of Area II/Area III plume, downgradient of fault
SP-881G	Downgradient portion of Area II/Area III plume, downgradient of fault
SP-890C	Downgradient portion of Area II/Area III plume, potentially upgradient of fault
SP-890G	Downgradient portion of Area II/Area III plume, potentially upgradient of fault

Note: Well locations shown on Figures 2-15.

Table 6-7. Target Flow Rates for P&T and Hydraulic Control Extraction Systems

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Target Treatment Area	Surface Dimensions of Groundwater Source Area Footprint (feet)	Estimated Saturated Thickness of Groundwater Source Zone (feet)	Total Maximum Depth (feet)	Hydraulic Gradient (foot/foot)[a]	Horizontal Hydraulic Conductivity (feet/day)	Computed Underflow (Q x 2 [gpm])[b]	Estimated Maximum Groundwater Extraction Rate (gpm)[c],[d]
ND-136 (Alfa Area)	150 by 150	200	475	0.020	1.3	8.1	16.2[e]
WS-09 (Bravo Area)	150 by 150	150	400	0.021	1.3	6.4	12.8
C-6 (Delta Area)	150 by 150	400	500	N/A	N/A	N/A	5.9[f]
Southern Seep Area (ND-138A)	N/A – Use well ND-138A	25	45	N/A	N/A	N/A	10[g]
Northern Seep Area (Building 204 Area)	250[h]	150	450	0.017	0.14	0.9	1.8
Northern Seep Area (ELV Area)	250[h]	220	400	0.017	0.14	1.4	2.8

[a] Horizontal hydraulic gradient computed from the third quarter 2016 interpretation included on Figure 4-16 of the draft NASA Groundwater RFI Report (NASA 2020a).

[b] Q calculated using Equation 1 above and multiplying by 2 to get underflow.

[c] Calculated as double the computed underflow. This includes a 2x factor of safety. Can be reduced to comply with GETS capacity.

[d] The total estimated maximum groundwater extraction rate is 49 gpm.

[e] Currently operating at 10 gpm.

[f] Based on aquifer test conducted on Well ND-169 (NASA 2022c)

[g] Assume, based on currently operating ND-138A; therefore, hydraulic gradient, horizontal hydraulic conductivity, and computed underflow are not included.

[h] Width of flow field requiring capture.

feet/day = feet per day

foot/foot = foot per foot

gpm = gallon(s) per minute

Q = groundwater underflow computed via Darcy's Law (Equation 1)

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Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
1. Protection of Human Health and Environment	Protective. ▪ LUCs will prevent use of groundwater (no complete groundwater pathways to humans) until MNA achieves MCOs. ▪ Once MCOs are achieved, further monitoring will not be required. ▪ No unacceptable ecological risks. ▪ Because there is no active treatment, bedrock vapor and groundwater may continue to migrate, but LUCs and monitoring will continue to protect human health. ▪ Downgradient plume will be addressed in Phase 2 CMS. ▪ There is no difference in how this technology is evaluated between the three different TTAs.	Protective. ▪ Groundwater treatment with EISB and bedrock vapor treatment will reduce contaminant concentrations. ▪ LUCs will be in place to protect human receptors, until MCOs have been achieved. ▪ Once MCOs are achieved, further monitoring will not be required. ▪ Source treatment will minimize downgradient contaminant migration. ▪ No unacceptable ecological risks. ▪ Downgradient plume will be addressed in Phase 2 CMS. ▪ BVE treatment will only be applied at the ND-136 TTA (additional sites will be evaluated in the Phase 2 CMS). ▪ Aside from BVE being implemented at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.	Protective. Text in Alt. 2a applies to this alternative.	Protective. The text presented for Alt. 2a applies to this alternative, with the only difference being that groundwater treatment will be accomplished with P&T technology instead of EISB.	Protective. ▪ ISCO used for groundwater treatment. ▪ ISCO will reduce the amount of downgradient mass transport, as long as the reagent remains reactive. However, ISCO treatment reagents are not as persistent as the other treatment alternatives and may result in less efficient treatment.. ▪ Once MCOs are achieved, further monitoring will not be required. ▪ No unacceptable ecological risks. ▪ Downgradient plume will be addressed in Phase 2 CMS. ▪ BVE treatment will only be applied at the ND-136 TTA (additional sites will be evaluated in the Phase 2 CMS). ▪ Aside from BVE being implemented at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.	▪ All alternatives are considered protective of human health and the environment. ▪ No unacceptable risks to ecological receptors. ▪ Human receptors would be protected with LUCs until MNA can achieve MCOs. ▪ Alt. 1 was assigned a score of 3 (able to protect human receptors but relying on LUCs and no treatment. Based on time of remediation estimates, MNA is expected to achieve comparable cleanup levels as those anticipated for alternatives using active treatment, albeit in a slightly longer timeframe. ▪ Given the long time frames estimated to achieve MCOs (refer to Criterion 2), no alternative received a score of 5. ▪ Alternatives 2a, 2b, 3, and 4 involve application of active treatment and will minimize downgradient contaminant transport. ▪ Alternatives 2a, 2b, and 3 were assigned a score of 4 and evaluation of these alternatives for this criterion was considered comparable (Figures 6-4, 6-5a, and 6-5b). ▪ Alt. 4 scored slightly lower (score of 3.5) because the chemical oxidant will likely have limited persistence, resulting in a slightly longer remedial timeframe (Figures 6-4, 6-5a, and 6-5b) ▪ BVE will be applied at ND-136 TTA. BVE treatment will not be deployed at the WS-09 or C-6 TTA as part of the Phase 1 CMS. BVE treatment will be evaluated at these locations as part of the Phase 2 CMS.
1. Criterion Score	3	4	4	4	3.5	N/A
2. Attain Media Cleanup Standards	This alternative is expected to achieve MCOs (3-1), which is consistent with the planned and future recreational use of this site.	This alternative is expected to achieve MCOs (Table 3-1), which is consistent with the planned and future recreational use of this site.	This alternative is nearly identical to Alt. 2a, with the only difference being that the temperature of the treatment	This alternative is expected to achieve MCOs (3-1), which is consistent with the planned and future recreational use of this site.	This alternative is expected to achieve MCOs (Table 3-1), which is consistent with the planned and future recreational use of this site.	▪ Alt. 1 is expected to be the least effective alternative.

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	1. Time to achieve MCOs is uncertain. One-dimensional modeling was performed to estimate the time of remediation (Table 6-1 and App. B): a. ND-136: 190 years b. WS-09: 360 years c. C-6: 270 years 2. Downgradient components of the plume would achieve MCOs sooner than treatment areas. 3. Bedrock vapor transport to groundwater could increase time of remediation. 4. NASA is currently completing fate and transport modeling, which can be used to estimate time of remediation for different alternatives. As part of the future Phase 2 CMS, NASA will evaluate potential bedrock contaminant migration scenarios and forecast potential impacts on time of remediation. Additionally, as more performance data is collected on Phase 1 and Phase 2 alternatives implementation, NASA will be able to better predict the impacts of bedrock vapor on contaminant recharge, versus matrix diffusion. 5. Monitoring well network will be established to assess alternative performance over time (Tables 6-3 through 6-5). 6. If new monitoring wells are needed, the ESAAP will be followed to protect cultural and archeological resources (Section 3.4). 7. If biological resources are identified during monitoring, the biological process will be followed to protect biological resources (Section 3.4). 8. The performance criteria for attaining MCOs is met with this alternative, though the length of time to achieve MCOs is considered very long.	1. This alternative involves active treatment and assumes a 90% reduction in contaminant concentrations in the target treatment zone. 2. The following timeframes were estimated to achieve MCOs (Table 6-1 and App. B): a. ND-136: 140 years (50 years shorter than Alt. 1) b. WS-09: 275 years (85 years shorter than Alt. 1) c. C-6: 215 years (55 years shorter than Alt. 1) 3. Time to achieve MCOs could be shorter if active treatment could accomplish more than 90% reduction, though 90% reduction is considered reasonable give the complex nature of the site. 4. Bullets 3 and 4 under Alt. 1 apply to this alternative. 5. Downgradient portions of the plume are expected to achieve MCOs sooner. 6. The same monitoring network would be implemented for this alternative as that described for Alt 1. 7. Aside from difference in estimated time to achieve MCOs, there is no difference in how this technology is evaluated between the three different TTAs. 8. While the time to achieve MCOs is shorter for this alternative, compared to Alt 1, time timeframe is still considered very long.	reagents would be increased by 10 degrees centigrade. 1. This could result in an increased rate of treatment within the fracture zone, by a factor of about two, but the benefits are uncertain. 2. The reagent treatment temperature increase is not expected to appreciably change the temperature of the rock matrix. 3. Back-diffusion is the limiting factor in decreasing time of remediation and increasing the temperature of the treatment reagents is not expected to change the rate of back-diffusion from the rock matrix. 4. Will result in faster utilization of treatment reagents, potentially resulting in limiting treatment of contaminants that back diffuse from rock. 5. Uncertain if increasing treatment reagent temperature will result in reducing estimated time to achieve MCOs. 6. Aside from difference in estimated time to achieve MCOs, there is no difference in how this technology is evaluated between the three different TTAs.	▪ The information presented for Alt. 2a also applies to this alternative.	▪ The information presented for Alt. 2a also applies to this alternative. However, lower oxidant longevity could increase the time to achieve MCOs. ▪ Data is not available to provide an estimate of increased treatment time (compared to the other active treatment alternatives). ▪ Aside from difference in estimated time to achieve MCOs, there is no difference in how this technology is evaluated between the three different TTAs.	▪ Active treatment Alternatives 2a, 2b, 3, and 4 are expected to achieve MCOs sooner than Alt. 1. ▪ For this CMS, it has been assumed a 90% concentration reduction could be achieved in 10 years. Time to achieve MCOs could be decreased if concentration reduction exceeds 90%, though this estimate is considered reasonable given the complex nature of the site. ▪ There is uncertainty in all the time estimates to achieve MCOs. Current remediation technology has limitations in not being able to practically remove contaminant mass from the sandstone matrix. NASA believes the estimates provide important context for evaluation time to achieve MCOs. Additional modeling is being performed to improve time estimates for treatment. Data from the GETS interim measure testing and EISB and BVE pilot studies will also help calibrate time estimates to achieve MCOs. However, this information is not currently available to be considered for this CMS. ▪ Alternatives 2a, 2b, and 3 are considered comparable in their ability to provide sustained treatment over a 10-year period. The addition of heat to Alt. 2b is not expected to change the time to achieve MCOs, so there is no difference on how these alternatives were scored. ▪ Alt. 3 is expected to provide sustained contaminant removal by extraction of contaminants. ▪ Alt. 4 is expected to be less effective in treatment do to less sustained treatment due to faster reagent (oxidant) utilization. ▪ Overall, active treatment is expected to reduce time to achieve MCOs by 20 to 26%, depending on the TTA, as compared to Alt. 1.

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	9. Aside from difference in estimated time to achieve MCOs, there is no difference in how this technology is evaluated between the three different TTAs.					▪ Given the long timeframes to achieve MCOs, Alternatives 2a, 2b, and 3 were assigned a maximum score of 3. Alt.4 was assigned a score of 2, based on limitations of treatment reagent longevity. Alt. 1 was assigned a score of 1.
2. Criterion Score	1	3	3	3	2	N/A
3. Remediation Source Releases	Past releases have resulted in groundwater contamination. Given this alternative does not involve active treatment or containment, this remedy does not comply with the requirement to control sources from releases.	This alternative satisfies the requirement for controlling the sources from releases with the application of EISB at the three groundwater TTAs and BVE at the ND-136 TTAs.	Same as Alt. 2a with the exception that water would be heated prior to injection.	Same as Alt. 2a except using pump and treat as the groundwater remedial technology.	Same as Alt. 2a except using ISCO as the groundwater remedial technology.	▪ Alt. 1 does not comply with requirement to control sources from releases. A score of 1 was assigned to this alternative. ▪ The other alternatives use active treatment to control sources of release and were considered comparable in addressing this criterion. A score of 5 was assigned to Alternatives 2a, 2b, 3, and 4.
3. Criterion Score	1	5	5	5	5	N/A
4. Long-Term Effectiveness[a] 4a. Reliability	1. This alternative is expected to attenuate the COCs identified for this site. 2. Attenuation will be achieved by a combination of physical, biological, and chemical processes. 3. MCOs are expected to be achieved in a time frame presented for Criterion 2. 4. Monitoring will provide information on the progress of the remedy, which will help protect human health and the environment. This information will determine if future actions are necessary. 5. Natural attenuation is a widely implemented alternative; SSFL site data indicate natural attenuation is occurring at the site, is preventing downgradient plume expansion, and is limiting COC migration in groundwater. However, it is not typically applied, without active treatment, to high concentration areas as those targeted by the Phase 1 CMS TTAs.	1. Operating period of EISB is estimated as 10 years, at which time the practical limits of the technology are expected to be achieved. 2. Supplemental EISB injections are likely to be required. 3. If performance indicates continued practical benefits of EISB operations, treatment will continue. 4. EISB technology is considered reliable and treatment system components will be maintained; the design for the remedy will include an O&M plan for system maintenance. 5. Performance monitoring samples will be collected to assess EISB effectiveness. 6. It is highly unlikely the beneficial impacts of EISB, BVE, and MNA could be changed, so the degree of confidence in this alternative is high, even if it will take many years to achieve MCOs.	Same as Alt. 2a, with the exception that water would be heated prior to injection. The heating approach described in Section 6.1.7 (thermally assisted EISB) is considered reliable. However, maintenance will be required to maintain the heating system and occasional descaling. The ability of the heating system to achieve and then maintain elevated temperatures in fractures is uncertain.	1. Operating period of P&T is estimated as 10 years, at which time the practical limits of the technology are expected to be achieved. 2. If performance indicates continued practical benefits of EISB operations, treatment will continue. 3. P&T technology is considered reliable and treatment system components will be maintained; the design for the remedy will include an O&M plan for system maintenance. 4. Performance monitoring samples will be collected to assess P&T effectiveness. 5. It is highly unlikely the beneficial impacts of P&T, BVE, and MNA could be changed, so the degree of confidence in this alternative is high, even if it will take many years to achieve MCOs.	1. Operating period of ISCO is estimated as 10 years, at which time the practical limits of the technology are expected to be achieved. 2. If performance indicates continued practical benefits of ISCO operations, treatment will continue. 3. ISCO technology is considered reliable though there are concerns about the ability of the ISCO reagent to stay resident in the TTA long enough to provide beneficial results. 4. Treatment system components will be maintained; the design for the remedy will include an O&M plan for system maintenance. 5. Performance monitoring samples will be collected to assess ISCO effectiveness. 6. It is highly unlikely the beneficial impacts of ISCO, BVE, and MNA could be changed, so the degree of confidence in this alternative is	▪ The reliability of achieving MCOs with the active treatment alternatives is greater than with Alt. 1, because the active treatment alternatives remove substantive mass from the TTAs before the transition to MNA, whereas Alt. 1 relies solely on MNA. Because more mass is in the TTA when MNA is applied with Alt. 1, the length of time to achieve MCOs with the active treatment alternatives will be 20 to 26% shorter depending on the TTA (refer to Table 6-1), compared to Alt. 1. ▪ There is a greater likelihood of challenges to achieving MCOs with Alt. 1, compared to the active treatment alternatives. Alternatives 2a, 2b, and 3 are considered comparable with respect to reliability. Alt. 4 was considered to be less reliable than Alternatives 2a, 2b, and 3 because of the limited persistence of the oxidant and its ability to achieve a comparable level of treatment.

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	6. While natural attenuation will minimize downgradient transport of contaminants, it is not as effective as active treatment alternatives that provide greater treatment and results in less contaminant transport downgradient. 7. If the results of the planned MNA decision process (Sections 6.1.1 and 6.1.9) indicate MNA is not performing as planned, additional testing or mitigation measures may be necessary. 8. Once the MCOs have been achieved, it is unlikely future conditions could change the beneficial impacts, so the degree of confidence in alternative is high, although it is estimated to take many years to achieve MCOs. 9. The MNA monitoring network will be periodically evaluated to assess whether the data collected is necessary and appropriate and if any changes to the network are warranted (e.g., increasing or decreasing the number of wells, parameters, and frequency of collected samples). 10. LUCs will be robust and address the intergenerational management of the site. Because of the long time frame to achieve MCOs, this alternative will take into consideration new technology developments and site changes resulting from seismic and potential extreme weather events. Periodic inspection of signs will be performed to verify they are being properly maintained, or replaced, when necessary. The deed restrictions involving water usage at the site will also be evaluated periodically for effectiveness.	7. BVE treatment is anticipated to operate for 5 years but may run longer if practical benefits continue (BVE systems are not considered long-term treatment technologies and typically operate for shorter durations than groundwater treatment technologies). 8. BVE technology has been pilot tested at SSFL and shown to be effective. 9. Periodic maintenance of the BVE blower, condensate collector, and off-gas treatment system will be required; the BVE design, through the O&M plan, will specify maintenance requirements. 10. The BVE system will be periodically assessed for optimization and to determine maintenance needs. 11. After the practical limits of treatment have been achieved, MNA is expected to reduce contaminant concentrations further, until MCOs are achieved, as described by Alt. 1. 12. Monitoring of MNA will be as described by Alt. 1. 13. SSFL site data indicate natural attenuation is occurring at the site, is preventing downgradient plume expansion, and is limiting COC migration in groundwater. 14. The time to achieve MCOs is shown in Criterion 2. 15. The text presented in Alt. 1 for the MNA network (No. 9) applies to the monitoring network for this alternative. 16. The text presented in Alt. 1 for LUCs (No. 10) applies to this alternative.		6. Bullet points 7-16 presented under Alt. 2a for this criterion also apply to this alternative.	high, even if it will take many years to achieve MCOs. 7. Bullet points 7-16 presented under Alt. 2a for this criterion also apply to this alternative.	For these reasons, Alt. 1 was assigned a score of 3, Alt. 4 was assigned a score of 4, and the other active treatment alternatives were assigned a score of 5 (Figures 6-4, 6-5a, and 6-5b).
4a. Criterion Score	3	5	5	5	4	N/A

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Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
4. Long-Term Effectiveness[a] 4b. Assessment of Long-term Performance and Effectiveness	1. Periodic performance monitoring data will be collected to assess progress of MNA. 2. Regular inspections of LUCs will be completed to assess their effectiveness in protecting human health. Should future information demonstrate potential plume migration that requires additional management, appropriate response actions will be put in place. 3. Once MCOs have been achieved, there is high confidence the alternative will continue to be protective. 4. Uncertainty exists about the impact of contamination in the vadose zone on length of time to achiever MCOs (vadose zone impacts to groundwater were not assessed). If future monitoring indicates additional migration of contaminants to groundwater the time frame for remediation may need to be extended. 5. There are no known complete risk pathways to human receptors and LUCs will involve system administrative actions, signage, and regular review to assure continued protection of human health (Section 2 describes the lack of plume boundary expansion and further downgradient migration is not expected). 6. LUCs will prevent human contact with TTA groundwater and bedrock vapor in their respective TTAs. 7. The data for regular monitoring efforts will be reviewed by DTSC and NASA to evaluate MNA progress. 8. Each of the three treatment areas pose challenges in optimizing placement of wells for monitoring because drill rig access is not possible due to the mountainous terrain.	1. The EISB component of this alternative delivers a fermentable carbon, nutrients, and additional microorganisms and brings them into contact with high concentrations of TCE in groundwater. This technology is expected to treat water within the fractures by coating the fracture walls with microorganisms so contaminants will biodegrade as they diffuse back out of the rock matrix. Implementation of this technology in a rock matrix is more challenging compared to porous media, as there is greater potential for the injected treatment reagents and microorganisms to be flushed from the fractures and move out of the TTA. 2. Groundwater extraction with injection wells in the TTA will help keep the treatment reagents and microorganisms within the TTA. A field pilot study will be conducted at ND-136 to further assess the feasibility of this technology. 3. Monitoring the EISB system components will be used to assess system performance and collect information on the progress of treatment from the three TTAs. Also, process parameters to assess the viability of the bioavailable organic carbon source and recharge frequency will be performed on a regular basis. This technology has proven to be successful in achieving contaminant reductions in a relatively short period of time through the process of recirculation and the continuous supply of fermentable carbon delivered in the TTA. The ability to reapply treatment reagents contributes to the improved outcomes with this technology.	1. As this alternative includes heating groundwater prior to it being reinjected, temperature monitoring will be a component of assessing the system. 2. With the exception of the heating component of this alternative, all other attributes of this criterion are identical to Alt. 2a.	1. Groundwater will be extracted from fractures in rock matrix. P&T component of this alternative accelerates mass removal through the physical removal of contaminants from the aquifer system and promoting back-diffusion from the rock matrix. P&T is applicable to mobile COCs in the groundwater system and has been proven effective at SSFL through past operations. 2. The disadvantages of groundwater extraction and ex situ treatment is mainly related to historical technology performance at the site. Overall, monitoring of groundwater extraction systems used for previous interim remediation measures has demonstrated that contaminant removal efficacy by this technology is low (refer to Section 6.1.5.2). 3. The P&T monitoring system will be used to assess performance and collect information on the progress of mass removal from the three TTAs. 4. The information presented for BVE operations under Alt. 2a (bullet 4 and 5) and MNA (bullets 6, 7, and 8) apply to this alternative. 5. Information for Bullet 6 under Alt. 2a applies to this alternative.	1. This technology is expected to treat water within the fractures. The potential exists for the oxidant to penetrate a short distance into the rock matrix. However, the ISCO pilot study performed at SSFL showed limited evidence of this occurring. Based on the SSFL ISCO Pilot Study, the oxidant residual was observed to penetrate up to 2.5 millimeters into the rock matrix. Additionally, the ISCO pilot study indicated that the oxidant was depleted quickly (approximately 2 to 3 weeks) likely as a result of the natural oxidant demand of the system. Because the oxidant was depleted quickly, it was detected at only a few locations and intervals across the injection monitoring network. The purple color of permanganate was observed only at 6 locations, whereas the tracer bromide was detected at 32 locations, indicating limited oxidant distribution. 2. For this technology to be successful, oxidant will need to treat the pore volume of water in the fracture before the oxidant is consumed. The rate of reapplication would be driven by the rate of oxidant consumption and the rate of contaminant rebound in the fractures. Implementation of this technology in a rock matrix is more challenging compared to porous media, as there is greater potential for the injected oxidants be flushed from the fractures and move out of the TTA. Groundwater recirculation with injection wells in the TTA will help keep the oxidants in the TTA. 3. The ISCO monitoring system will be used to assess performance	▪ For all five alternatives, the performance of each component will be regularly assessed and reviewed by DTSC and NASA. In the context of long-term monitoring and operation of the remedy, NASA refers to whichever government agency has ongoing responsibility for site O&M for the property at that point in time. ▪ Performance of all active treatment alternatives will be evaluated and subjected to performance evaluations at regular intervals throughout the implementation of the alternatives; adaptive site management may be used to optimize performance of alternatives. ▪ Implementation of MNA, which is common to all five alternatives, will provide periodic information on the progress of natural attenuation. If future information demonstrates potential plume migration that requires additional management, appropriate response actions will be implemented. ▪ LUCs, which are common to all five alternatives, will be robust to address intergenerational management of the site. Also, because of the long time period estimated to achieve MCOs, implementation of this alternative will consider new technology developments and be adaptive to potential extreme weather changes or seismic events at SSFL until MCOs are achieved. Regular inspections of LUCs will be completed and may be modified, as appropriate, to address changed conditions related to the long time estimated to achieve MCOs for all five alternatives. ▪ The BVE system is a component of all four active treatment alternatives, in the ND-136 TTA. The BVE system will be monitored through its estimated 5-year operating period to assess performance and effectiveness. Pilot

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		4. Concurrent BVE treatment with EISB will be implemented where bedrock vapor concentrations exceed 12,000,000 μg/m^3 in the Phase 1 CMS TTAs. BVE operations are expected to reduce the amount of contaminant recharge from the vadose zone migration to groundwater. It is uncertain, however, if this benefit can be verified with field measurements. During remediation, it will be uncertain if potential increases in groundwater concentrations will be from matrix diffusion, vadose zone, or both (and in what proportion). NASA can better estimate vadose zone impacts, and matrix diffusion, in the future based on how treatment at the ND-136 TTA responds to treatment. The benefits of concurrent groundwater treatment and BVE at the same well location will be further evaluated in the Phase 2 CMS 5. The BVE system at wells in the ND-136 TTA and monitoring networks will be monitored continually to assess performance. 6. Each of the three treatment areas pose challenges in optimizing placement of treatment wells because drill rig access is not possible due to the mountainous terrain. 7. This alternative will provide periodic information on the progress of the MNA component of the remedy, which will be implemented after EISB and BVE treatment are completed. 8. MNA monitoring same as described by Alt. 1. 9. LUCs component of this alternative same by Alt. 1 (No. 2, 5, and 6).			and collect information on the progress of mass removal from the three TTAs. 4. The information presented for BVE operations under Alt. 2a (bullet 4 and 5) and MNA (bullets 6, 7, and 8) apply to this alternative. 5. Information for Bullet 6 under Alt. 2a applies to this alternative.	tests have shown this technology is effective in the recovery of bedrock vapor mass. While it is likely each of the treatment alternatives may have different time estimates to achieve MCOs, it is not possible to forecast these differences at this time. It is expected the time to achieve MCOs for the active treatment alternatives, while likely not be exactly as described for this criterion, will be comparable. However, because Alt. 1 will take the longest time to achieve MCOs and does not include active source treatment, it is likely to be more challenging to assess performance of the remedy. The presence of a high concentration source with Alt. 1 will minimize the observance of natural attenuation until the source has been significantly depleted. Based on the above, appropriate monitoring for performance and effectiveness is considered comparable among the four active treatment alternatives and all were assigned a score of 5. Given the challenges of discerning a natural attenuation signal with Alt. 1, the score for this criterion was assigned as 1 (Figures 6-4, 6-5a, and 6-5b).
4b. Criterion Score	1	5	5	5	5	N/A

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4. Long-Term Effectiveness[a] 4c. Residual Risks	1. Once MCOs are achieved, residual risks are likely to be considered acceptable. However, as previously noted in Criterion 2, the time to achieve MCOs is very long and will vary by TTA. 2. Once MCOs are achieved there will be no threat from migrating plumes. Because there are no ongoing sources of groundwater contamination, additional contamination from new sources is unlikely. 3. Once cleanup activities are completed, no additional impacts to the environment associate with the remedy implementation will occur. 4. There is no difference in how this technology is evaluated between the three different TTAs.	The length of time to achieve MCOs for this alternative (refer to Criterion 2) could be reduced if greater source reduction becomes possible. However, given the complex hydrogeology at this site, a one order-of-magnitude reduction with active treatment is optimistic. Bullet points 1, 2, 3, and 4 from Alt. 1 apply to this alternative.	The residual risks of this alternative are expected to be identical to Alt. 2a.	The residual risks of this alternative are expected to be identical to Alt. 2a.	The residual risks of this alternative are expected to be identical to Alt. 2a.	As presented above, all five alternatives are likely to have acceptable residual risks once MCOs are achieved. Because the four active treatment alternatives are expected to reach MCOs 20 to 26% faster than Alt. 1, there is less opportunity for something to prevent residual risks from being achieved. Therefore, the active treatment alternatives received a score of 5 and Alt. 1 was assigned a score of 1 (Figures 6-4, 6-5a, and 6-5b).
4c. Criterion Score	1	5	5	5	5	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5a. Toxicity	1. This alternative reduces toxicity of the COCs via naturally occurring degradation processes, which ultimately convert the COCs to non-toxic daughter and degradation products. 2. In some cases, however, degradation could stall or pause at more toxic daughter products such as VC. The MNA monitoring program will be designed to evaluate this potential concern. Additional testing or mitigation measures will follow the Adaptive Management Plan. Refer to "Types of Treatment Residuals" (5e) for further information. 3. Natural attenuation of COCs through non-degradation or destructive processes such as absorption into the rock matrix or adsorption on rock media prevent them from being bioavailable.	1. The EISB technology will support ERD and other biological treatment processes, as well as abiotic removal, for example, via iron sulfides that may form as a result of reducing conditions. This technology could potentially create additional daughter products. For example, TCE will degrade to VC. A properly maintained system should allow the degradation pathway to degrade VC to non-toxic ethene or ethane. 2. EISB sometimes causes temporary mobilization of metals, which would allow the mobilized metals to become bioavailable. However, this is expected to be a temporary condition and the metals will convert to their previous immobile form after then natural geochemistry is re-established after treatment. 3. Natural attenuation COCs through non-degradation or destructive processes such as absorption into	The toxicity evaluation for this alternative is expected to be identical to Alt. 2a.	Groundwater and vapor will be extracted from the three groundwater extraction wells and two BVE extraction wells to remove mass from the system and reduce the toxicity associated with that mass. Bullet points 3, 4, and 5 under Alt. 2a apply to the BVE and MNA component of this alternative.	1. The ISCO technology will oxidize COCs in groundwater. The ISCO pilot study report (CH2M 2016) noted a potential for natural organic carbon in the subsurface to become bioavailable and contribute to the biological degradation of COCs. For example, TCE will degrade to VC and then ethene, which is non-toxic. 2. Adding oxidants will introduce some contaminants to the subsurface. For example, if a sodium or potassium permanganate is introduced as a treatment reagent, sodium or potassium, as well as manganese, will be introduced into the subsurface. If sodium persulfate is introduced as a treatment reagent, sodium and sulfate will be introduced into the subsurface. The concentrations of these added constituents are typically much higher than natural	▪ By the time MCOs are achieved, all five alternatives will have reduced the toxicity of contaminants in the TTAs. ▪ Alt. 1 relies on natural processes and the other four alternatives address most of the toxicity reduction through active treatment in the groundwater. ▪ The four active treatment alternatives also remove toxicity from the vadose zone by physically removing contaminants with BVE. ▪ The potential exists for the generation of VC with any of the alternatives, but it is greatest with Alternatives 1, 2a, and 2b because of the application of biological reduction processes. However, under Alternatives 2a and 2b, the generation of VC can be managed with proper monitoring and the application of treatment reagents that optimize biodegradation. Alternatives 2a, 2b, and 4 may temporarily mobilize redox sensitive

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	4. There is no difference in how this technology is evaluated between the three different source areas.	the rock matrix and adsorption onto rock surfaces, prevent them from being bioavailable. 4. Vapor extracted from the BVE extraction well will remove mass from the system and the toxicity associated with the mass will be removed. 5. There is no difference in how this technology is evaluated between the three different TTAs.			background concentrations. Over time, however, these additional constituents are expected to attenuate through the processes of adsorption onto rock surfaces or diffusion into the rock matrix. ISCO sometimes causes temporary mobilization of redox sensitive metals, which would allow the mobilized metals to become bioavailable. However, this is expected to be a temporary condition and the metals will convert to their previous immobile form once natural geochemistry is re-established after treatment. 3. The SSFL pilot study noted that "…concentrations of redox-sensitive metals, especially chromium, increased in some ports following the start of injection but concentrations generally returned to, at, or near baseline levels by the end of the monitoring period as natural aquifer conditions were restored" (CH2M 2016a). However, at one location the concentrations continued to rise through the pilot study performance period, but these levels were expected to decline as natural aquifer conditions are restored, though in the case of manganese at one location, the time to achieve these lower concentrations is uncertain. 4. Bullet points 3, 4, and 5 under Alt. 2a apply to the BVE and MNA component of this alternative.	metals (e.g., arsenic and chromium), resulting in their becoming more bioavailable. However, after treatment, these metals are expected to convert to their previously insoluble forms as the natural geochemistry in the TTA is re-established. Alt. 4 will introduce inorganic treatment reagents (e.g., manganese and sodium if sodium permanganate is used as an oxidant). ▪ Alt. 3 removes the toxicity via groundwater extraction and does not generate temporary metal mobilization or result in residual treatment reagents in the groundwater. ▪ Based on this discussion, Alt. 1 was assigned a score of 1, Alt. 3 scored highest with an assigned score of 5, Alternatives 2a and 2b were assigned a score of 4, and Alt. 4 was assigned a score of 3 (Figures 6-4, 6-5a, and 6-5b).
5a. Criterion Score	1	4	4	5	3	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5b. Mobility	1. Natural attenuation of COCs (included in Table 3-1) through natural biodegradation of TCE, cis- and trans-DCE, and VC. 2. Adsorption of COCs on aquifer media and absorption of COCs into	1. Operation of source treatment technologies in the source groundwater and bedrock vapor TTAs will treat and reduce COC concentrations. The technologies will reduce the mass and concentrations of COCs migrating	The mobility evaluation for this alternative is expected to be identical to Alt. 2a.	1. Operation of P&T in the source groundwater and bedrock vapor extraction in the TTAs will remove and reduce contaminant concentrations. P&T will reduce the mass and concentration of contaminants that can migrate	1. Operation of ISCO in the source groundwater and bedrock vapor extraction in the TTAs will treat and reduce contaminant concentrations. The technologies will reduce the mass and concentration of contaminants	▪ Alt. 1 would only reduce mobility as a result of natural attenuation processes (adsorption and diffusion of contaminants along the pathways of contaminant migration).

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	the rock matrix contributes to natural attenuation by increasing the retention time of the COCs within the site boundaries, allowing more time for degradation to occur, while minimizing the downgradient transport of contaminants. 3. There is no difference in how this technology is evaluated between the three different TTAs.	from the groundwater TTAs and migrating to the groundwater from the vadose zone for the bedrock vapor TTAs. However, incomplete ERD of chlorinated ethenes could result in the production of daughter products that could migrate downgradient from the groundwater TTAs; however, the recirculation system could minimize this. The performance monitoring plan will assess different lines of evidence to minimize the potential for this occurrence. 2. Adsorption onto aquifer media and absorption of the COCs into the rock matrix during the active and post-active treatment MNA phase contribute to natural attenuation by increasing the retention time of the COCs within the site boundaries, providing more time for attenuation processes to mitigate COCs, while minimizing the potential for downgradient transport. 3. Operation of the recirculation system will prevent some high concentration groundwater from migrating downgradient and keep contaminants resident in the TTA. The degree to which this can occur is uncertain. 4. There is no difference in how this technology is evaluated between the three different TTAs.		downgradient from the groundwater TTAs and that can migrate to groundwater from the vadose zone for the bedrock vapor TTAs. 2. Adsorption of contaminants onto aquifer media and absorption of contaminants into the rock matrix during the active and post-active treatment MNA phase contribute to natural attenuation by increasing the retention time of the COCs within the site boundaries, providing more time for the attenuation processes to mitigate COCs and minimizing the potential for downgradient transport. 3. The groundwater extraction well, while operating, will prevent some high concentration groundwater from migrating downgradient and keep COCs resident in the TTA, to the degree possible. The degree to which this can occur without applying the technology is uncertain. 4. There is no difference in how this technology is evaluated between the three different TTAs.	that can migrate downgradient from the groundwater TTAs and migrate to groundwater from the vadose zone for the BVE TTAs. 2. If ISCO facilitates biodegradation, TCE daughter products could migrate downgradient from the groundwater TTAs. The performance monitoring plan will assess different lines of evidence to minimize the potential for this occurrence. 3. Some increased mobility of treatment reagents, such as sodium, potassium, sulfate, or manganese depending on the oxidant used, is expected. 4. Additionally, other redox sensitive metals naturally present could be mobilized as well (e.g., arsenic and chromium). 5. Over time, these added reagents and elevated redox sensitive metal increases are expected to attenuate over time as natural aquifer conditions are restored. 6. If ISCO delivery uses recirculation, will prevent some high concentration groundwater from migrating downgradient and keep resident in the TTA, to the degree possible. The degree to which this can occur is uncertain. 7. Bullet point 3 and 4 under Alt. 3 applies to this alternative.	▪ All the active treatment alternatives employ BVE of bedrock vapors at the ND-136 TTA, which reduce the mobility of contaminants in the vadose zone. ▪ All active treatment alternatives use some form of hydraulic control that would limit contaminant migration. Alternatives 2a, 2b, and 4 use in situ treatments that would reduce contaminant mobility through in situ treatment. Alt. 3 would remove the contaminants from the TTAs in groundwater, preventing them from being transported down gradient. ▪ Of all five alternatives, Alt. 1 would reduce mobility the least and was assigned a score of 1. Alt. 3, which removes contaminants in the TTAs and operates under long-term pumping conditions, was assigned a score of 5. Alternatives 2a and 2b were assigned the same score of 4, which is lower than Alt. 3 because the contaminants are treated in place and not removed from the TTAs. Alt. 4 was assigned a score of 3, which is lower than Alternatives 2a and 2b because less mass is expected to be treated during the active treatment phase, which is expected to result in more mobility of contaminants (Figures 6-4, 6-5a, and 6-5b).
5b. Criterion Score	1	4	4	5	3	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5c. Volume	1. COCs will naturally attenuate in fractures, or the primary porosity features of the rock matrix, where further degradation may occur or the COCs may be sequestered. 2. Adsorption and absorption of COCs will increase the retention time of the COCs within the site boundaries, allowing more time for degradation	1. Degradation of contaminant mass by EISB treatment will enhance natural biodegradation, primarily in fractures, resulting in a decreased plume size. 2. COCs will naturally attenuate in fractures, or the primary porosity features of the rock matrix, where further degradation may occur or	The volume evaluation for this alternative is expected to be identical to Alt. 2a.	Extraction of contaminated groundwater from the source groundwater TTA rock fractures will reduce contaminant water volume and some rock matrix mass from diffusion to extracted groundwater. Bullet points 2, 3, and 4 for Alt. 2a apply to this alternative.	1. Destruction of contaminant mass in the rock fractures by ISCO will decrease the plume size. 2. There is some concern about the persistence of the oxidant and its resulting effectiveness in reducing concentrations. If the oxidant is	▪ As a result of active treatment, the contaminant volume in the fractures of the TTAs will decrease quickly. However, the volume of contaminant mass remaining in the bedrock vapor and groundwater TTAs eventually will be limited by back-diffusion properties of the system.

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	to occur and minimizing the opportunity for contaminant transport. 3. As natural attenuation progresses, more contaminants will be treated through natural degradation processes or adsorbed. 4. The result of natural attenuation will be a reduction of mass available for transport, which will collapse the size of the contaminant plumes after a long period of time. 5. There is no difference in how this technology is evaluated between the three different TTAs.	the COC may be sequestered. Adsorption and absorption of COCs will increase the retention time of the COCs within the site boundaries, allowing more time for degradation processes to occur while minimizing the opportunity for contaminant transport. As natural attenuation progresses, more contaminants will be treated through natural degradation processes or adsorbed. The result of natural attenuation will be a reduction of mass available for transport, which will collapse the size of the contaminant plumes after a long period of time. 3. Removal of mass at ND-136 TTA with the BVE system is expected to reduce the volume of contaminated vapor and related sorbed liquid COCs in the vadose zone and minimize contaminating groundwater volume in the future. 4. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.			not persistent, this will negatively impact volume reduction. 3. Bullet points 2, 3, and 4 for Alt. 2a apply to this alternative.	▪ The overall volume of remaining contaminants cannot be reduced until back-diffusion of contaminants from the rock matrix is complete, though the absolute volume of high concentration groundwater in fractures will reduce. Over time, the volume of contaminants in the rock matrix will reduce but monitoring the process will be difficult as only periodic high-resolution rock coring could monitor this progress. ▪ Eventually, when MCOs are achieved, all five alternatives are expected to have achieved the same amount of volume reductions. ▪ With respect to volume reduction, Alternatives 2a, 2b, and 3 are considered comparable with scores of 5, followed by Alt. 4, which is expected to be less effective in treatment (due to concerns about oxidant persistence), with a score of 4. Alt. 1 is the least effective in volume reduction and was assigned a score of 1 (Figures 6-4, 6-5a, and 6-5b).
5c. Criterion Score	1	5	5	5	4	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5d. Irreversibility of Treatment	1. The process of natural attenuation via biodegradation is irreversible and all the organic COCs are expected to biodegrade. 2. Once COCs degrade, they will not reform. However, those contaminants that are attenuated through diffusion into the rock matrix or adsorption on aquifer media surfaces could be released back into groundwater through back diffusion out of the rock matrix or desorb from the fracture surfaces. 3. The rate of desorption and back-diffusion, and the degree to which rebound could occur, are unknown.	1. The processes of EISB and natural attenuation via biodegradation are irreversible and all the organic COCs are expected to biodegrade. 2. Once COCs degrade, they will not reform. However, those contaminants that are attenuated through diffusion into the rock matrix or adsorption on aquifer media surfaces could be released back into groundwater through back diffusion out of the rock matrix and desorption. 3. The rate of desorption and back-diffusion, and the degree to which rebound could occur, are unknown.	The irreversibility of treatment evaluation for this alternative is expected to be identical to Alt. 2a.	The process of removing contaminants via P&T and BVE is irreversible. Bullet points 2, 3, 4, 5, and 6 of Alt. 2a apply to the MNA component of this alternative.	The process of ISCO is irreversible. Once COCs oxidize, they will not reform. Bullet points 2, 3, 4, 5, and 4 of Alt. 2a apply to the MNA component of this alternative.	As described previously, the active treatment components of Alternatives 2a, 2b, 3, and 4 are irreversible. Degradation processes associated with natural attenuation are also irreversible. However, contaminants attenuated through adsorption or diffusion into the rock matrix could be desorbed and flow with groundwater. Because the active treatment alternatives all employ treatment that is irreversible, they were assigned a higher score. Alternatives 2a, 2b, and 3 were assigned a score of 5 because their level of treatment is considered comparable. Alt. 4 was assigned a score of 4 because of concerns about oxidant persistence,

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	4. The proper monitoring, assessment, and interpretation of data are expected to provide the necessary decision-making confidence to assess whether MCOs have been achieved or whether future matrix diffusion could potentially impact groundwater at levels above the MCOs.	4. The proper monitoring, assessment, and interpretation of data are expected to provide the necessary decision-making confidence to assess whether MCOs have been achieved or whether future matrix diffusion could potentially impact groundwater at levels above the MCOs. 5. Removal of contaminants by BVE at the ND-136 TTA is an irreversible process. 6. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.				which may require more reliance on MNA. Alt. 1 was assigned a score of 3 to reflect a larger role for desorption and back diffusion, which are the result of reversible processes (Figures 6-4, 6-5a, and 6-5b).
5d. Criterion Score	3	5	5	5	4	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5e. Types of Treatment Residuals	1. No treatment residuals will be produced with the MNA component of this alternative, provided proper conditions support the natural attenuation process. 2. As TCE degrades, intermediate degradation or daughter products such as cis- and trans-1,2-DCE and VC, may be produced and these contaminants have been previously identified in site groundwater. 3. These daughter products are degradable by biological and abiotic processes when the proper site conditions exist. 4. Complete degradation of TCE and the other organic COCs results in innocuous end products such as chloride and CO_2. 5. If natural attenuation is not complete, however, some of the daughter products could persist in groundwater. 6. Monitoring the formation and subsequent attenuation of these daughter products is an important element of an MNA remedy and performance monitoring.	1. No treatment residuals will be produced with the EISB and MNA component of this alternative. It is recognized that as TCE degrades, intermediate degradation ("daughter") products such as cis- and trans-1,2-DCE and VC, may be produced and have been previously identified in site groundwater. These daughter products are degradable by both biological and abiotic processes, provided the proper conditions exist at the site. Complete degradation of TCE and the other organic COCs results in innocuous end products such as chloride and CO_2. 2. Monitoring the formation and subsequent attenuation of these daughter products is an important element of the EISB and MNA remedy and performance monitoring. 3. Injection of emulsified oils could result in well fouling and reduction of hydraulic conductivity in treatment areas. 4. Spent activated carbon associated with BVE system operation will be	The types of treatment residuals evaluation for this alternative are expected to be identical to Alt. 2a.	1. Treatment residuals will be produced at the GETS and include the following: a) Spent bag filters (approximately 14 per month), b) Backwash tank settled solids (approximately one 20-gallon drum disposed of every quarter), c) Spent carbon transported offsite for reactivation (approximately 12,000 pounds per year), d) Spent single-use ion-exchange resin (approximately 2,000 pounds per year). These quantities are estimates based on total flow to the GETS. NASA's portion is assumed to be approximately 50%, with the other 50% coming from extraction wells on Boeing property. 2. All waste is managed offsite at an appropriately permitted waste management facility for disposal, treatment, or reactivation. 3. Treated groundwater will be discharged to injection well WS-5 and comply with the existing WDR permit. A portion of the treated effluent may be used for	1. One potential by-product of ISCO is the formation of manganese oxides in the subsurface. While these by-products do not create a waste residual that requires management, they can reduce hydraulic conductivity. 2. Bullet points 1, 2, 4, 5, and 6 under Alt. 2a apply to this alternative.	▪ The degradation components of Alt. 1 (MNA) and Alternatives 2a and 2b (EISB) can result in the accumulation of daughter products. In the cases of Alternatives 2a and 2b, these daughter products can be managed with proper monitoring and the application of reagents during the active treatment phase where the majority of contaminants are expected to be treated. ▪ With Alt. 1, these residuals will be more difficult to manage because active treatment is not employed, but the daughter products are still anticipated to degrade over time. ▪ With Alt. 4, residual manganese dioxide precipitant will form in the aquifer as part of the ISCO phase of treatment and is considered inert. Over time, this precipitant is expected to slowly redissolve into groundwater at concentrations below those that would be considered a regulatory concern. Depending on the oxidant used, potassium, sodium, and/or sulfate levels can remain in the TTA after active treatment is complete. Over time, these reagent products are

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	7. There is no difference in how this technology is evaluated between the three different source areas.	returned and regenerated by the carbon supplier. 5. Condensation water may be collected during colder months and require management as a contaminated waste. 6. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different source areas.		site dust suppression, particularly during the period when soil remediation is occurring. Discharge of treated water to a surface water body is considered less viable due to the potential changes that would be incurred in the receiving ecosystems and impacts on stream bed alteration. 4. A portion of the treated effluent may be used for site dust suppression, particularly during the period when soil remediation is occurring. Discharge of treated water to a surface water body is considered less viable due to the potential changes that would be incurred in the receiving ecosystems and impacts on stream bed alteration. 5. Similarly, spent activated carbon associated with BVE system operation will be returned and regenerated by the carbon supplier (approximately 6,000 pounds per year). 6. No treatment residuals will be produced with the MNA component of this alternative, provided proper conditions support the natural attenuation process. As TCE degrades, intermediate degradation or daughter products such as cis- and trans-1,2-DCE and VC may be produced and these contaminants have been previously identified in site groundwater. These daughter products are degradable by biological and abiotic processes when the proper site conditions exist. Complete degradation of TCE and the other organic COCs results in innocuous end products such as chloride and CO_2. 7. Monitoring the formation and subsequent attenuation of these		expected to attenuate, though the amount of time for this to occur is uncertain. ▪ Treatment reagents for Alternatives 2a, 2b, and 4 may reduce hydraulic conductivity in treatment areas. ▪ The P&T component of Alt. 3 will generate waste, as described above, which will be appropriately managed offsite. ▪ The BVE component of the four active treatment alternatives will generate spent activated carbon, which will be managed offsite. ▪ While Alt. 3 generates the largest amount of treatment residual, the majority of the residual can be physically collected and managed offsite compared to the other alternatives, for which the treatment residuals are generated in situ and cannot be physically recovered. ▪ Based on this discussion, Alt. 1 was assigned a score of 2, Alternatives 2a, 2b, and 4 were assigned as score of 3.5, and Alt. 3 was assigned a score of 4.5 (Figures 6-4, 6-5a, and 6-5b). While Alt. 3 creates more visible treatment residuals, they are easier to manage compared to those that may develop in situ.

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				daughter products is an important element of an MNA remedy and performance monitoring. 8. Bullet points 1, 2, 4, 5, and 6 under Alt. 2a apply to this alternative.		
5e. Criterion Score	2	4	4	4.5	3.5	N/A
5. Reduction in Toxicity, Mobility and Volume[b] 5f. Amount of Hazardous Constituents that will be Treated	The estimated mass of contaminants in each AIG was presented in Sections 2.3.1.2, 2.3.2.2, 2.3.3.2, and 2.3.4.2 (Nature and Extent of COCs). While estimating the amount of contaminant mass in the subsurface is difficult, it is anticipated that the organic COC mass will be reduced via biodegradation and other attenuation processes to levels that comply with the MCOs identified in 3-1.	The estimated mass of contaminants in each AIG was presented in Sections 2.3.1.2, 2.3.2.2, 2.3.3.2 and 2.3.4.2 (Nature and Extent of COCs). While estimating the amount of contaminant mass in the subsurface is difficult, it is anticipated that the organic COC mass will be reduced via biodegradation (EISB and MNA), physical removal (BVE), and other attenuation processes to levels that comply with MCOs identified in Table 3-1.	Same as Alt. 2a.	Same as Alt. 2a.	Due to concerns with oxidant persistence, this alternative may be less efficient in amount of mass that will be treated, compared to the other alternatives.	▪ The estimated mass of contaminants in each AIG was presented in Sections 2.3.1.2, 2.3.2.2, 2.3.3.2, and 2.3.4.2 (Nature and Extent of COCs). ▪ While estimating the amount of contaminant mass in the subsurface is difficult, it is anticipated that all the contaminant mass will be reduced to levels that comply with the MCOs identified in Table 3-1. ▪ Based on this information, all four active treatment alternatives were assigned high scores. Alternatives 2a, 2b, and 3 were assigned a score of 5 because of their ability to treat contaminants is considered comparable. Alt. 4 was assigned a score of 4 because of concerns about oxidant persistence and likely inability to affect as much treatment as the other active treatment alternatives. Alt. 1 was assigned a score of 1 because less treatment is employed (Figures 6-4, 6-5a, and 6-5b).
5f. Criterion Score	1	5	5	5	4	N/A
6. Short-term Effectiveness[c] 6a. Community Protection	1. The community will be protected during this phase of remedy implementation because there are no known complete COC pathways to the community. 2. LUCs will provide an extra measure of protection to the community. The length of time to maintain community protection is estimated to be 190 years for the ND-136A TTA, 360 years for the WS-09 TTA, and 270 years for the C-6 TTA	1. The community will be protected during this phase of remedy implementation because there are no known complete COC pathways to the community. 2. LUCs will provide an extra measure of protection to the community. The length of time for source treatment to achieve MCOs—assuming a 90% reduction is possible—is estimated to be 140 years for the ND-136A TTA,	Same as Alt. 2a.	This alternative involves the transportation of waste treatment residuals offsite. The waste will be appropriately labelled and stored at the until it is removed for offsite management. The wastes will be stored and disposed of in U.S. Department of Transportation-approved trucks and containers. Bullet points 2, 3, and 4 of Alt. 2a apply to this alternative.	The ISCO treatment reagents for this alternative are strong oxidants. These oxidants will be trucked to the site in U.S. Department of Transportation-approved trucks and containers. While onsite, these oxidants will be stored in areas with secondary containment to prevent the uncontrolled release of oxidants to the environment. Bullet points 2, 3, and 4 of Alt. 2a apply to this alternative.	▪ As presented above, each alternative was judged to be equally protective of the community. ▪ All five protect the community with LUCs. ▪ No complete COC pathways were identified for the community. ▪ The long time period needed to achieve MCOs should be considered in the LUCs and monitoring controls for these alternatives.

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Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	based on the modeling presented in Appendix B and Table 6-1. 3. The long time period needed to achieve MCOs should be considered in the LUCs and monitoring controls for this alternative. 4. There is no difference in how this technology is evaluated between the three different TTAs.	275 years for the WS-09 TTA, and 215 years for the C-6 TTA based on modeling completed for the Alfa, Bravo, and Delta AIGs, which have the highest starting concentrations. This reduces the estimated timeframe for achieving MCOs in the TTAs by 50, 85, and 55 years for the ND-136A, WS-09, and C-6 TTAs, respectively. The length of time to achieve MCOs could be reduced if greater source reduction becomes possible. However, given the complex hydrogeology at this site, a one order-of-magnitude reduction with active treatment is optimistic. 3. The long time period needed to achieve MCOs should be considered in the LUCs and monitoring controls for this alternative. 4. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.				▪ Based on this information, all five alternatives were assigned a score of 5 for this criterion (Figures 6-4, 6-5a, and 6-5b).
6a. Criterion Score	5	5	5	5	5	N/A
6. Short-term Effectiveness[c] 6b. Worker Protection	1. Workers will be protected during this phase of remedy implementation because all planning, implementation, and construction-related activities such as monitoring well construction will be completed under an approved health and safety plan. 2. Site workers will be monitored under an established medical monitoring program provided by their employer and will be properly trained in site management activities. 3. Regular safety briefings will be provided for onsite workers to remind them of potential safety risks at the site, such as biological risks (insects and snakes). The long	1. Workers will be protected during this phase of remedy implementation because all planning, implementation, and construction-related activities, such as injection/extraction well construction and EISB operations, will be completed under an approved health and safety plan. 2. In addition to the monitoring of this remedy, the construction and operation risks associated with this alternative include construction of the extraction wells for the BVE system and extraction/injection wells for the EISB system, along with system operations for all active treatment components of this alternative.	1. This alternative involves heating extracted groundwater prior to reinjection. The use of the heating process poses an incremental risk for workers beyond that described for Alt. 2a. However, these risks can be managed with appropriate updates to the health and safety plan and O&M plan. 2. Bullet points 3, 4, 5 and 6 for Alt. 2a apply to this alternative.	1. Operation of this alternatives involve workers being exposed to GETS treatment reagents, mechanical risks, and pressurized equipment. Workers will be protected during GETS remedy implementation because all planning, implementation, and construction-related activities such as extraction well construction will be completed under an approved health and safety plan. 2. Construction and operation risks associated with this alternative also include construction of the extraction wells and monitoring systems for the BVE treatment system, along with system	1. Operation of this alternatives involve workers being exposed to ISCO treatment reagents, mechanical risks, and pressurized equipment. 2. Workers will be protected during ISCO remedy implementation because all planning, implementation, and construction-related activities such as extraction well construction will be completed under an approved health and safety plan. 3. Bullets points 2, 3, 4, and 5 of Alt. 2a apply to this alternative.	▪ As presented above, each alternative has different operational elements. ▪ All five alternatives involve monitoring. All of the active treatment alternatives use BVE at the ND-136 source location, as well as different active treatment technologies, with groundwater. ▪ While each technology has unique variables, all remediation operations will be completed under an approved health and safety plan and use a properly trained work force. ▪ Project-related risks will be defined and activity hazard analysis for each element of work will be defined. The workers will also be trained to recognize risk and have the authority

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives

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Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	time period needed to achieve MCOs should be considered in the health and safety plan for this alternative. 4. While plans will be in place to maximize worker protection, this does not imply the work activities are risk-free. Accidents, such as slips, trips, falls, and biological hazard impacts do happen with even the best plans and training in place. 5. There is no difference in how this technology is evaluated between the three different TTAs.	3. Site workers will be monitored under an established medical monitoring program provided by their employer and will be properly trained in site management activities. 4. Regular safety briefings will be provided for onsite workers to remind them of potential safety risks at the site, such as biological risks (insects and snakes). The long time period needed to achieve MCOs should be considered in the health and safety plan for this alternative. 5. While plans will be in place to maximize worker protection, this does not imply the work activities are risk free. Accidents such as slips, trips, falls, biological hazard impacts, and accidents with machinery (e.g., recirculation system) happen even with the most comprehensive plans and training in place. 6. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.		operations for all active treatment components of this alternative. 3. Bullets points 3, 4, 5, and 6 apply to this alternative.		to stop operations if a risk is identified. ▪ While worker protection risks can be managed, they do not guarantee absolute worker protection. It is reasonable that more involved alternatives that use more mechanical and chemical reagents have greater risk potential. For these reasons, Alt. 3 was assigned the lowest score of 2, because it poses more work hazards due to the continued use of mechanical equipment and chemical reagents. Alternatives 4 and 2b were assigned a score of 3 because of the use of a chemical oxidant and heat, respectively; Alt. 2a was assigned a score of 3.5 since the treatment reagents pose less of hazard compared to Alternatives 3 and 4; and Alt. 1 was assigned a score of 4 (Figures 6-4, 6-5a, and 6-5b).
6b. Criterion Score	4	3.5	3	2	3	N/A
6. Short-term Effectiveness[c] 6c. Environmental Impacts	1. The DTSC Green Remediation Evaluation Matrix (GREM) was used to identify potential environmental impacts associated with implementing this alternative. 2. The GREM matrix includes multiple evaluation criteria for different stressors, specifically substance/release production, thermal releases, physical disturbances/disruptions, and resource depletion/gain. 3. Some of the criteria for each stressor was not applicable to this alternative. For those criteria considered applicable to this	1. Bullet points 1, 2, 3, and 5 of Alt. 1 apply to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered relatively low.	1. Bullet points 1, 2, 3, and 5 of Alt. 1 apply to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered relatively low.	1. Bullet points 1, 2, 3, and 5 of Alt. 1 apply to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered relatively high.	1. Bullet points 1, 2, 3, and 5 of Alt. 1 apply to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered relatively low.	▪ The GREM matrix includes multiple evaluation criteria for different stressors, specifically substance/release production, thermal releases, physical disturbances/disruptions, and resource depletion/gain. Some of the criteria for each stressor were not applicable to this alternative. For those criteria considered applicable to this alternative, a qualitative statement about this alternative for each criterion is provided and is presented in the GREM evaluation matrix presented in Appendix E1.

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives

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	alternative, a qualitative statement about this alternative for each criterion is presented in the GREM evaluation matrix in Appendix E1. 4. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered very low. 5. The GREM matrix also includes relative scoring, which is discussed further in the comparative analysis section below.					▪ With each qualitative statement, a relative score between 1 and 5 was assigned. A 1 was assigned to an alternative that represents the lowest impact for the subject criterion and 5 was assigned to a criterion for the highest impact. ▪ The scores for the other alternatives were then interpolated between these two scores. With each alternative have a criterion score, the total score could be added to provide insight into relative environmental impacts of each alternative. The lower the total score is, the lower the perceived environmental impact of the alternative is. The results presented in Appendix E1 indicate the environmental impacts associated with Alt. 1 are the lowest, as indicated by the lowest total score, so this alternative was assigned a score of 5. Environmental impacts associated with Alt. 3 are the highest, as indicated by the highest total score, so this alternative was assigned a score of 1. Alternatives 2a, 2b, and 4 are comparable and were assigned a score of 3. In general, Alt. 3 would have the greatest environmental impact because it uses the greatest amount of infrastructure and energy. Conversely, Alt. 1 had the lowest environmental impact because no active treatment is employed. The specific rationales for the scores are noted in the GREM in matrix in Appendix E1 and are summarized on Figures 6-4, 6-5a, and 6-5b.
6c. Criterion Score	5	3	3	1	3	N/A
7. Implementability[d] 7a. Construction and Operation	1. Within the first year, all LUCs will be put in place and monitored for effectiveness until MCOs (Table 3-1) are achieved. 2. MNA operations will be initiated at the completion of the CMD and	This alternative is considered constructible and operable. EISB treatment systems will be installed at the three groundwater TTAs. A new BVE system will be installed at ND-136 and construction of this system will be	The construction and operation of this alternative is identical to Alt. 2a, with the exception that a heating system will be included in this construction and operation of the remedy. This	This alternative is considered constructible and operable and much of the infrastructure is already in place.	This alternative is considered constructible and operable. • The ISCO systems will be constructed within 1 year of completing the CMD and operated for an estimated period	▪ All five alternatives are constructible and operable. ▪ The components of Alt. 1 are the easiest to construct and operate. The monitoring network is already in place, and a few additional

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
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Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	operate until cleanup objectives are achieved. 3. The MNA well network will be periodically evaluated to assess the appropriateness of the wells, frequency of analysis, and target analytes. 4. Monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved with MNA.	similar to the system used in the pilot studies. The implementation timeline for this alternative involves the following: 1. The EISB system will be constructed within 1 year of completion of the CMD and operated for an estimated period of 10 years; it is assumed the practical limits of EISB will have been achieved after 10 years of operation. An EISB pilot test will be in place at ND-136 in 2021 that could be expanded upon for full-scale ND-136 TTA treatment, if necessary. A new well is planned for the C-6 area that could be included in an EISB treatment system at the C-6 TTA. 2. The MNA well network will be periodically evaluated to assess the appropriateness of the wells, frequency of analysis, and target analytes. 3. Monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved. 4. Within the first year, all LUCs will be put in place and monitored for effectiveness until cleanup objectives are achieved. 5. The BVE treatment system will be installed within 1 year of the completion of the CMD and operated for an estimated 5 years; it is assumed the practical limits of BVE will have been achieved after 5 years of operation. A BVE pilot system is currently operating at the ND-136 TTA and it can be expanded if necessary. 6. The MNA operations will be initiated after the CMD is completed. MNA monitoring will be initiated before active treatment	addition is considered constructible and can be operated onsite.	The MNA system is a network of monitoring wells installed within and surrounding the treatment areas. The GETS is already constructed on Boeing's property and wells ND-136 and WS-09, two of the three wells needed to treat high TCE groundwater TTAs, are connected to the GETS. Adding the other well near C-6 will be similar to the process implemented for installing wells ND-136 and WS-09 (a new C-6 area well is planned to be installed in 2021 to support the Phase 1 groundwater CMI). However, NASA-specific flow restrictions to GETS may require other GETS interim measure wells to be taken offline to allow the new TTA P&T flow (e.g., HAR-7 and RD-41B). Based on NASA GETS well performance, it may be appropriate to have different extraction wells operate at different times, which may alleviate GETS capacity limitations. The implementation timeline for this alternative involves the following: ▪ Within the first year, all LUCs will be put into place and monitored for effectiveness until cleanup objectives are achieved. ▪ The P&T system will be constructed within 1 year of completing the CMD and operated for an estimated period of 10 years. Bullet points 2, 3, 4, 5, 6, and 8 for Alt. 2a apply to this alternative.	of 10 years; it is assumed the practical limits of ISCO will have been achieved after 10 years of operation. • Bullet points 2, 3, 4, 5, 6, 7, and 8 for Alt. 2a apply to this alternative.	monitoring wells, if any, are anticipated to be necessary. ▪ For Alt. 3, two of the three extraction wells (ND-136 and WS-09 TTAs) are already connected to the GETS interim measure treatment system and only one new extraction well (C-6 TTA) will need to be installed and connected to the treatment system. ▪ A BVE pilot system is operating at the ND-136 TTA and can be expanded if necessary. ▪ The infrastructure for Alternatives 2a and 4 will exist at the ND-136 TTA after the EISB pilot study system is constructed (the EISB and ISCO delivery system will be similar). The experience from constructing the pilot study system will be beneficial when constructing the EISB or ISCO remediation systems at other TTAs. ▪ Given the experience with operating the GETS interim measure treatment system at SSFL, the operation of Alt. 3 is implementable. ▪ Recirculation is being pilot tested using EISB at the ND-136 TTA and more will be learned about operating the EISB recirculation systems during the pilot study, which will also be applicable to ISCO recirculation technology. ▪ The heating element of Alt. 2b has not been deployed at SSFL, so there is uncertainty in its operability. ▪ As discussed in criterion 7d, the Delta Skim Pond in the C-6 TTA is in post closure care. Given that Alternatives 2a, 2b, and 4 involve construction of more wells than Alt. 3, the location of the Delta Skim Pond could inhibit optimal well placement for treatment. For this reason, these alternatives scored lower for the for the C-6 TTA, compared to the other two TTAs.

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Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
		operations and operate until cleanup objectives are achieved. 7. The location of the Delta Skim Pond and its PCP status could result in construction challenges for in situ treatment alternatives in the C-6 TTA. 8. With the exception of BVE treatment at the ND-136 TTA and the note in 7 above related to construction challenges, there is no difference in how this technology is evaluated between the three different TTAs.				For these reasons, Alternatives 1 and 3 were assigned a score of 5 for all three TTAs; for ND-136 and WS-09 TTAs, Alternatives 2a and 4 were assigned a score of 4, and Alt. 2b was assigned a score of 3.5; for the C-9 TTA, Alternatives 2a and 4 were assigned a score of 3, and Alt. 2b was assigned a score of 2.5 (Figures 6-4, 6-5a, and 6-5b).
7a. Criterion Score ND-136 and WS-09 TTA	5	4	3.5	5	4	N/A
7a. Criterion Score C-6 TTA	5	3	2.5	5	3	N/A
7. Implementability[d] 7b. Administrative Feasibility	The technologies used in this alternative are expected to be permitted, as the technologies are commonly implemented. All work will occur on NASA-administered property. However, this alternative is viewed to be unacceptable by regulatory agencies because active treatment is not performed.	The technologies used in this alternative are expected to be administratively feasible. NASA has implemented a BVE pilot study and plans to implement an EISB pilot study at the ND-136 TTA. All work will occur on NASA-administered property. The technologies employed with this alternative are proven in the remediation industry and have been deployed in the State of California. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.	The administrative feasibility of this alternative is identical to Alt. 2a, with the exception that a heating system will be included. While heating reinjection water is uncommon in the remediation industry, there are no foreseen administrative challenges to adding the heating process to Alt. 2a.	The technologies used in this alternative are expected to be administratively implementable. The P&T technology has been implemented at SSFL with the GETS interim measures. BVE pilot testing has also been implemented. All work will occur on NASA-administered property. Implementation of this alternative is considered administratively feasible. The technologies employed with this alternative are proven to work at SSFL. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.	The technologies used in this alternative are expected to be administratively feasible, as these technologies are commonly implemented. An ISCO pilot study was implemented for operation by Boeing, and a BVE pilot study was implemented for NASA. All work will occur within NASA-administered areas. This technology was administratively implementable for a pilot study at SSFL. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.	▪ BVE and P&T technologies have been implemented previously at SSFL. ▪ The EISB pilot study has been approved by DTSC and the LARWQCB and is currently being implemented. ▪ ISCO has been applied as part of the SSFL ISCO pilot study. ▪ The thermally assisted EISB technology has not been applied at SSFL but is a small variation on Alt. 2a that will be pilot tested. ▪ Alt. 1 is unlikely to be administratively implementable because active treatment is not employed at high concentration TCE areas and would not likely receive regulatory approval. For these reasons, all four alternatives employing active treatment were assigned a score of 5 and Alt. 1 was assigned a score of 1 (Figures 6-4, 6-5a, and 6-5b).
7b. Criterion Score	1	5	5	5	5	N/A

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7. Implementability[d] 7c. Availability of Services and Materials	The technology materials and services associated with implementing this alternative are readily available.	The technology materials and services associated with implementing this alternative are readily available.	The services and materials for this alternative are identical to Alt. 2a, with the exception that a heating system will be included. The heating system is commercially available.	The technology materials and services associated with implementing this alternative are readily available.	The technology materials and services associated with implementing this alternative are readily available.	▪ All five alternatives use technology components that are commonly used and available in southern California. ▪ No challenges are expected with acquiring the services or materials to construct and operate the five different alternatives. All five alternatives and their associated technology components were considered in assigning the same score of 5 with respect to this criterion (Figures 6-4, 6-5a, and 6-5b).
7c. Criterion Score	5	5	5	5	5	N/A
7. Implementability[d] 7d. Permitting	The implementation of MNA and LUCs is common at cleanup sites. In California, LUCs are implemented through Land Use Agreements; implementing a Land Use Agreement is not expected to be difficult. MNA would be documented in the approved work plan and the CMI. Federal, state and local laws described in Section 3.4 will be followed. In addition, obtaining permits (e.g., new well installation is necessary) to implement this remedy is not expected to be difficult.	1. The implementation of MNA and LUCs is common at cleanup sites. In California, LUCs are implemented through Land Use Agreements; implementing a Land Use Agreement is not expected to be difficult. MNA would be documented in the approved work plan and the CMI. Federal, state, and local laws described in Section 3.4 will be followed, including possible LARWQCB permits, and VCAPCD permits for BVE. 2. Technology-specific requirements apply to the BVE and EISB technologies, as well as the requirements discussed in Section 3.4. 3. The BVE technology is subject to air quality requirements limiting emissions. Vapor-phase GAC change-outs and condensate management are subject to hazardous waste management requirements. The solar array and battery used to power the BVE system must be permitted by Ventura County Fire Department. Similarly, the EISB technology will comply with the following: a. Installation of new extraction and injection wells.	The permitting of this alternative is identical to Alt. 2a, with the exception that a heating system will be included in this construction and operation of the remedy. The WDR permit will need to address the addition of heat to reinjected groundwater. No permitting challenges are anticipated for Alt. 2b.	The GETS is already permitted. The GETS can accommodate additional flow provided the system has capacity. Permitting of new extraction wells will be necessary. MNA would be documented in the approved work plan and the CMI. Federal, state, and local laws described in Section 3.4 will be followed, including possible LARWQCB permits such as WDR and possible VCAPCD permits for BVE. Because permits for the installation of GETS and BVE have been granted as part of past work at this site, they are expected to be granted for this remedy. Bullet points 3, 4, and 6 under Alt. 2a apply to this alternative.	The ISCO technology has previously been implemented by Boeing for a pilot study at SSFL. Similar permitting requirements implemented for the pilot study would be applicable to this project (e.g., well construction permits, WDR permit). Bullet points 3, 4, and 6 under Alt. 2a apply to this alternative.	▪ BVE, ISCO, EISB, and P&T technologies have been implemented previously at SSFL. ▪ New wells necessary for active remediation or monitoring are expected to be permitted, similar to past well permits have been approved at SSFL. ▪ There are no expected obstacles to permitting any of the alternatives. ▪ The Delta Skim Pond is currently in post-closure care under a Hazardous Waste Facility PCP (Number PC-94/95-3-03; DTSC, 2013) as discussed in Section 2.1. NASA will work with DTSC to address how this alternative could be implemented in the C-6 TTA without impacting the status of that permit. All five alternatives and their associated technology components were considered to score the same with respect to this criterion and were assigned a score of 5 (Figures 6-4, 6-5a, and 6-5b).

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		b. Any applicable RCRA permitting for the treatment technology. c. Protection of surface and groundwater requirements, including possible LARWQCB permits such as WDR. d. Protection of the air shed, including possible VCAPCD permits for discharges from vapor extraction systems. 4. Permits for the BVE and EISB systems have been granted for pilot study work. 5. The Delta Skim Pond is currently in post-closure care under a Hazardous Waste Facility PCP (Number PC-94/95-3-03; DTSC, 2013) as discussed in Section 2.1. NASA will work with DTSC to address how this alternative could be implemented in the C-6 TTA without impacting the status of that permit. 6. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.				
7d. Criterion Score	5	5	5	5	5	N/A
8. Cost	1. The total capital cost to implement this alternative is $220,000. This cost includes development of an MNA and LUC plan. 2. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Tables 6-3 and 6-5 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-1. 3. As stated in Section 6.2.8, costs were evaluated over a 30-year timeframe. Annual monitoring and LUC costs were estimated at approximately $317,470, for a 30-year present value of $7.1	1. The total capital cost to implement this alternative is estimated at approximately $11.4 million for the WS-09 and C-6 TTA. Construction for the ND-136 TTA is completed and not included in capital costs. 2. This cost includes development of an MNA and LUC plan, installation of the EISB recirculation system (injection/extraction network, recirculation network, dosing equipment) at each source groundwater TTA, and implementation of the BVE treatment systems at ND-136.	1. The cost summary for Alt. 2b is identical to Alt. 2a with the exception that costs for heating water prior to injection and monitoring temperature in the TTA are included in this alternative. This results in an approximately $3.3 million increase in capital costs ($14.6 million) and $0.7 million increase in life-cycle O&M costs ($20 million), for a total of 10 years of the thermally assisted EISB system. 2. Annual O&M costs are detailed in Appendix G-1 for this alternative and vary by year. The total	1. The total capital cost to implement this alternative is estimated at approximately $1.4 million. 2. This cost includes development of an MNA and LUC plan, installation of a new extraction well and conveyance line for the C-6 TTA, and implementation of the BVE treatment systems at the ND-136 TTA. The extraction wells and conveyance lines for the ND-136 TTA and WS-09 TTA have already been constructed. 3. Annual O&M costs include long-term monitoring of groundwater	1. The total capital cost to implement this alternative is estimated at approximately $11.6 million for the WS-09 and C-6 TTA. Construction costs for the ND-136 TTA are not included in this cost because this alternative can use the EISB pilot study infrastructure already in place. 2. This cost includes development of an MNA and LUC plan, installation of the ISCO recirculation system (injection/extraction network, recirculation network, dosing equipment) at each source groundwater TTA, and implementation of the BVE	Capital Costs • Capital costs for the five alternatives are summarized in Table 6-11. • Capital costs for Alternatives 2a and 4 are comparable as they are based on similar configurations for the delivery of treatment reagents. Alt. 4 is significantly more expensive due to additional costs associated with heating. • Alt. 3 has significantly lower capital costs than the other active treatment alternatives because the infrastructure is already in place at two of the TTAs and the cost to

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	million attributable to monitoring natural attenuation and LUC management. 4. The total 30-year life-cycle cost for this alternative is estimated at approximately $7.3 million . These alternative costs are detailed in Appendix G-1. 5. These costs are considered conceptual only. It is typical to apply a plus 50% and minus 30% to conceptual costs to represent uncertainty related to conceptual estimates. More detailed information on this cost estimate is presented in Appendix G-1.	3. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Tables 6-3 through 6-5 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-1. Other annual O&M costs include reapplication of EISB treatment reagent at years 4 and 7, well maintenance and pump replacement at year 5, carbon replacement for the BVE systems, and energy costs (line power for EISB and solar power for the BVE system) to operate the systems. 4. Costs were evaluated over a 30-year time frame. It has been assumed the EISB component of this alternative would operate for 10 years, the BVE system would operate for 5 years, and monitoring and LUC inspections would occur for 30 years. 5. Annual O&M costs are detailed in Appendix G-1 for this alternative and vary by year. The total present value O&M for 30 years is approximately $19.2 million, of which approximately $7.1 million is attributable to monitoring natural attenuation and LUC management, and BVE operations is $7.7 million. 6. The total 30-year life-cycle cost for this alternative is estimated at approximately $30.6 million . These alternative costs are detailed in Appendix G-1. 7. Based on system performance the rate of reapplication of treatment reagents could be more frequent (if adequate substrate is not available for the microbes) or less frequent (if the microbes can effectively reduce contaminant concentrations with less frequent reagent application). Also, treatment beyond 10 years may be warranted if contaminant concentrations in	present value O&M for 30 years is approximately $20 million, of which approximately $7.1 million is attributable to monitoring natural attenuation and LUC management and BVE operations is $7.7 million. 3. The total 30-year life-cycle cost for this alternative is estimated at approximately $34.6 million . These alternative costs are detailed in Appendix G-1.	at the wells identified in Tables 6-3 through 6-5 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-1. 4. Other annual O&M costs energy costs to operate the extraction wells, annual costs for treatment of groundwater at the GETS costs, and carbon replacement for the BVE systems. 5. Costs were evaluated over a 30-year time frame. It has been assumed the P&T component of this alternative would operate for 10 years, the BVE system would operate for 5 years, and monitoring and LUC inspections would occur for 30 years. 6. Annual O&M costs are detailed in Appendix G-1 for this alternative and vary by year. The total present value O&M for 30 years is approximately $18.8 million, of which approximately $7.1 million is attributable to monitoring natural attenuation and LUC management and BVE operations is $7.7 million. 7. The total 30-year life-cycle cost for this alternative is estimated at approximately $20.2 million . These alternative costs are detailed in Appendix G-1. 8. The greatest contributor to cost uncertainty is the effectiveness of the P&T technology in removing contaminant mass. As the P&T technology is deployed primarily for mass removal in the TTAs, the focus of treatment should be on optimizing contaminant mass removal. This could involve pulsed pumping if it can be demonstrated this mode of operation could remove the same amount of mass as continuous pumping (provided unacceptable	treatment systems at the ND-136 TTA. 3. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Tables 6-3 through 6-5 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-1. 4. Other annual O&M costs include reapplication of ISCO treatment reagent every year for 10 years, well maintenance and pump replacement at year 5, carbon replacement for the BVE systems, and energy costs to operate the systems. 5. Costs were evaluated over a 30-year time frame. It has been assumed the ISCO component of this alternative would operate for 10 years, the BVE system would operate for 5 years, and monitoring and LUC inspections would occur for 30 years. 6. Annual O&M costs are detailed in Appendix G-1 for this alternative and vary by year. The total present value O&M for 30 years is approximately $19.9 million, of which approximately $7.1 million is attributable to monitoring natural attenuation and LUC management and BVE operations is $7.7 million. 7. The total 30-year life-cycle cost for this alternative is estimated at approximately $31.6 million . These alternative costs are detailed in Appendix G-1. 8. The greatest contributor to cost uncertainty is the frequency of reapplication of treatment reagents. It has been assumed that treatment reagents would be applied every year. However, the pilot study completed at SSFL showed very low persistence of	construction an extraction well and transmission line to GETS is significantly less expensive than constructing new EISB and ISCO treatment locations. • Alt. 1 is the lowest cost alternative as the monitoring network is already established for the TTAs. However, additional monitoring wells may be required in the future. Based on these capital costs, Alt. 1 was assigned a score of 5, Alt. 3 was assigned a score of 4.5, Alternatives 2a and 4 were assigned a score of 2, and Alt. 2b was assigned a score of 1 (Figures 6-4, 6-5a, and 6-5b). O&M • Alt. 1 has the lowest O&M costs as only monitoring and LUC management is included. • Alternatives 2a and 3 had comparable O&M costs, as did Alternatives 2b and 4. Based on these costs, Alt. 1 was assigned a score of 5, Alternatives 2a and 3 were assigned a score of 3, and Alternatives 2b and 4 were assigned a score of 2 (Figures 6-4, 6-5a, and 6-5b).

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
		one or more TTAs rebound. Conversely, if the rate of back diffusion is very low, one application of treatment reagent may be all that is needed. 8. For BVE treatment, while the time of operation has been assumed to be 5 years, this time could be shorter if the rate of back diffusion of contaminants from the rock matrix into the BVE extraction field is low or longer if the rate of back diffusion is higher. 9. Bullet point 1 for Alt. 1 applies to this alternative.		concentrations of COCs do not migrate downgradient during the period when extraction is not occurring). The scheduled for pulsed pumping will depend on the rate of back diffusion and the amount of pore volume turnover in the TTA, which are currently unknown variable. Also, if the rate of back diffusion is high, a period of treatment longer than 10 years may be required. 9. Bullet point 1 for Alt. 1 applies to this alternative. 10. Bullet point 8 of Alt. 2a applies to this alternative.	the oxidant after treatment. Depending on the rate of back diffusion of COCs from the rock matrix into the target treatment zone, more frequent applications may be required. This would be a substantial cost as the oxidant reagent is rather expensive (refer to Appendix G-1). However, if the rate of back diffusion is low and pore volume replacement is frequent, annual applications could be considered reasonable. 9. Bullet point 1 for Alt. 1 applies to this alternative. 10. Bullet point 8 of Alt. 2a applies to this alternative.	
8. Criterion Score – Capital Costs	5	2	1	4.5	2	N/A
8. Criterion Score – O&M Costs	5	3	2	3	2	N/A
9. Community Acceptance	This criterion cannot be assessed until the alternatives have been presented to the community.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	N/A
10. State Acceptance	This criterion cannot be assessed until the alternatives have been reviewed by the state.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	N/A
11. Adaptive Management	1. If future offsite migration of groundwater plumes is observed and is considered attributable to ineffective natural attenuation of the TTA, NASA will develop a contingency remedy to address offsite migration as part of the adaptive site management process. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA. 2. The MNA well network and groundwater monitoring constituent list will be periodically evaluated to assess the appropriateness of the wells, frequency of analysis, and target analytes.	1. Bullet points 1 through 4 for Alt. 1 apply to the MNA and LUC components of this alternative. 2. Monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved. 3. The performance of the BVE component of the alternative will assess mass removal in accordance with project metrics. 4. If project metrics are not achieved, optimization opportunities will be evaluated. If optimization alternatives are not feasible or successful, a shutdown of active treatment components, as described in Section 6.1.9	The evaluation of Alt. 2a applies to this alternative. As this alternative involves heating groundwater before injection, the adaptive management component will assess the ability of this alternative to increase the temperature of groundwater and the corresponding benefit.	Bullet points 1, 2, and 3 for Alt. 2a apply to this alternative. Additionally, monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved.	Bullet points 1, 2, and 3 for Alt. 2a apply to this alternative. Additionally, monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved.	N/A

Table 6-8. Detailed and Comparative Analysis of Phase 1 Groundwater Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. 1. MNA and LUCs	Alt. 2a. Groundwater treatment using EISB followed by MNA, BVE for soil vapor, and LUCs	Alt. 2b. Groundwater treatment using EISB with thermal heating followed by MNA, BVE for soil vapor, and LUCs	Alt. 3. Groundwater treatment using P&T followed by MNA, BVE for soil vapor, and LUCs	Alt. 4. Groundwater treatment using ISCO followed by MNA, BVE for soil vapor, and LUCs	Comparative Analysis
	3. Performance monitoring data will be evaluated to assess whether concentration reductions are occurring. The process by which data are collected and evaluated, and the subsequent decisions from this activity, will be documented in the design for the remedy. 4. Results of LUC inspections will be routinely evaluated to determine if LUCs are sufficiently protective of human receptors in the TTAs.	(Adaptive Site Management), will be pursued. 5. The performance of the EISB component of the alternative will assess mass removal in accordance with project metrics. A field-scale pilot study is currently being implemented at ND-136. If this technology is not successful in achieving project metrics, NASA will consider returning to GETS interim measure pumping or using a monitoring-only strategy. The adaptive site management strategy described in Section 6.1.9 will be used for this evaluation and to define metrics for ceasing active treatment operations. 6. With the exception of BVE treatment at the ND-136 TTA, there is no difference in how this technology is evaluated between the three different TTAs.				

[a] The period for this Criterion 4 begins when the remedy is determined to be operating properly and successfully and ends when MCOs have been achieved. The time of remediation estimates for this alternative are listed in Criterion 2 "Attain Media Cleanup Standards."

[b] Remedies should reduce the toxicity, mobility, and/or volume of COCs.

[c] Short-term effectiveness is generally considered the period between the start of remedy implementation and the time at which the remedy is determined to be operating properly and successfully.

[d] Implementability addresses the technical and administrative feasibility of implementing the alternative and the availability of services and materials necessary to implement and operate the remedy.

μg/m^3 = microgram(s) per cubic meter
AIG = area of impacted groundwater
Alt. = Alternative
Boeing = The Boeing Company
BVE = bedrock vapor extraction
CO_2 = carbon dioxide
CMD = corrective measures design
CMS = corrective measures study
COC = chemical of concern
DCE = dichloroethene
DTSC = California Department of Toxic Substances Control
EISB = enhanced in situ bioremediation
ERD = enhanced reductive dechlorination
ESAAP = Environmentally Sensitive Area Action Plan
GAC = granular activated carbon
GETS = groundwater extraction treatment system
GREM = Green Remediation Evaluation Matrix
ISCO = in situ chemical oxidation
LARWQCB = California Regional Water Quality Control Board, Los Angeles Region
LUC = land use control
MCO = media cleanup objective
MNA = monitored natural attenuation
NASA = National Aeronautics and Space Administration
O&M = operation and maintenance
P&T = pump and treat
PCP = Post-Closure Permit
RCRA = Resource Conservation and Recovery Act of 1976
SSFL = Santa Susana Field Laboratory
TCE = trichloroethene
TTA = target treatment area
VC = vinyl chloride
VCAPCD = Ventura County Air Pollution Control District
WDR = waste discharge requirement

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Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
1. Protection of Human Health and Environment	**Northern Seep Area – Protective** **1.** No HHRA COCs or ecological risk assessment COECs were identified for the seeps and springs medium. **2.** While some Phase 1 COCs were detected in seep sample locations north of B204/ELV, these concentrations were below their MCOs (NASA 2020a) and were not associated with human health or ecological risk COCs (NASA 2020g [in progress]). **3.** Groundwater COCs have not reached, and are not expected to reach, the B204/ELV AIG-related seeps at concentrations above the MCOs in Table 3.1 (NASA 2020a). **4.** Northern Seep Area is considered protective of human health and the environment because there are no unacceptable human health and ecological risks. **5.** However, this alternative is included in this Phase 1 groundwater CMS as a contingency in case concentrations increase in the future. **Southern Seep Area – Protective** **1.** There are no unacceptable risks in the seeps and springs in the Southern Seep Area, and no HHRA COCs or ecological risk assessment COECs were identified for the seeps and springs medium.	**Northern Seep Area – Protective (should implementation be necessary)** 1. Bullet points 1 through 4 for Alt. SP-1 apply to this alternative. Based on this information, this alternative is considered protective of human health and the environment should its implementation be necessary. **2.** This contingency treatment alternative is included in this Phase 1 groundwater CMS in case concentrations increase in the future. **3.** Should groundwater COCs be observed at unacceptable levels in the future, this alternative could be implemented through an adaptive management process and would be expected to prevent further migration of site contaminants to the seep locations. **Southern Seep Area – Protective** 1. Bullet points 1 through 7 under Alt. SP-1 for the Southern Seep Area apply to this alternative. 2. Hydraulic containment is expected to minimize the contaminant migration at the location of the planned extraction well (Figure 4-3) and is expected to be protective of human health.	This technology has the potential to mobilize dissolved natural iron, manganese, and arsenic, which could create an unacceptable ecological and aesthetic risk. **Northern Seep Area – Protective (should implementation be necessary)** 1. Bullet points 1 through 4 for Alt. SP-1 apply to this alternative. Based on this information, this alternative is considered protective of human health and the environment should its implementation be necessary. **2.** This contingency treatment alternative is included in this Phase 1 groundwater CMS in case concentrations increase in the future. **3.** Should groundwater COCs be observed at unacceptable levels in the future, this alternative could be implemented through an adaptive management process and would be expected to prevent further migration of site contaminants to the seep locations. **Southern Seep Area – Protective** 1. Bullet points 1 through 7 under Alt. SP-1 for the South Seep Area apply to this alternative. 2. EISB technology is expected to facilitate contaminant degradation and reduce downgradient contaminant concentrations to levels protective of human health, as groundwater passes through a zone in which reagents or	**Northern Seep Area:** All three alternatives are protective of human health and the environment. However, Alt. SP-3 has the potential to mobilize dissolved natural iron, manganese, and arsenic, which could create an unacceptable ecological risk. For this reason, Alt. SP-3 was assigned a score of 3, and the other alternatives were assigned a score of 5 (Figures 6-6 and 6-7). **Southern Seep Area:** Alt. SP-3 has the potential to mobilize dissolved natural iron, manganese, and arsenic, which could create an unacceptable ecological risk. For this reason, Alt. SP-3 was assigned a score of 3, and the other alternatives were assigned a score of 5 (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	2. MCO exceedances of TCE, cis-1,2-DCE, trans-1,2-DCE, and VC were identified in shallow groundwater seep wells south of the Coca/Delta AIG, potentially along a COC migration pathway originating from Boeing Area III sources and NASA Coca/Delta AIG source areas. **3.** The highest concentrations reported were in the SP-890 seep well cluster in the southern areas of the NASA Delta Area, north of the Burro Flats Fault Zone. Concentrations decrease down-drainage, with COCs below MCOs a short distance south of the Burro Flats Fault Zone (NASA 2020a). However, this alternative does not address seep and seep well clusters south of the NASA-administered property boundary on Boeing property. 4. No analytes in surface water collected from seeps downgradient of the Coca/Delta AIG were retained as human health or COECs. 5. Based on this information, there is no risk related to seep water and, therefore, this alternative is likely protective of human health and environment. 6. Treatment in the Delta Area C-6 TTA and operating GETS interim measure well at HAR-07 may reduce contaminant concentrations downgradient in the NSGW, but it is		amendments of EISB have been injected creating a permeable treatment zone.	

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	uncertain when this benefit will be realized. The remediation time estimates in Table 6-1 are based on achieving MCOs in the C-6 TTA; it is anticipated the plume will contract at a time sooner than this, though the specific timeframe is uncertain.			
1. Criterion Score NSA	5	5	3	N/A
1. Criterion Score SSA	5	5	3	N/A
2. Attain Media Cleanup Standards[a]	**Northern Seep Area** 1. The human and ecological risk assessments concluded there are no unacceptable risks at the Northern Seep Area and, therefore, the MCOs in Table 3-1 have been achieved. 2. This alternative is also evaluated against the goal of cleaning up the area to background levels. This alternative may achieve background concentrations; however, the length of time to achieve background has not been estimated. 3. The areas of compliance for this alternative are the locations where seeps are expressed, and the seep monitoring locations presented in Table 6-2. **Southern Seep Area** **1.** Several COCs exceed MCOs in seep well shallow groundwater. This alternative is	**Northern Seep Area** 1. It is uncertain when this alternative could achieve background concentrations. 2. The ability to achieve background will be based on proper placement of extraction wells. 3. Even if extraction wells are properly placed, it will be difficult to determine if any concentrations downgradient of the TTA are the result of inefficient hydraulic control or back diffusion from the aquifer material downgradient of the TTA. 4. The points of compliance for this alternative are the locations of the seeps and springs in the Northern Seep Area (Table 6-3). 5. The length of time of operation for this alternative is uncertain. As long as there are contaminants above background levels in groundwater upgradient, there will be a potential for contaminants to exceed	This technology has the potential to mobilize dissolved natural iron, manganese, and arsenic, which could create an unacceptable ecological risk. **Northern Seep Area** 1. Bullet points 1, 4, and 5 under Alt. SP-2 for the Northern Seep Area applies to this alternative. 2. This alternative may achieve background concentrations but the length of time it takes to achieve such treatment is uncertain and dependent on the distribution of EISB treatment reagents. 3. The ability to achieve background concentrations will be based on proper placement of EISB injection wells. 4. Even if injection wells are properly placed, it will be difficult to determine if any concentrations downgradient of the TTA are the result of inefficient	**Northern Seep Area:** COC concentrations are below MCOs in the Northern Seep Area. However, it is uncertain if the three technologies could achieve cleanup to background levels. Alternatives SP-2 and SP-3 are better suited to this challenge because they employ active treatment, although Alt. SP-3 will have limited effectiveness in groundwater with low COC concentrations. Considering that the Northern Seep Area COC concentrations are below MCOs and achieving background is uncertain, Alt. SP-2 appears to be best suited to achieve cleanup objective; however, even the success of this alternative is highly uncertain. Alt. SP-3 may result in the migration of natural metals such as iron, manganese, and arsenic, which could cause additional concerns. Given these challenges, Alt. SP-2 was assigned a score of 3, Alt. SP-1 was

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	unlikely to achieve NSGW MCOs in the future if treatment at the Delta C-6 TTA, GETS interim measure groundwater extraction well HAR-07 and ND-138A, treatment of groundwater in Area III by Boeing, natural attenuation, and/or other potential Phase 2 groundwater CMS cleanup actions do not reduce upgradient MCO concentrations to the degree where MCOs can be achieved in the Southern Seep Area. **2.** The time to achieve background concentrations could be considerably longer. The point of compliance for this alternative are locations where seeps and springs discharge in the Southern Seep Area. 3. The areas of compliance for this alternative are the locations where seeps are expressed in the SP-890 area in NASA-administered areas and the seep monitoring locations presented in Table 6-6.	background levels in the Northern Seep Area. For the purposes of this CMS, it has been assumed that hydraulic containment would be needed for 10 years. **Southern Seep Area** 1. It is uncertain when this alternative could achieve MCOs or background concentrations, if it is possible. 2. Bullet points 2 and 3 for the Northern Seep Area apply to this alternative. **3.** The system should maintain MCO compliance as long as the hydraulic control remedy is operating successfully, up to a time in the future when it is no longer necessary. **4.** That time will be based on future treatment at the Delta C-6 TTA, GETS interim measure groundwater extraction well HAR-07 and ND-138A, treatment of groundwater in Area III by Boeing, and other potential Phase 2 groundwater CMS cleanup actions to reduce upgradient MCO concentrations in shallow groundwater to the degree where MCOs can be achieved in the Southern Seep Area without further operation of this alternative. **5.** The points of compliance for this alternative are the locations where seeps are expressed in the SP-890 area in NASA-administered areas and the seep monitoring locations presented in Table 6-6.	hydraulic control and reagent distribution or back diffusion from the aquifer material downgradient of the TTA. 5. The EISB technology is challenged when concentrations are already low (e.g., less than 10 μg/L) because, in the case of halorespiring bacteria, elevated concentrations of chlorinated ethenes are required to create a critical mass of microbes that can degrade the contaminants. 6. It is uncertain how effective the technology will be with low chlorinated ethene concentrations; therefore, a bench-scale test, or pilot study, may be warranted to assess low concentration groundwater treatment before full-scale implementation of this alternative. **Southern Seep Area** 1. Bullet points 1, 4, and 5 under Alt. SP-2 for the Southern Seep Area applies to this alternative. **2.** Bullet points 3, 4, 5, and 6 for the Northern Seep Area under Alt. SP-3 apply to this alternative. **3.** The EISB technology is expected to perform better in this location compared to the Northern Seep Area, because COC concentrations are higher.	assigned a score of 1, and Alt. SP-3 was assigned a score of 2 (Figures 6-6 and 6-7). **Southern Seep Area:** The MCOs for several COCs are exceeded in shallow groundwater in this area (but not reported in seep water). All three alternatives are expected to achieve MCOs; however, the length of time to achieve MCOs with Alt. SP-1 is likely much longer. Alt. SP-3 may result in the migration of natural metals such as iron, manganese, and arsenic, which could cause additional concerns. With respect to achieving background concentrations, the same rationale described for the Northern Seep Area applies to the Southern Seep Area. Given these challenges, Alt. SP-2 was assigned a score of 3, Alt. SP-1 was assigned a score of 1, and Alt. SP-3 was assigned a score of 2 (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
		6. For the purposes of this groundwater CMS, it has been assumed that hydraulic containment would be needed for 10 years.		
2. Criterion Score NSA	1	3	2	N/A
2. Criterion Score SSA	1	3	2	N/A
3. Remediation Source Releases	**Northern Seep Area:** The sources of seep contamination will be addressed in the Phase 2 groundwater CMS. **Southern Seep Area:** One source of the Southern Seep Area is the C-6 TTA, which is addressed in this Phase 1 groundwater CMS. Other potential sources will be addressed in the Phase 2 groundwater CMS or separately by Boeing for contributing Area III sources.	Same as Alt. SP-1.	Same as Alt. SP-1.	**Northern Seep Area:** The sources of seep contamination will be addressed in the Phase 2 groundwater CMS. **Southern Seep Area:** One source of the Southern Seep Area is C-6 TTA, which is addressed in this Phase 1 groundwater CMS. Other potential sources will be addressed in the Phase 2 groundwater CMS or separately by Boeing for contributing Area III sources. Because the sources of the seeps will be addressed in the Phase 2 groundwater CMS, this criterion was not scored.
3. Criterion Score NSA	N/A	N/A	N/A	N/A
3. Criterion Score SSA	N/A	N/A	N/A	N/A
4. Long-term Effectiveness[b] 4a. Reliability	**Evaluation applicable to Northern and Southern Seep Areas** 1. Deed restrictions and signage are proven and reliable long-term LUCs. Periodic inspections of signs will be performed to verify they are properly maintained. Replacement or	**Evaluation applicable to Northern and Southern Seep Areas** 1. Bullet points 1-4 under the evaluation applicable to the northern and southern seep areas for Alt. SP-1 applies to this alternative.	**Evaluation applicable to Northern and Southern Seep Areas** 1. Bullet points 1-4 under the evaluation applicable to the northern and southern seep areas for Alternative SP-1 applies to this alternative.	**Northern Seep Area:** Currently, MNA is effectively attenuating contaminants, given concentrations are below the MCOs shown in Table 3-1. It is uncertain if any of the alternatives can achieve background concentrations. Alt. SP-2 was considered to be the most reliable of the alternatives with

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	maintenance of signs will occur as necessary. 2. The deed restrictions involving water usage at the site will also be periodically evaluated for effectiveness. 3. The MNA component will provide ongoing information on the progress of the remedy and potential plume migration. This information will help protect human health by showing how the plume changes over time and could potentially trigger future action if unexpected changes to plume migration pathways could affect human health. 4. The MNA monitoring network will be periodically evaluated to assess whether the data being collected are necessary and appropriate. The assessment may entail future additions or subtractions of monitoring well locations, changing monitoring frequency, and changing analytes targeted for analysis. **Northern Seep Area:** 1. If this alternative is necessary, the MNA component of this remedy is expected to continue to attenuate the COCs identified in groundwater at this site and result in concentrations continuing to stay below MCOs. 2. Concentrations of several COCs have been detected below MCOs in the seep	2. As part of the design, an O&M plan will be prepared and implemented to assure extraction wells are properly maintained. 3. Performance monitoring samples will be collected to monitor the progress of contaminant removal with hydraulic containment operations. 4. Groundwater extracted from the seep areas will be treated at the Boeing GETS, and O&M for that system will be managed by Boeing. **Northern Seep Areas** **1.** If this remedy is implemented in the Northern Seep Area (as this is a contingency remedy for the Northern Seep Area), the operating period for hydraulic control is assumed to be 10 years. **2.** However, if performance testing indicates that longer operational timeframes are beneficial, it is likely the system will continue to operate until upgradient background groundwater concentrations or MCOs are met. **3.** The technology described in Section 6.1.5 for hydraulic containment is considered reliable, provided the extraction wells are placed in the proper location. **Southern Seep Area** **1.** The confidence in being able to accomplish treatment goals in the Southern Seep Area is higher than the Northern Seep Area.	**Northern Seep Areas** **2.** If this remedy is implemented in the Northern Seep Area (as this is a contingency remedy for the Northern Seep Area), the operating period for EISB is assumed to be 10 years. **3.** The technology described in Section 6.1.6 for EISB is considered reliable, provided the EISB injection system is placed in the proper location and it is accessible. 4. Access to optimal treatment system locations is challenging in this portion of SSFL due to the rugged terrain. **5.** Bullet point 2 under the Northern Seep Area evaluation for Alt. SP-2 applies to this alternative. **6.** EISB technology is challenged when concentrations are already low because, in the case of halorespiring bacteria, elevated concentrations of chlorinated ethenes are required to create a critical mass of microbes that can degrade the contaminants. Therefore, the lower contaminant concentrations in the Northern Seep Area could challenge the reliability of this technology in that area. **7.** Typically, EISB applications require supplemental injections. As long as the treatment system remains operational, this system is expected to operate effectively for 10 years.	a score of 4; the greatest challenge with this alternative is the proper placement of the extraction wells. Alternatives SP-3 and SP-1 were considered comparable with respect to reliability. While Alt. SP-3 employs active treatment, the ability of the technology to create an effective treatment zone with such low COC concentrations, and the potential makes this alternative equivalent to Alt. SP-1. Based on this, Alternatives SP-1, SP-2, and SP-3 were assigned scores of 3, 4, and 3, respectively. These scores represent achieving MCOs, which all the alternatives do, and background concentrations, which will be much more challenging (Figures 6-6 and 6-7). **Southern Seep Area:** Alt. SP-1 will not achieve MCOs or lower levels in shallow groundwater until upgradient groundwater is addressed; therefore, Alt. SP-1 was assigned a score of 1. Alt. SP-2 was assigned a score of 5 because preliminary information indicates a hydraulic connection between extraction well ND-138A and the SP-890 well cluster. Alt. SP-3 was assigned a score of 3 because, while concentrations are higher in this location (compared to the Northern Seep Area), the ability to achieve an EISB treatment zone is less certain. These scores represent achieving MCOs, which all the alternatives do, and background concentrations, which will be much more challenging (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	area north of the B204/ELV AIG. It is unknown if COCs can be attenuated to background concentrations in this area. **Southern Seep Area:** 1. This alternative is unlikely to achieve MCOs in shallow groundwater until upgradient groundwater concentrations are reduced through natural attenuation or active treatment (but MCOs are achieved in seep surface water). 2. If the remedy effectiveness is based on shallow seep-area groundwater, this alternative is not considered reliable for the Southern Seep Area.	**2.** Preliminary data from the ND-138A extraction wells indicate a hydraulic connection to seep cluster SP-890. **3.** As long as the extraction wells, transmission piping, and the GETS remains operational, this system is expected to operate effectively for 10 years. **4.** However, if performance testing indicates that longer operational timeframes are beneficial, it is likely the system will continue to operate until upgradient background groundwater concentrations or MCOs are met.	**8.** As part of the design, an O&M plan will be prepared and implemented to assure extraction and injection wells are properly maintained. **9.** Performance monitoring samples will be collected to monitor the progress of degradation with EISB. **Southern Seep Area** 10. Confidence in being able to accomplish this in the Southern Seep Area is higher than in the Northern Seep Area, as the latter is dependent on proper well spacing in each transect, which could be challenged by access of drilling equipment. 11. Bullet points 2, 3, 5, 7, 8, and 9 under the Northern Seep Area apply to this technology.	
4a. Criterion Score NSA	3	4	3	N/A
4a. Criterion Score SSA	1	5	3	N/A
4. Long-term Effectiveness[b] 4b. Assessment of Long-term Performance and Effectiveness	1. This alternative will provide periodic information on the progress of the MNA component of the remedy. 2. Regular inspections of LUCs will be completed to assess their effectiveness in protecting human health. 3. This information can be used by decision-makers to assess long-term effectiveness and reliability. Should	1. The hydraulic containment monitoring system will be used to assess performance and the effectiveness of preventing downgradient contaminant migration towards northern or southern seep areas. 2. Bullet points 1 through 7 under Alt. SP-1 apply to this alternative.	1. The EISB component of this alternative will be assessed for performance and the effectiveness in preventing downgradient contaminant migration towards northern or southern seep areas. 2. Bullet points 1 through 7 under Alt. SP-1 apply to this alternative.	For each seep area and each alternative, the performance of each component will be regularly assessed and reviewed by DTSC and NASA. Performance in all active treatment areas will be evaluated and subjected to adaptive site management considerations and performance evaluations at regular intervals throughout the implementation of the alternatives.

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	future information demonstrate the need for additional management, appropriate response actions and additional protections will be put into place. 4. Once the MCOs have been achieved and MNA monitoring has been discontinued, there is high confidence that the alternative will continue to be protective. 5. The LUCs will be regularly monitored to assess compliance with objectives. 6. The data from regular monitoring efforts and seep management performance will be reviewed by DTSC and NASA to evaluate MNA progress. If progress is not considered satisfactory, additional testing or mitigation measures may be required. 7. Additionally, DTSC and NASA will continue to evaluate the effectiveness of the LUCs and make changes, as appropriate. **Southern Seep Area** The southern seep area has a confirmed source that results in MCO exceedances in in the Southern Seep Area during the wet season. While concentrations are not indicative of a high strength source, the episodic observations may make it challenging to monitor the natural attenuation signal.			Implementation of MNA, which is common to all three alternatives, will provide periodic information on the progress of natural attenuation. If future information demonstrates potential plume migration that requires additional management, appropriate response actions will be implemented. LUCs, which are common to all three alternatives, will be regularly monitored to assess compliance with objectives. The data from regular monitoring efforts will be reviewed by DTSC and NASA to evaluate the progress of this alternative. If the progress is not considered satisfactory, additional testing or mitigation measures may be required. Additionally, DTSC and NASA will continue to evaluate the effectiveness of the LUCs and make changes, as appropriate. Based on this information, appropriate monitoring for performance and effectiveness is considered comparable among the five alternatives. All alternatives were assigned a score of 5 (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
4b. Criterion Score NSA	5	5	5	N/A
4b. Criterion Score SSA	5	5	5	N/A
4. Long-term Effectiveness[b] 4c. Residual Risks	**Northern Seep Area:** Currently, there are no unacceptable human and ecological risks in the Northern Seep Area. If this alternative is implemented and cleanup to background levels is required, the residual risks will be much lower than acceptable risk thresholds. **Southern Seep Area:** Currently, there are no unacceptable human and ecological risks in the Southern Seep Area surface water. Once MCOs are achieved in the Southern Seep Area shallow groundwater, residual risks are expected to be acceptable. If this alternative is implemented and cleanup to background levels is required, the residual risks will be much lower than acceptable risk thresholds.	The analysis presented for Alt. SP-1 applies to this alternative.	The analysis presented for Alt. SP-1 applies to this alternative.	**Northern Seep Area:** Currently, there are no unacceptable human and ecological risks in the Northern Seep Area. If this alternative is implemented and cleanup to background levels is required, the residual risks will be much lower than acceptable risk thresholds. All alternatives were assigned a score of 5 (Figures 6-6 and 6-7). **Southern Seep Area:** Once MCOs are achieved in the Southern Seep Area, residual risks are expected to be acceptable. If this alternative needs to be implemented and cleanup to background levels is required, the residual risks will be much lower than acceptable risk thresholds. All alternatives were assigned a score of 5 (Figures 6-6 and 6-7).
4c. Criterion Score NSA	5	5	5	N/A
4c. Criterion Score SSA	5	5	5	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5a. Toxicity	1. This alternative does not reduce contaminants above MCOs or background levels through active treatment. 2. However, over the long term of natural attenuation, the toxicity of these	This alternative reduces the mobility of contaminants as they are intercepted by the hydraulic recovery system and prevented from migrating downgradient. Adsorption onto aquifer media and absorption into the rock matrix during the active and post-active	The EISB technology will support ERD and other biological treatment processes, as well as abiotic removal, for example, via iron sulfides that may form as a result of reducing conditions. The potential exists for this technology to create additional	Alt. SP-1 relies on natural processes to support toxicity reduction without using treatment. Alt. SP-2 accomplishes toxicity reduction by physically removing contaminants, whereas Alt. SP-3 accomplishes this using EISB treatment.

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Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	contaminants will decrease through natural degradation processes. 3. In some cases, however, degradation could stall or pause at more toxic daughter products such as VC, though the low concentrations of contaminants in the seep TTAs minimize the impacts of this potential risk. 4. The MNA monitoring program will be designed to evaluate this potential concern. 5. Additional testing or mitigation may be required if this is observed. 6. Natural attenuation of other COCs, through non-degradation or destructive processes such as absorption into the rock matrix and adsorption on the rock surface, and dispersion in groundwater, will prevent them from being bioavailable.	treatment MNA phase of the alternative contribute to natural attenuation of the COCs by increasing the retention time of the COCs within the site boundaries, providing more time for attenuation processes to occur and minimizing the potential for downgradient transport.	daughter products. For example, TCE will degrade to VC. A properly maintained system should allow the degradation pathway to degrade VC to non-toxic ethene or ethane. Natural attenuation of other COCs through non-degradation or destructive processes such as absorption into the rock matrix and adsorption onto the rock surface and dispersion in groundwater will result in contaminants not being bioavailable.	Alternatives SP-1 and SP-3 have the greatest potential of creating daughter products through natural and active biodegradation, but Alt. SP-3 can be designed to minimize this process through monitoring and providing adequate nutrient fermentable carbon for halorespiring microbes. Alt. SP-1 was assigned a score of 1, Alt. SP-2 was assigned a score of 5, and Alt. SP-3 was assigned a score of 4 (Figures 6-6 and 6-7).
5a. Criterion Score NSA	1	5	4	N/A
5a. Criterion Score SSA	1	5	4	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5b. Mobility	• Natural attenuation through natural biodegradation will occur, with some attenuation happening in the groundwater fractures and some in the rock matrix. • Adsorption of contaminants on aquifer media and absorption of contaminants into the rock matrix will contribute to	This alternative reduces the mobility of contaminants as they are intercepted by the hydraulic recovery system and prevented from migrating downgradient. Adsorption onto aquifer media and absorption into the rock matrix during the active and post-active treatment MNA phase of the alternative contribute to natural attenuation of the COCs by	• This alternative reduces the mobility of contaminants by treating them as they pass through the EISB treatment zone. • Natural attenuation through natural biodegradation will occur, with some attenuation happening in the	Alt. SP-1 would reduce mobility only as a result of natural attenuation processes (adsorption and diffusion of contaminants along the pathways of contaminant migration) without using treatment. Alt. SP-2 would reduce mobility by intercepting groundwater contaminants and physically removing them from the groundwater. Alt.

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Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	natural attenuation by increasing the retention time of the COCs within the site boundaries, allowing more time for degradation to occur and minimizing the opportunity for the downgradient transport of contaminants.	increasing the retention time of the COCs within the site boundaries, providing more time for attenuation processes to occur and minimizing the potential for downgradient transport.	groundwater fractures and some in the rock matrix. • Adsorption of contaminants on aquifer media and absorption of contaminants into the rock matrix will contribute to natural attenuation by increasing the retention time of the COCs within the site boundaries, allowing more time for degradation to occur and minimizing the downgradient transport of contaminants	SP-3 reduces mobility by injecting EISB treatment reagents to create a treatment zone to help reduce contaminant concentrations and minimize downgradient contaminant migration. Alt. SP-1 would reduce mobility the least of all three alternatives and was assigned a score of 1. Alt. SP-2, which would remove contaminants in the TTAs and operate under pumping conditions, was assigned a score of 5. Alt. SP-3 was assigned a score of 4 because contaminants are treated in place and not removed from the TTAs (Figures 6-6 and 6-7).
5b. Criterion Score NSA	1	5	4	N/A
5b. Criterion Score SSA	1	5	4	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5c. Volume	This alternative reduces the volume of contaminants through the following mechanisms: Natural attenuation of COCs will occur through natural biodegradation and/or adsorption on aquifer media and absorption into the rock matrix, where further degradation may occur or the COCs may be sequestered. Adsorption and absorption of COCs will increase the retention time of the COCs within the site boundaries, allowing more time for degradation processes to occur and minimizing the opportunity for contaminant transport. As natural	This alternative reduces the volume of contaminants through the extraction of contaminated groundwater from each seep TTA. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.	This alternative reduces the volume of contaminants by providing a permeable treatment zone where contaminant concentrations will be reduced, thus minimizing the contaminant mass that can migrate downgradient. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.	Alt. SP-1 reduces volume through natural attenuation, resulting in a decreased downgradient contamination volume, albeit through natural processes. Alt. SP-2 has a more immediate impact on downgradient volume reduction by physically removing the contaminants, as does Alt. SP-3 through the implementation of an EISB treatment zone. However, Alt. SP-3 is expected to be less effective in preventing downgradient contaminant migration. Alt. SP-1 would reduce volume the least and was assigned a score of 1. Alt. SP-2, which removes contaminants in the TTAs

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Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	attenuation progresses, more contaminants will be treated through natural degradation processes or adsorbed. The result of natural attenuation will be a reduction of mass available for transport, which will reduce the overall mass and peak concentrations of contaminant plumes after a long period of time. **Southern Seep Area** As the upgradient contaminated groundwater is treated or attenuated and the plume contracts, the contamination area in the Southern Seep Area is expected to be reduced, resulting in a decrease in volume.			and operates under pumping conditions, was assigned a score of 4 in the Northern Seep Area because of the complexity of the hydrogeology and confidence in the technology in reducing volume. A score of 5 was assigned to Alt. SP-2 in the Southern Seep Area because the preliminary information in the Southern Seep Area shows a hydraulic connection between extraction well ND-138A and the SP-890 seep cluster. Alt. SP-3 was assigned a score 1 point lower for each seep area because it is perceived to be less effective compared to Alt. SP-2 (Figures 6-6 and 6-7).
5c. Criterion Score NSA	1	4	3	N/A
5c. Criterion Score SSA	1	5	4	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5d. Irreversibility of Treatment	The process of natural attenuation via biodegradation is irreversible and all the Phase 1 COCS are expected to biodegrade. Once contaminants degrade, they will not reform. However, those contaminants that are attenuated through diffusion into the rock matrix or adsorption on aquifer media surfaces could be released back into groundwater through back diffusion out of the rock matrix and de-adsorption. The proper monitoring, assessment, and interpretation of data are expected to provide the necessary decision-making	The process of removing contaminants via hydraulic recovery and treatment at the GETS is irreversible. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.	The processes of EISB and natural attenuation via biodegradation are irreversible and all the organic COCs are expected to biodegrade. Once COCs degrade, they will not reform. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.	The process of natural biodegradation of organic COCs is irreversible. However, those contaminants that are attenuated through diffusion into the rock matrix or adsorption on aquifer media surfaces could be released back into groundwater through back diffusion out of the rock matrix and de-adsorption. Because Alternatives SP-2 and SP-3 achieve removal or in situ treatment of COCs, the impact of reversable MNA processes may be less, but only marginally so considering the low concentrations.

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
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Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	confidence to assess whether background concentrations have been achieved or whether future matrix diffusion could potentially impact groundwater at levels above MCOs or background levels.			Alt. SP-1 was assigned a score of 3 because it has a higher potential of reversing reduced contaminant reduction. Alternatives SP-2 and SP-3 were considered to be the same with respect to this criterion and were assigned a score of 5 (Figures 6-6 and 6-7).
5d. Criterion Score NSA	3	5	5	N/A
5d. Criterion Score SSA	3	5	5	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5e. Types of Treatment Residuals	No treatment residuals will be produced with the MNA component of this alternative, provided proper conditions support the natural attenuation process. As TCE degrades, intermediate degradation or daughter products such as cis- and trans-1,2-DCE and VC may be produced, and these contaminants have been identified previously in site groundwater. These daughter products are degradable by biological and abiotic processes when the proper site conditions exist. Complete degradation of TCE and other organic COCs results in innocuous end products such as chloride and CO_2. If natural attenuation is not complete, however, some of the daughter products could persist in groundwater. Monitoring the formation and subsequent attenuation of these daughter products is an important element of an MNA remedy and performance monitoring.	Treatment residuals will be produced at the GETS and include the following: 1. Spent bag filters (approximately 14 per month) 2. Backwash tank settled solids (approximately one 20-gallon drum disposed of every quarter) 3. Spent carbon transported offsite for reactivation (approximately 12,000 pounds per year) 4. Spent single-use ion-exchange resin (approximately 2,000 pounds per year) These quantities are estimates based on total flow to the GETS. NASA's portion is assumed to be approximately 50%, with the other 50% coming from extraction wells on Boeing property. All waste is managed offsite at an appropriately permitted waste management facility for disposal, treatment, or reactivation. Treated	No treatment residuals will be produced with the EISB and MNA components of this alternative. As TCE degrades, intermediate degradation or daughter products such as cis- and trans-1,2-DCE and VC may be produced and these contaminants have been previously identified in site groundwater. These daughter products are degradable by biological and abiotic processes when the proper site conditions exist. Complete degradation of TCE and the other organic COCs results in innocuous end products such as chloride and CO_2. Monitoring the formation and subsequent attenuation of these daughter products is an important element of an MNA remedy and performance monitoring. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.	Alt. SP-2 produces the most treatment residuals because of the physiochemical processes used at the GETS facility. However, these residuals can be properly managed and represent a minimal threat. The natural attenuation degradation components can result in the accumulation of daughter products; the degree to which this is a concern for each alternative is based on how much the alternative relies on natural biodegradation to reduce COC concentrations and the relative concentrations that require reduction. Alt. SP-3 could result in the production of daughter products, which can be controlled with proper monitoring and the application of treatment reagents, and the potential for risks from these products is minimized as contaminant concentrations in seep water are very low. While Alt. SP-2 would generate the most treatment residuals, these treatment

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		groundwater will be discharged to injection well WS-5 and comply with the existing WDR. A portion of the treated effluent may be used for site dust suppression, particularly during the period when soil remediation is occurring. Discharge of treated water to a surface water body is considered less viable due to the potential changes that would be incurred in the receiving ecosystems and impacts on stream bed alteration. The natural attenuation information presented for Alt. SP-1 applies to the natural attenuation component of this alternative.		residuals could be properly managed; therefore, this alternative scored the highest with 4.5. Alt. SP-3 scored slightly lower than Alt. SP-2 because of the potential to create daughter products in the EISB treatment zone, so it was assigned a score of 4. Alt. SP-1 scored the lowest because it relies the most on natural degradation, with an assigned score of 3; however, the relative concentration reduction required to achieve cleanup objectives is relatively low (Figures 6-6 and 6-7).
5e. Criterion Score NSA	3	4.5	4	N/A
5e. Criterion Score SSA	3	4.5	4	N/A
5. Reduction in Toxicity, Mobility, and Volume[c] 5f. Amount of Hazardous Constituents that will be Treated	No hazardous constituents will be actively treated with this alternative. Organic COCs are expected to degrade through natural attenuation processes. The amount of hazardous constituents has not been estimated for this area; however, given the low contaminant concentrations, the contaminant amount treated through natural attenuation process is expected to be very low.	All contaminants extracted with this alternative will be treated at the GETS. The amount of hazardous constituents has not been estimated for this area; however, given the low contaminant concentrations, the contaminant amount treated through natural attenuation process is expected to be very low.	Biodegradable contaminants will be treated with this alternative. The amount of hazardous constituents has not been estimated for this area; however, given the low contaminant concentrations, the contaminant amount treated through natural attenuation process is expected to be very low.	The amount of hazardous constituents treated has not been estimated for the seep alternatives because the concentrations are already low in the TTAs. Alt. SP-2 is expected to treat the most hazardous constituents, followed by Alt. SP-3 and then Alt. SP-1, which provides the least treatment. However, as the concentrations of COCs are very low in all three seep areas, the amount of hazardous constituents to be treated among all three alternatives is low and may not result in a substantive differences between the alternatives. Based on this, Alt. SP-2 was assigned a score of 5, Alt. SP-3 was assigned a score of 4, and Alt.

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				SP-1 was assigned a score of 3 (Figures 6-6 and 6-7).
5f. Criterion Score NSA	3	5	4	N/A
5f. Criterion Score SSA	3	5	4	N/A
6. Short-term Effectiveness[d] 6a. Community Protection	The community will be protected during this phase of remedy implementation because there are no known complete COC pathways to the community. LUCs will provide an extra measure of protection to the community. **Northern Seep Area:** The community is currently protected because there are no unacceptable risks. **Southern Seep Area:** The community is currently protected because there are no unacceptable risks in seep	The evaluation for Alt. SP-1 applies to this alternative.	The evaluation for Alt. SP-1 applies to this alternative.	The community will be protected in both the Northern and Southern Seep Areas because there are no COC pathways to the community, and LUCs will be implemented until MCOs can be achieved. In the Northern Seep Area, no unacceptable human or ecological risks exist in seep surface water. In the Southern Seep Area, the seep location is on NASA-administered property. All alternatives were assigned a score of 5 (Figures 6-6 and 6-7).
6a. Criterion Score NSA	5	5	5	N/A
6a. Criterion Score SSA	5	5	5	N/A
6. Short-term Effectiveness[d] 6b. Worker Protection	1. Workers will be protected during this phase of remedy implementation because all planning, implementation, and construction-related activities, such as monitoring well construction, will be completed under an approved health and safety plan. 2. Site workers will be monitored under an established medical monitoring	1. Workers will be protected during this phase of remedy implementation because all planning, implementation, and construction-related activities, such as the construction of the hydraulic recovery system, will be completed under an approved health and safety plan.	1. Workers will be protected during this phase of remedy implementation because all planning, implementation, and construction-related activities, such as the construction of the EISB injection system, will be completed under an approved health and safety plan.	As presented above, each alternative has different operational elements. All three of the alternatives involve monitoring. Alternatives SP-2 and SP-3 involve active treatment. While each technology has unique variables, all remediation operations will be completed under an approved health and safety plan and use a properly trained work force. Project-related risks will

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	program provided by their employer and will be properly trained in site management activities. 3. Regular safety briefings will be provided for onsite workers to remind them of potential safety risks at the site, such as biological risks (insects and snakes). 4. While plans will be in place to maximize worker protection, this does not imply the work activities are risk free. 5. Accidents such as slips, trips, falls, and biological hazard impacts happen even with the most comprehensive plans and training in place.	2. Additionally, staff at the GETS are working under an approved health and safety plan. 3. Bullet points 2, 3, and 4 presented for Alt. SP-1 apply to this alternative. 4. Accidents such as slips, trips, falls, biological hazard impacts, accidents with machinery and exposure to treatment reagents (e.g., work at the GETS) happen even with even the most comprehensive plans and training in place.	2. Bullet points 2, 3, and 4 presented for Alt. SP-1 apply to this alternative. 3. Accidents such as slips, trips, falls, biological hazard impacts, and accidents with machinery (e.g., associated with EISB reagent delivery) happen even with the most comprehensive plans and training in place.	be defined and activity hazard analysis for each element of work will be defined. The workers will also be trained to recognize risk and have the authority to stop operations if a risk is identified. While worker protection risks can be managed, they do not guarantee absolute worker protection. It is reasonable that more involved alternatives that use more mechanical and chemical reagents have greater risk potential. For these reasons, Alt. SP-2 was assigned the lowest score of 2, Alt. SP-3 was assigned at score of 3, and Alt. SP-1 was assigned a score of 4 (Figures 6-6 and 6-7).
6b. Criterion Score NSA	4	2	3	N/A
6b. Criterion Score SSA	4	2	3	N/A
6. Short-term Effectiveness[d] 6c. Environmental Impacts	1. The DTSC GREM was used to identify potential environmental impacts associated with implementing this alternative. The GREM matrix includes multiple evaluation criteria for different stressors, specifically substance/release production, thermal releases, physical disturbances/disruptions, and resource depletion/gain. Some criteria for each stressor were not applicable to this alternative. For those criteria considered applicable to this alternative, a qualitative statement	1. Bullet point 1 for Alt. SP-1 applies to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered relatively high.	1. Bullet point 1 for Alt. SP-1 applies to this alternative. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered moderate.	The GREM matrix includes multiple evaluation criteria for different stressors, specifically substance/release production, thermal releases, physical disturbances/disruptions, and resource depletion/gain. Some criteria for each stressor were not applicable to an alternative. For those criteria considered applicable to an alternative, a qualitative statement about this alternative for each criterion is provided and presented in the GREM evaluation matrix in Appendix E2. With each qualitative statement, a relative

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	about this alternative for each criterion is presented in the GREM evaluation matrix in Appendix E2. 2. Based on the information in the GREM evaluation matrix, the environmental impacts associated with implementing this alternative are considered very low.			score between 1 and 5 was assigned. A score of 1 was assigned to an alternative to represent the lowest impact for the subject criterion, and a score of 5 was assigned to an alternative to represent the highest impact for the subject criterion. The scores for the other alternatives were then interpolated between these two scores. Once each alternative had a criterion score, the total score could be added to provide insight into the relative environmental impacts of each alternative. The lower the total score, the lower perceived environmental impact of the alternative. The results presented in Appendix E2 indicate the environmental impacts associated with Alt. SP-1 are the lowest as indicated by the lowest total score, so this alternative was assigned a score of 5. Environmental impacts associated with Alt. SP-2 are the highest, as indicated by the highest total score, so this alternative was assigned a score of 1. Alt. SP-3 was assigned a score of 3, as the total score presented in Appendix E2 is between Alternatives SP-1 and SP-2 (Figures 6-6 and 6-7).
6c. Criterion Score NSA	5	1	3	N/A
6c. Criterion Score SSA	5	1	3	N/A

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NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
7. Implementability[e] 7a. Construction and Operation	1. This alternative is considered constructible and operable. 2. The MNA system is a network of monitoring wells installed within and surrounding the treatment areas. Installation of signage and deed restrictions can be accomplished easily. 3. Within the first year, all LUCs will be put into place and monitored for effectiveness until cleanup objectives are achieved. 4. The MNA operations will be initiated at the completion of the CMD and operated until cleanup objectives are achieved. 5. The MNA well network will be periodically evaluated to assess the appropriateness of the wells, frequency of analysis, and target analytes. 6. Monitoring data will be evaluated to assess whether reasonable concentration reductions are being achieved with MNA.	1. This alternative is considered constructible and operable. 2. The GETS is already constructed on Boeing's property. Well ND-138A is already operating in the southern portion of the Delta Area. 3. Adding three new extraction wells north of the B204/ELV AIG can be accomplished in a manner similar to the installation and connection of previous wells to GETS. 4. The hydraulic containment system will be constructed within 1 year of completing the CMD and operated for an estimated period of 10 years. 5. Bullet points 2, 3, 4, 5, and 6 for Alt. SP-1 apply to this alternative.	1. This alternative is considered constructible and operable. 2. EISB treatment systems will be installed at the two seep TTAs, constructed within 1 year of completing the CMD, and operated for an estimated period of 10 years. 3. For the northern seep area, there may be challenges related to placement of the 10 EISB injection wells. The current configuration, as shown on Figure 4-5 (only transects are shown, individual wells are not represented), has two transects consisting of five EISB injection wells installed in each transect (refer to Section 6.1.6.1). The well spacing has been designed to optimize delivery of EISB treatment reagents. If, because of access limitations, this spacing cannot be maintained or optimized, the delivery of EISB treatment reagents could be compromised. 4. For the southern seep area, the EISB treatment reagents will be injected through ND-138A. 5. Bullet points 2, 3, 4, 5, and 6 for Alt. SP-1 apply to this alternative.	▪ All three alternatives are considered constructible and operable. Alt. SP-1 employs groundwater and seep monitoring. ▪ The extraction well for the Southern Seep Area in Alt. SP-2 has already been constructed and is in operation, and can be repurposed as an EISB injection well, if necessary. This alternative can be implemented in the Northern Seep Area, if necessary, with the installation of three new extraction wells. ▪ Alt. SP-3 would require the construction of 10 new EISB injection wells in the Northern Seep Area. Access limitations in the Northern Seep Area could prevent optimal well placement of injection wells and result in compromised EISB treatment reagent delivery. ▪ For the Southern Seep Area, the EISB treatment reagents would be delivered into ND-138A. The direct injection approach in Alt. SP-3 is less complex than the recirculation approach described for the source area alternatives. ▪ Because of access challenges related to the installation of Alt. SP-3, it was assigned a lower score of 3 for the Northern Seep Area. The rest of the alternatives were assigned a score of 5 (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
7a. Criterion Score NSA	5	5	3	N/A
7a. Criterion Score SSA	5	5	5	N/A
7. Implementability[e] 7b. Administrative Feasibility	The technologies used in this alternative are expected to be permitted, as the technologies are commonly implemented. As active treatment is not included in this alternative, the regulatory agencies are unlikely to endorse this alternative at this location. **Northern Seep Area:** Work in the Northern Seep Area will occur within NASA-administered areas and on Boeing and Brandis-Bardin properties; permission from these property owners is expected to be granted. **Southern Seep Area:** Work in the Southern Seep Area will occur within NASA-administered areas.	1. The technologies used in this alternative are expected to be permitted, as these technologies are commonly implemented. 2. The technologies employed with this alternative are proven to work at SSFL. Implementation of this alternative is considered administratively feasible. 3. The GETS has capacity limits and NASA will work with Boeing to coordinate the addition of new flow to the system. 4. Because this activity will occur in the future, it is possible GETS could have additional capacity at that time if wells currently operating are taken offline by then. 5. The locations of extraction wells in the Southern Seep Area are in a culturally sensitive area. If additional wells are needed, there could be limitations on where those new wells could be installed. 6. The evaluation information for the northern and southern seep area under Alt. SP-1 applies to this alternative.	1. The technologies used in this alternative are expected to be permitted, as these technologies are commonly implemented in the region. 2. The technologies employed with this alternative are proven in the remediation industry and have been deployed in locations near SSFL. 3. Implementation of this alternative is considered administratively feasible. **Northern Seep Area** 1. The evaluation information for the northern seep area under Alt. SP-1 applies to this alternative. **Southern Seep Area** 1. Work in the Southern Seep Area will occur within NASA-administered areas. The location of injection wells in the Southern Seep Area are in a culturally sensitive area. If additional wells are needed, there could be limitations on where those new wells could be installed. **2.** Implementation of this alternative will require that well ND-138A be repurposed as an EISB injection well, which will require coordination with	Work in the Northern Seep Area will occur in NASA-administered areas and on Boeing and Brandis-Bardin properties; permission from these property owners is expected to be granted. Work in the Southern Seep Area will occur within NASA-administered areas. As active treatment is not included Alt. SP-1, this alternative is unlikely to be endorsed in the Southern Seep Area by regulators. The locations of extraction or EISB injection wells in the Southern Seep Area are in a culturally sensitive area. If additional wells are needed, there could be limitations on where those new wells could be installed. Additionally, Alt. SP-3 would require that extraction well ND-138A be repurposed as an EISB injection well. Alternatives SP-2 and SP-3 are considered equally feasible from an administrative implementation perspective assuming only ND-138A will be utilized with Alt. SP-2; each alternative was assigned a score of 5. However, if additional extraction wells are necessary for Alt. SP-2, cultural and biological areas will need to be considered. Alt. SP-1 should be administratively acceptable to regulators for the Northern Seep Area and was assigned a score of 5, given there are no exceedances of MCOs.

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
			DTSC. This administrative change is not expected to be difficult as NASA will temporarily repurpose extraction well ND-136 for the EISB pilot study.	Alt. SP-1 is unlikely to be acceptable in the Southern Seep Area and was assigned a score of 1 (Figures 6-6 and 6-7).
7b. Criterion Score NSA	5	5	5	N/A
7b. Criterion Score SSA	1	5	5	N/A
7. Implementability[e] 7c. Availability of Services and Materials	The technology materials and services associated with implementing this alternative are readily available.	The technology materials and services associated with implementing this alternative are readily available.	The technology materials and services associated with implementing this alternative are readily available.	Materials for all three alternatives are readily available. All alternatives were assigned a score of 5 (Figures 6-6 and 6-7).
7c. Criterion Score NSA	5	5	5	NA
7c. Criterion Score SSA	1	5	5	N/A
7. Implementability[e] 7d. Permitting	1. The implementation of MNA and LUCs is common at cleanup sites. 2. Obtaining permits to implement these remedies is not expected to be difficult. 3. In California, LUCs are implemented through Land Use Agreements; implementing a Land Use Agreement is not expected to be difficult. 4. MNA would be documented in the approved work plan and the CMI. 5. Federal, state, and local laws described in Section 3.4 will be followed.	1. The GETS is already permitted. The GETS can accommodate additional flow provided the system has capacity. 2. Because permits for the installation of GETS have been granted as part of past site work, they are expected to be granted for this remedy. 3. Permitting of new extraction wells will be necessary. 4. Bullet points 1, 2, 3, and 4 for Alt. SP-1 applies to this alternative. 5. Federal, state, and local laws described in Section 3.4 will be followed, including possible LARWQCB permits such as WDR.	Technology-specific requirements apply to the EISB technology, as well as the requirements discussed in Section 3.4. The EISB technology will comply with the following: • Installation of new injection wells • Any applicable RCRA permitting for the treatment technology • Protection of surface and groundwater requirements, including possible LARWQCB permits such as WDR An EISB pilot system has been permitted in the Alfa Area, so it is likely that permits	All three are considered to be equivalent with respect to permitting and were assigned a score of 5 (Figures 6-6 and 6-7).

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
			could be granted for this alternative in other site locations. Bullet points 1, 2, 3, 4, and 5 for Alt. SP-1 apply to this alternative.	
7d. Criterion Score NSA	5	5	5	N/A
7d. Criterion Score SSA	5	5	5	N/A
8. Cost	1. Costs are considered conceptual only and it is typical to apply a plus 50% and minus 30% to conceptual costs to represent uncertainty related to conceptual estimates. These costs are presented in Appendix G. Costs were evaluated over a 10-year time frame. **Northern Seep Area** 1. Capital cost is estimated at $48,090. This cost includes development of an MNA and LUC plan. 2. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Table 6-2 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-2. 3. Annual monitoring and LUC costs were estimated at approximately $127,300. The total 10-year life-cycle cost for this alternative is estimated at approximately $1.192 million. These alternative costs are detailed in Appendix G-2.	Bullet 1 for Alt. SP-1 applies to this alternative. **Norther Seep Area** 1. Capital cost is estimated as $3.785 million and includes the MNA and LUC costs defined in Alt. SP-2 for MNA and LUC costs. 2. Annual monitoring, LUC costs, and GETS treatment costs were estimated at approximately $219,000, of which $127,300 are attributable to monitoring natural attenuation and LUC management. The total 10-year life-cycle cost for this alternative is estimated at approximately $5.801 million. These alternative costs are detailed in Appendix G. **Southern Seep Area** 1. Bullet 1 of Alt. SP-1 Southern Sweep Area applies to this alternative. The infrastructure for the hydraulic containment system is already in place for this TTA. 2. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Table 6-6 using the	The note for Alt. SP-1 applies to this alternative. **Norther Seep Area** 1. Capital cost is estimated as $6.440 million and includes the MNA and LUC costs defined in Alt. SP-2 for MNA and LUC costs. 2. Annual monitoring, LUC costs, and EISB treatment costs were estimated at approximately $248,300, of which $127,300 are attributable to monitoring natural attenuation and LUC management. The total 10-year life-cycle cost for this alternative is estimated at approximately $8.669 million. These alternative costs are detailed in Appendix G. **Southern Seep Area** 1. Capital cost is $231,100, of which $48,090 is related to MNA and LUCs. 2. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Table 6-6 using the	Capital Costs The capital costs for the Northern and Southern Seep Areas are the same for Alt. SP-1. The capital costs for the active treatment alternatives are much lower in the Southern Seep Area because the infrastructure already exists for Alternatives SP-2 and SP-3. O&M All the alternatives have relatively low O&M costs. The costs for Alt. SP-1 are related to monitoring and LUC management. These costs are also included in Alternatives SP-2 and SP-3. Alt. SP-2 includes costs for treatment of groundwater at the GETS, whereas Alt. SP-3 includes costs for the periodic addition of EISB treatment reagents. Based on these costs, Alt. SP-1 and the Southern Seep Area for Alt. SP-3 were assigned a score of 5 and the rest of the

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
	Southern Seep Area 1. Capital cost to implement this alternative in the Southern Seep Area is estimated at $48,090. This cost includes development of an MNA and LUC plan. 2. Annual O&M costs include long-term monitoring of groundwater at the wells identified in Table 6-6 using the groundwater parameters specified in the MNA-Lab sheet of Appendix G-2. 3. Costs were evaluated over a 10-year time frame. Annual monitoring and LUC costs were estimated at approximately $63,600. The total 10-year life-cycle cost for this alternative is estimated at approximately $620,000. These alternative costs are detailed in Appendix G-2.	groundwater parameters specified in the MNA-Lab sheet of Appendix G-2. 3. Annual monitoring, LUC costs, and GETS treatment costs were estimated at approximately $242,300 (of which approximately $63,700 is attributable to monitoring natural attenuation and LUC management). The total 10-year life-cycle cost for this alternative is estimated at approximately $2.226 million. These alternative costs are detailed in Appendix G-2.	groundwater parameters specified in the MNA-Lab sheet of Appendix G-2. 3. Annual monitoring, LUC costs, and ERD treatment costs were estimated as $78,800 (of which approximately $63,700 is attributable to monitoring natural attenuation and LUC management). The total 10-year life-cycle cost for this alternative is estimated at approximately $0.94 million. These alternative costs are detailed in Appendix G-2.	alternatives were assigned a score of 3 (Figures 6-6 and 6-7).
8. Capital Cost Criterion Score NSA	5	2	1	N/A
8. Capital Cost Criterion Score SSA	5	5	5	N/A
8. O&M Criterion Score NSA	5	3	3	N/A
8. O&M Criterion Score SSA	5	3	5	N/A

Table 6-9. Detailed and Comparative Analysis of Phase 1 Seep Water Alternatives
NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Criterion	Alt. SP-1 MNA and LUCs	Alt. SP-2. Hydraulic Control of Seep Water, MNA, and LUCs	Alt. SP-3. EISB, MNA, and LUCs	Comparative Analysis
10. Community Acceptance	This criterion cannot be assessed until the alternatives have been presented to the community.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	N/A
11. State Acceptance	This criterion cannot be assessed until the alternatives have been reviewed by the state.	Alt. 1 text is also applicable to this alternative.	Alt. 1 text is also applicable to this alternative.	N/A
12. Adaptive Management	1. The previous analysis highlights several elements of adaptive site management that would be implemented with this alternative. These elements are summarized as follows: 2. Monitoring potential seeps in the SP-890 area and B204/ELV AIG will be used to assess whether there could be a complete pathway in the future. 3. The MNA well network and groundwater monitoring constituent list will be periodically evaluated to assess the appropriateness of the wells, frequency of analysis, and target analytes. 4. Monitoring data will be evaluated to assess whether reasonable plume area reduction and mass reductions are being achieved. 5. MNA data will be evaluated periodically to determine whether it is effective.	1. Bullet points 1, 2, 3, 4, and 5 for Alt. SP-1 apply to this alternative. 2. Criteria to transition from active hydraulic containment to MNA will be defined. 3. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA.	1. Bullet points 1, 2, 3, 4, and 5 for Alt. SP-1 apply to this alternative. 2. Criteria to transition from active EISB to MNA will be defined. 3. The decision process by which contingency remedies are implemented will be developed by DTSC and NASA.	N/A

[a] Remedies are required to achieve MCOs, as outlined in Table 3-1. SWRBC Resolution No. 92-49 requires that the Regional Board “ensure that dischargers are required to clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable.” Therefore, this alternative is also evaluated against the goal of cleaning up to background.

[b] The period for this criterion begins when the remedy is determined to be operating properly and successfully and ends when MCOs have been achieved. The time to achieve MCOs or background concentrations has not been estimated. For the purposes of this CMS, it has been assumed that monitoring would occur as long as upgradient contamination is in groundwater.

[c] Remedies should reduce the toxicity, mobility, and/or volume of COCs.

[d] Short-term effectiveness is generally considered the period between the start of remedy implementation and the time at which the remedy is determined to be operating properly and successfully.

[e] Implementability addresses the technical and administrative feasibility of implementing the alternative and the availability of services and materials necessary to implement and operate the remedy.

µg/L = microgram(s) per liter
AIG = area of impacted groundwater
Alt. = Alternative
B204 = Building 204
Boeing = The Boeing Company
CMD = corrective measures design
CMI = corrective measures implementation
CMS = corrective measures study
CO_2 = carbon dioxide
COC = chemical of concern
COEC = chemical of ecological concern
DCE = dichloroethene
DTSC = California Department of Toxic Substances Control
EISB = enhanced in situ bioremediation
ELV = expendable launch vehicle
ERD = enhanced reductive dechlorination
GETS = groundwater extraction treatment system
GREM = Green Remediation Evaluation Matrix
HHRA = human health risk assessment
LARWQCB = California Regional Water Quality Control Board, Los Angeles Region
LUC = land use control
MCO = media cleanup objective
MNA = monitored natural attenuation
NA = not applicable
NASA = National Aeronautics and Space Administration
NSA = Northern Seep Area
NSGW = near-surface groundwater
O&M = operation and maintenance
SSA = Southern Seep Area
SWRCB = State Water Resources Control Board
TCE = trichloroethene
TTA = target treatment area
VC = vinyl chloride
WDR = Waste Discharge Requirement

Table 6-10. Cost Summary for Groundwater Alternatives

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Element	Alt. 1: MNA and LUCs	Alt. 2a: EISB, BVE, MNA, and LUCs	Alt. 2b: T-EISB, BVE, MNA, and LUCs	Alt. 3: P&T, BVE, MNA, and LUCs	Alt. 4: ISCO, BVE, MNA, and LUCs
Capital Cost: MNA & LUCs	$220,000	0	0	$220,000	0
Capital Cost: EISB	0	$11,096,039	0		0
Capital Cost: T-EISB	0	0	$14,362,558	0	0
Capital Cost: P&T	0	0	0	$943,275	0
Capital Cost: ISCO	0	0	0	0	$11,355,571
Capital Cost: BVE @ ND-136 TTA	0	$278,902	$278,902	$278,902	$278,902
Capital Subtotal	$220,000	$11,374,940	$14,641,459	$1,442,177	$11,634,472
PV O&M Costs: MNA & LUCs (30 years)	$7,111,000	$7,111,000	$7,111,000	$7,111,000	$7,111,000
PV O&M Costs: EISB (10 years)	0	$4,320,253	0	0	0
PV O&M Costs: T-EISB (10 years)	0	0	$5,029,344	0	0
PV O&M Costs: P&T (10 years)	0	0	0	$3,895,000	0
PV O&M Costs: ISCO (10 years)	0	0	0	0	$5,082,623
PV O&M Costs: BVE @ ND-136 TTA (5 years)	0	$7,747,387	$7,747,387	$7,747,387	$7,747,387
PV O&M Subtotal	$7,111,000	$19,178,640	$19,887,731	$18,753,387	$19,941,010
Total Present Value of Alternative (NPV @ 2%) for 30 years	$7,331,000	$30,553,580	$34,529,190	$20,195,564	$31,575,482
+50% NPV Costs for 30 years	$10,996,500	$45,830,370	$51,793,785	$30,293,346	$47,363,223
-30% NPV Costs for 30 years	$5,131,700	$21,387,506	$24,170,433	$14,136,895	$22,102,837

BVE = Bedrock Vapor Extraction
EISB = enhanced in situ bioremediation
ISCO = in situ chemical oxidation
LUC = land use control
MNA = monitored natural attenuation
NPV = net present value
P&T = pump and treat
TTA = target treatment area

Table 6-11. Cost Summary for Seep Alternatives

NASA Phase 1 Groundwater Corrective Measures Study, SSFL, Ventura County, California

Element	Alt. SP-1: SP1 MNA (North)	Alt. SP-1: SP1 MNA (South)	Alt. SP-2: SP2 Hydraulic Control (North)	Alt. SP-2: SP2 Hydraulic Control (South)	Alt. SP-3 SP3 - EISB TZ (North)	Alt. SP-3 SP3 - EISB TZ (South)
Capital Cost: MNA & LUCs	$48,090	$48,090	$48,090	$48,090	$48,090	$48,090
Capital Cost: Hydraulic Containment	0	0	$3,784,750	0 (already in place)	0	0
Capital Cost: EISB TZ	0	0	0	0	$6,391,561	$182,854
Capital Subtotal	$48,090	$48,090	$3,832,840	$48,090	$6,439,651	$230,944
PV O&M Costs (10 Years): MNA & LUCs	$1,144,000	$572,000	$1,144,000	$572,000	$1,143,500	$572,000
PV O&M Costs (10 Years): Hydraulic Containment	0	0	$824,000	$1,606,000	0	0
PV O&M Costs (10 Years): EISB TZ	0	0	0	0	$1,084,900	$137,000
PV O&M Subtotal	$1,144,000	$572,000	$1,968,000	$2,178,000	$2,228,400	$709,000
Total Present Value of Alternative (NPV @ 2%) for 10 years	$1,192,090	$620,090	$5,800,840	$2,226,090	$8,668,051	$939,944
+50% NPV Costs for 30 years	$1,716,000	$858,000	$2,952,000	$3,267,000	$3,342,600	$1,063,500
-30% NPV Costs for 30 years	$800,800	$400,400	$1,377,600	$1,524,600	$1,559,880	$496,300

BVE = Bedrock Vapor Extraction
EISB = enhanced in situ bioremediation
ISCO = in situ chemical oxidation
LUC = land use control
MNA = monitored natural attenuation
NPV = net present value
P&T = pump and treat
TZ = treatment zone

Figures

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Miles: 0 5 10 20 30

Kilometers: 0 5 10 20 30 40 50

20-JUN-2007
Drawn By:
D. Scott Stevens

Figure 2-1
Santa Susana Field Laboratory Location Map
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: (O:\NASA_GIS_Data\SSFL\maps\SSFL_LocArea.mxd)

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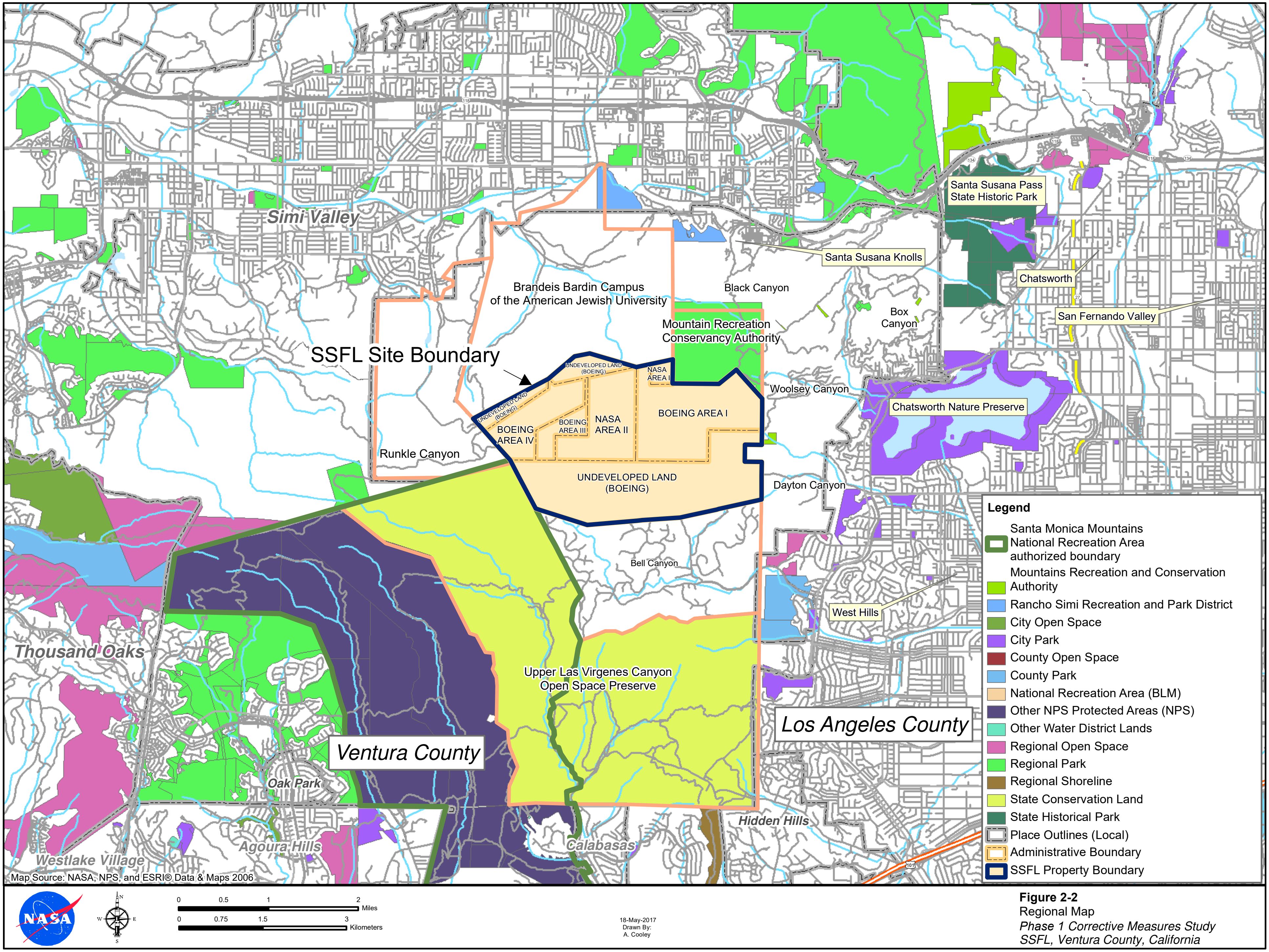

18-May-2017
Drawn By:
A. Cooley

Figure 2-2
Regional Map
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\RegionalMap_Landmarks.mxd

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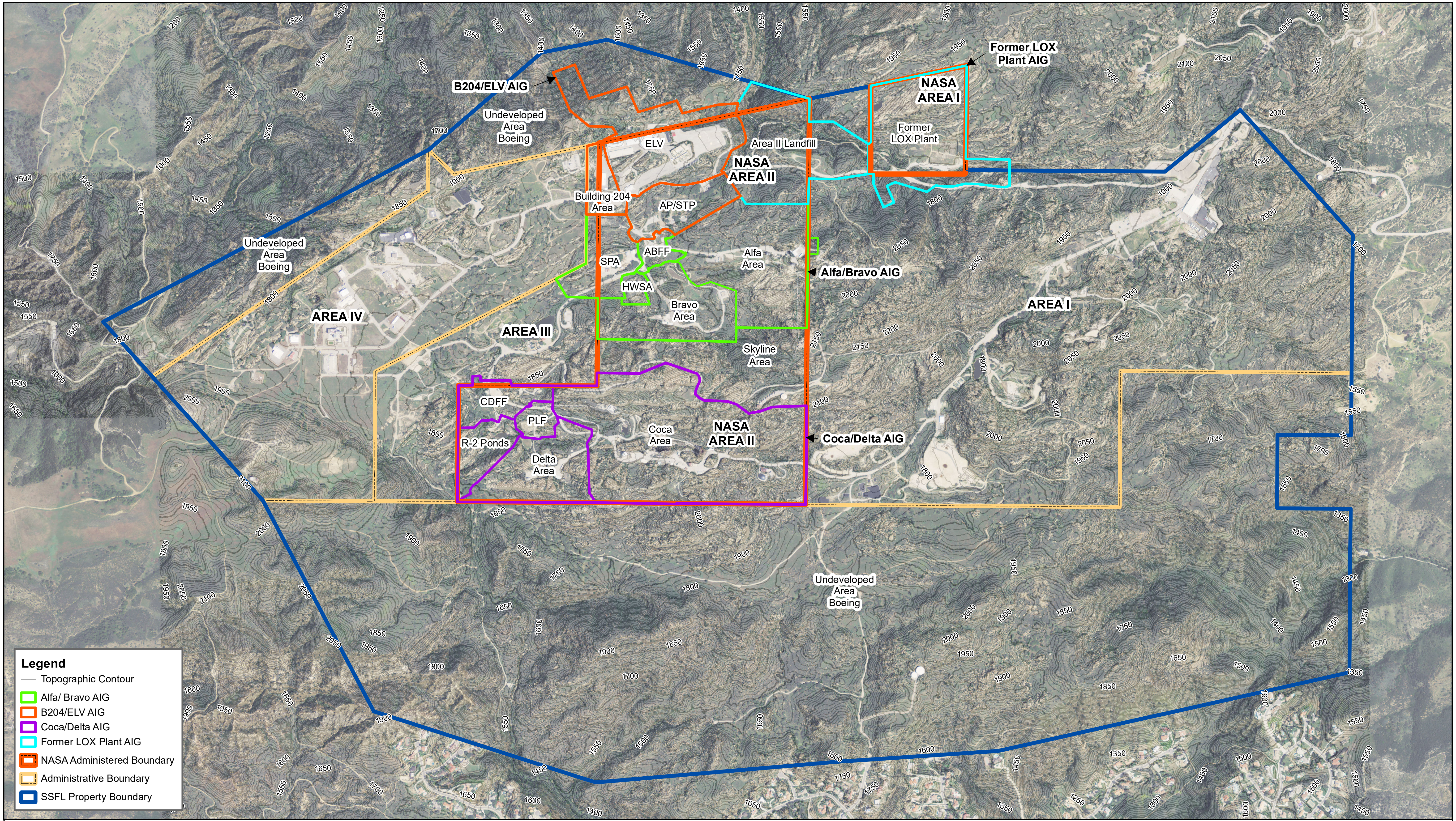

N
W E
S

0 500 1,000 2,000 Feet

0 150 300 600 Meters

11-May-2017
Drawn By:
A. Cooley

Figure 2-3
NASA AIG Locations
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AIG_Overview.mxd

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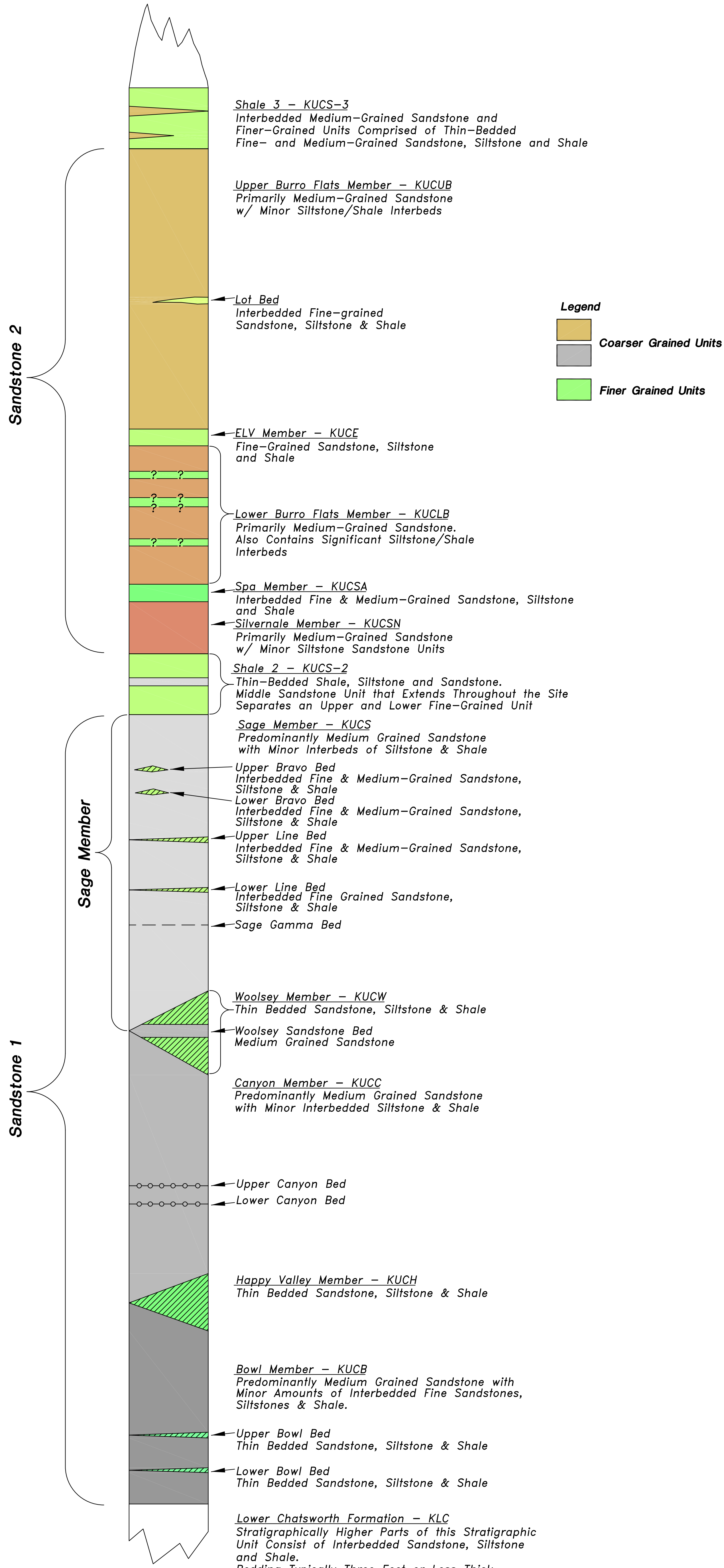

Note:
Modified from Figure 5-6 of the Draft Site-wide Groundwater Remedial Investigation Report (MWH, 2009).

Figure 2-4
Stratigraphic Column of the Chatsworth Formation
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

SCO678336.01.02.AD SSFL_ELV_stratigraphic_column_chatsworth_formation_CMS.ai 2/17

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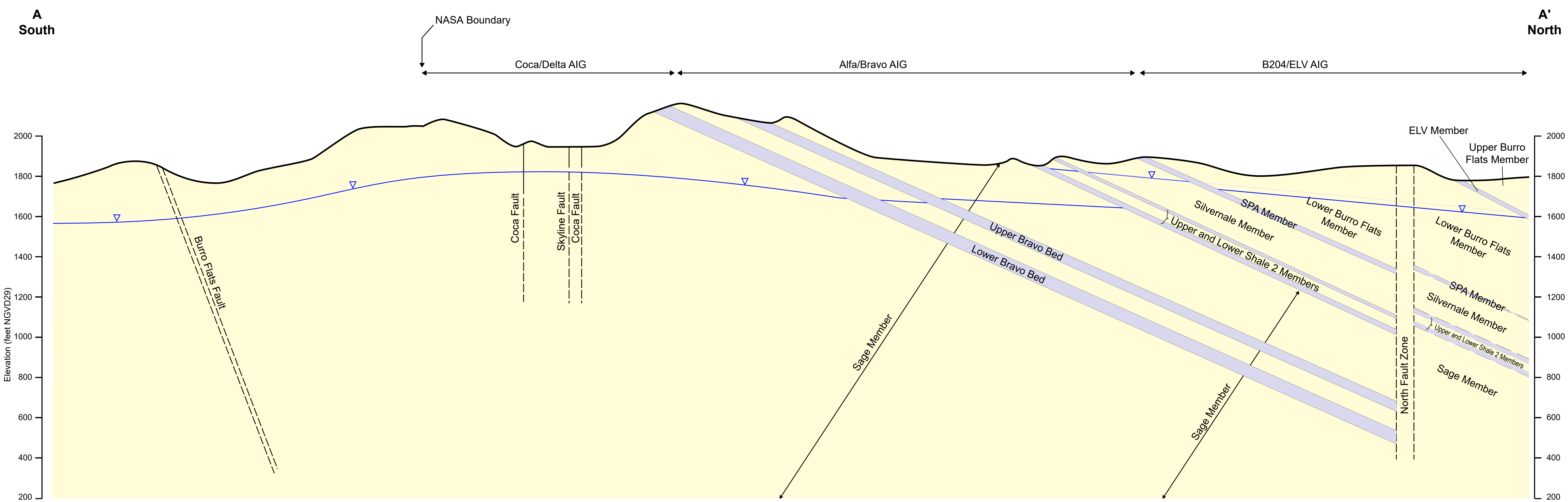
Notes:
[a] No contact line indicates that the area was not mapped by NASA. Fine grained unit contact lines are from CH2M Hill, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California.* April.
[b] NASA area fault source is CH2M Hill, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California.* April. Faults outside NASA areas are from MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA.* Final. November.
[c] Dips included on the map are true dips.

The cross section displayed on this map is provided as Figure 2-6.

19-Jul-2018
Drawn By:
A. Cooley

Figure 2-5
Bedrock Geology Map
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\GeologyOverview.mxd



200 ft

200 ft

Vertical Exaggeration = 1

Chatworth Formation Groundwater Elevation

Geological Contact

Sandstone (medium to coarse-grained)

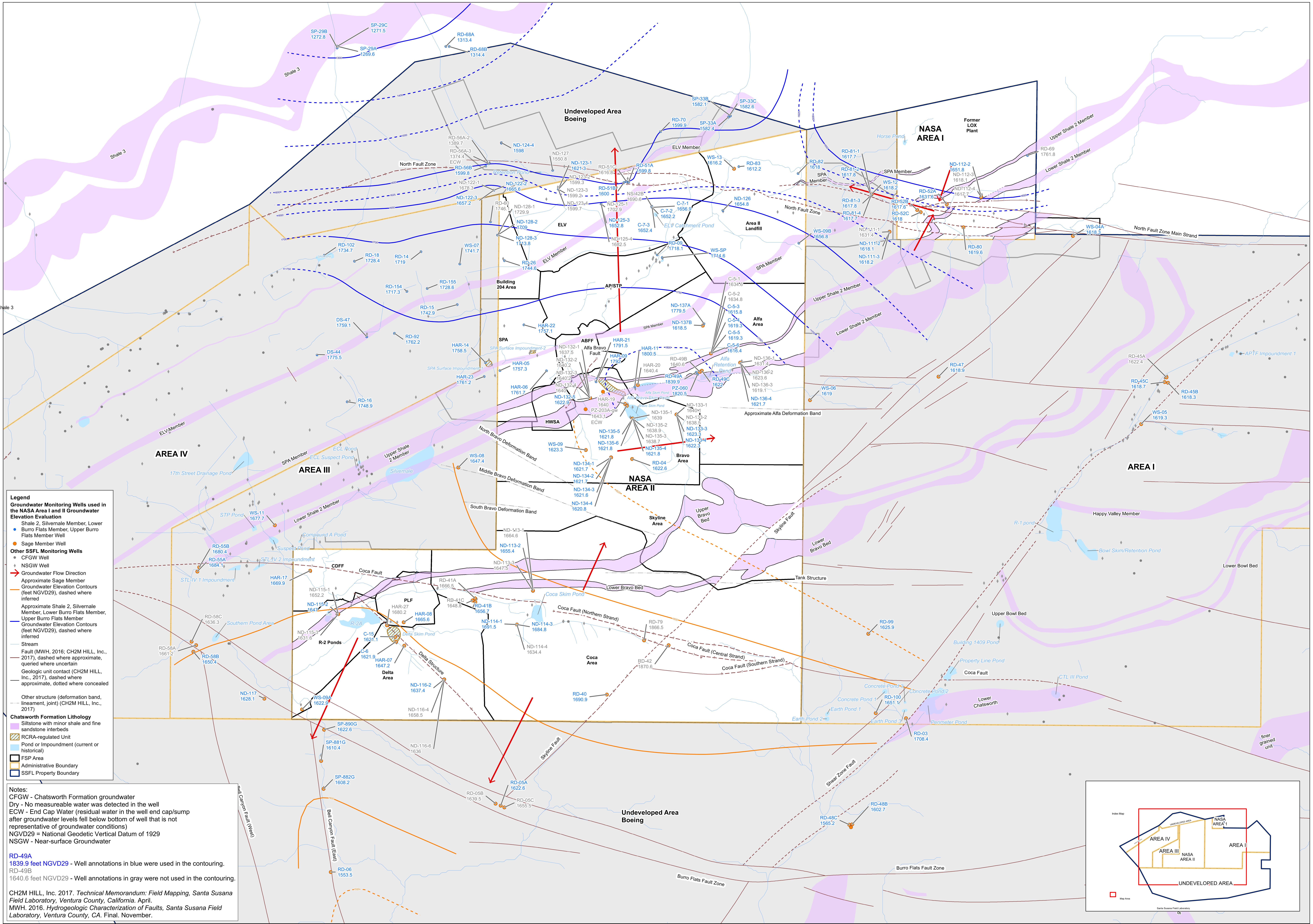
Siltstone with Minor Shale and Fine Sandstone Interbeds

Fault

Notes:
1. The location and orientation of this cross section can be viewed on Figure 2-5.
2. Subsurface nature of faults is unknown and depicted as vertical lines for simplicity.
3. The dips of geologic units depicted on this cross section are apparent dips.
NGVD29 - National Geodetic Vertical Datum of 1929

Figure 2-6
NASA Area II Geologic Cross Section
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

SCO678336.01.02.AD Figure 2-06_Xsection_20180719.pdf 07/19/18



NASA

20-Jul-2018
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A. Cooley

Figure 2-7
Chatsworth Formation Groundwater Elevations, Third Quarter 2016
Phase 1 Corrective Measures Study
SSFL, Ventura County, CA

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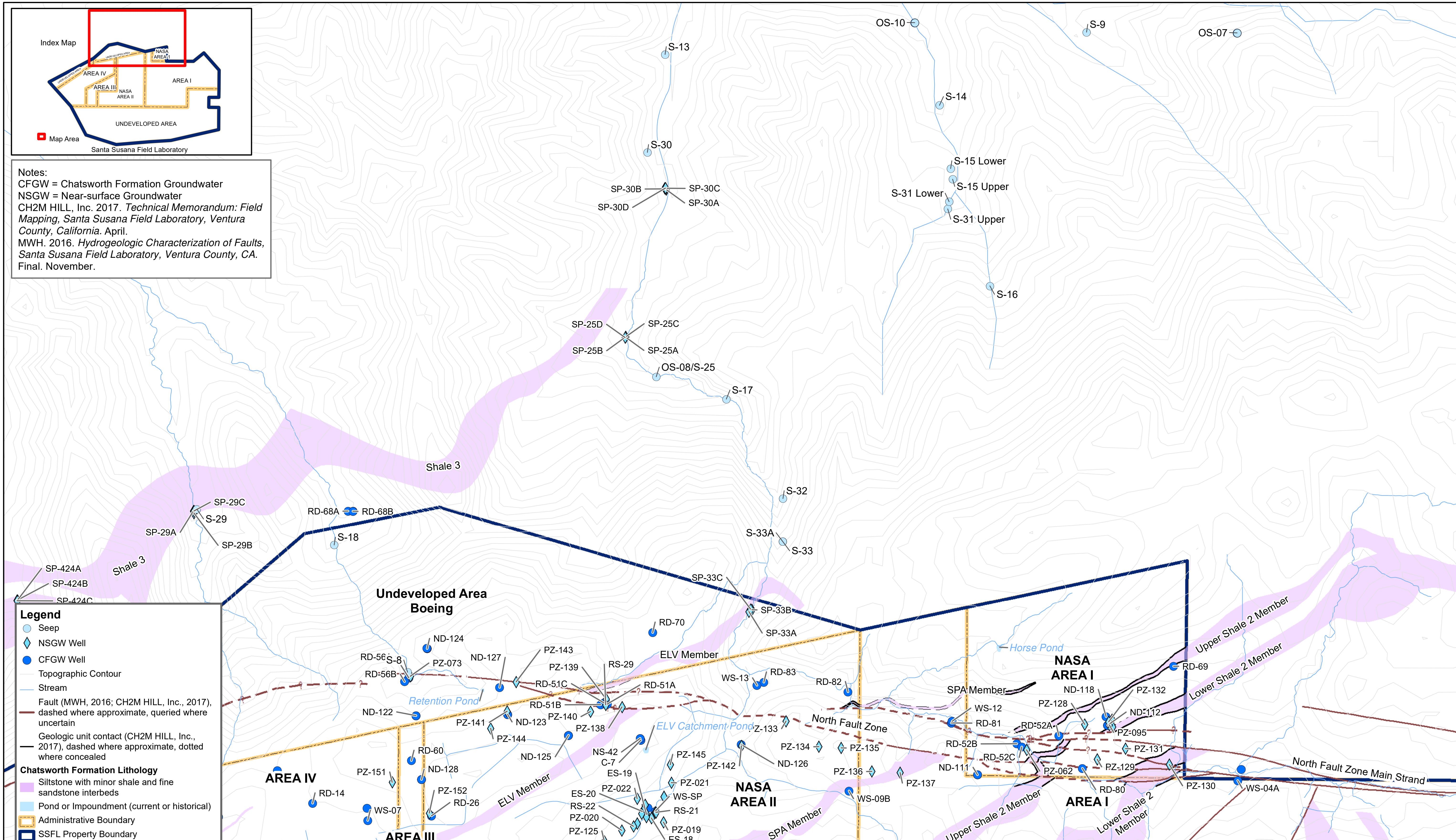


NASA

N W E S

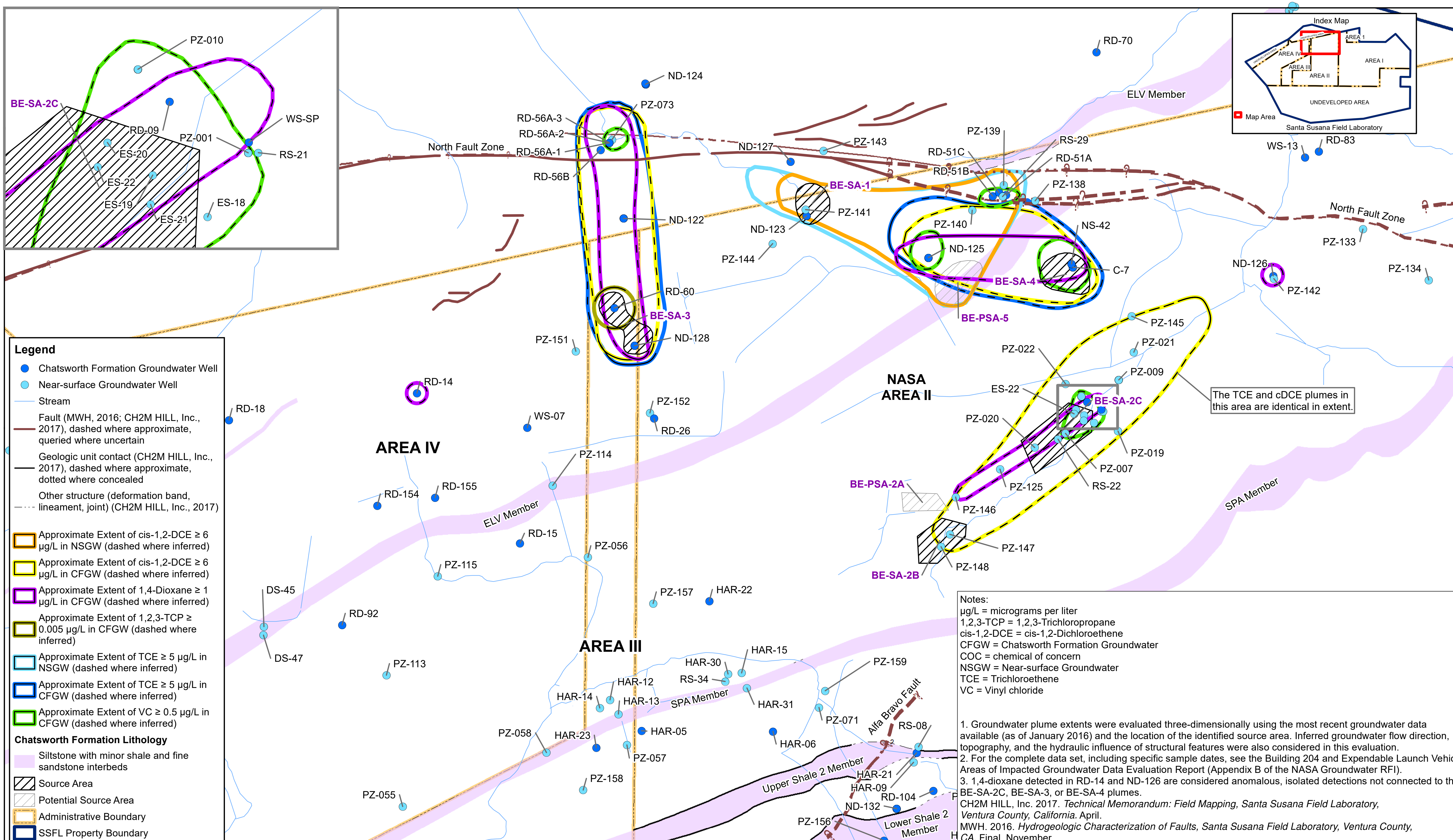
0 300 600 1,200 Feet

0 87.5 175 350 Meters

16-Oct-2023
Drawn By:
Erin Eppling

Figure 2-8
Former LOX Plant AIG and B204/ELV AIG Seep Locations
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\BE_LOX_SeepLocs.mxd



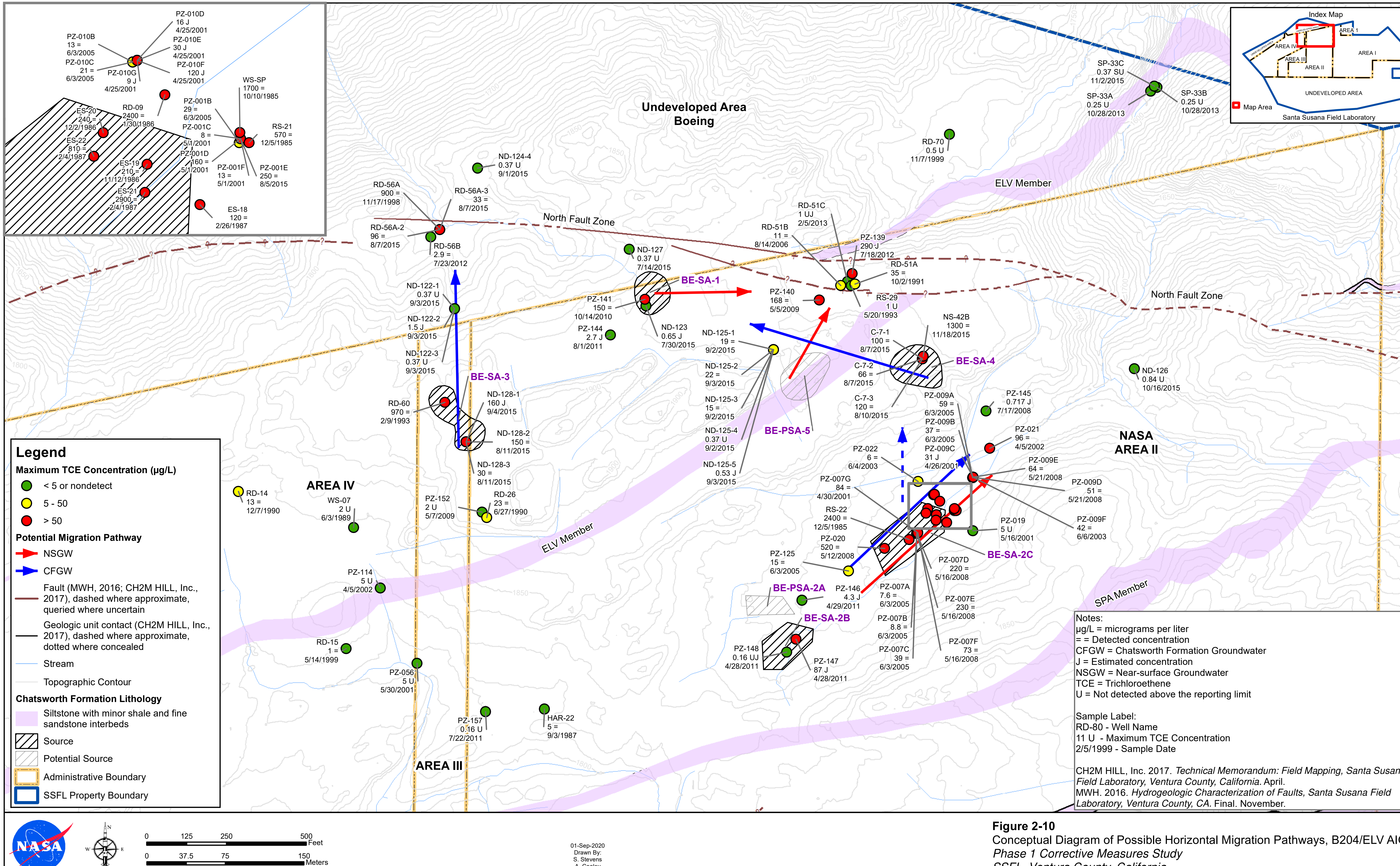
Notes:
µg/L = micrograms per liter
1,2,3-TCP = 1,2,3-Trichloropropane
cis-1,2-DCE = cis-1,2-Dichloroethene
CFGW = Chatsworth Formation Groundwater
COC = chemical of concern
NSGW = Near-surface Groundwater
TCE = Trichloroethene
VC = Vinyl chloride

1. Groundwater plume extents were evaluated three-dimensionally using the most recent groundwater data available (as of January 2016) and the location of the identified source area. Inferred groundwater flow direction, topography, and the hydraulic influence of structural features were also considered in this evaluation.
2. For the complete data set, including specific sample dates, see the Building 204 and Expendable Launch Vehicle Areas of Impacted Groundwater Data Evaluation Report (Appendix B of the NASA Groundwater RFI).
3. 1,4-dioxane detected in RD-14 and ND-126 are considered anomalous, isolated detections not connected to the BE-SA-2C, BE-SA-3, or BE-SA-4 plumes.

CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California.* April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA.* Final. November.

01-Sep-2020
Drawn By:
S. Stevens
A. Cooley

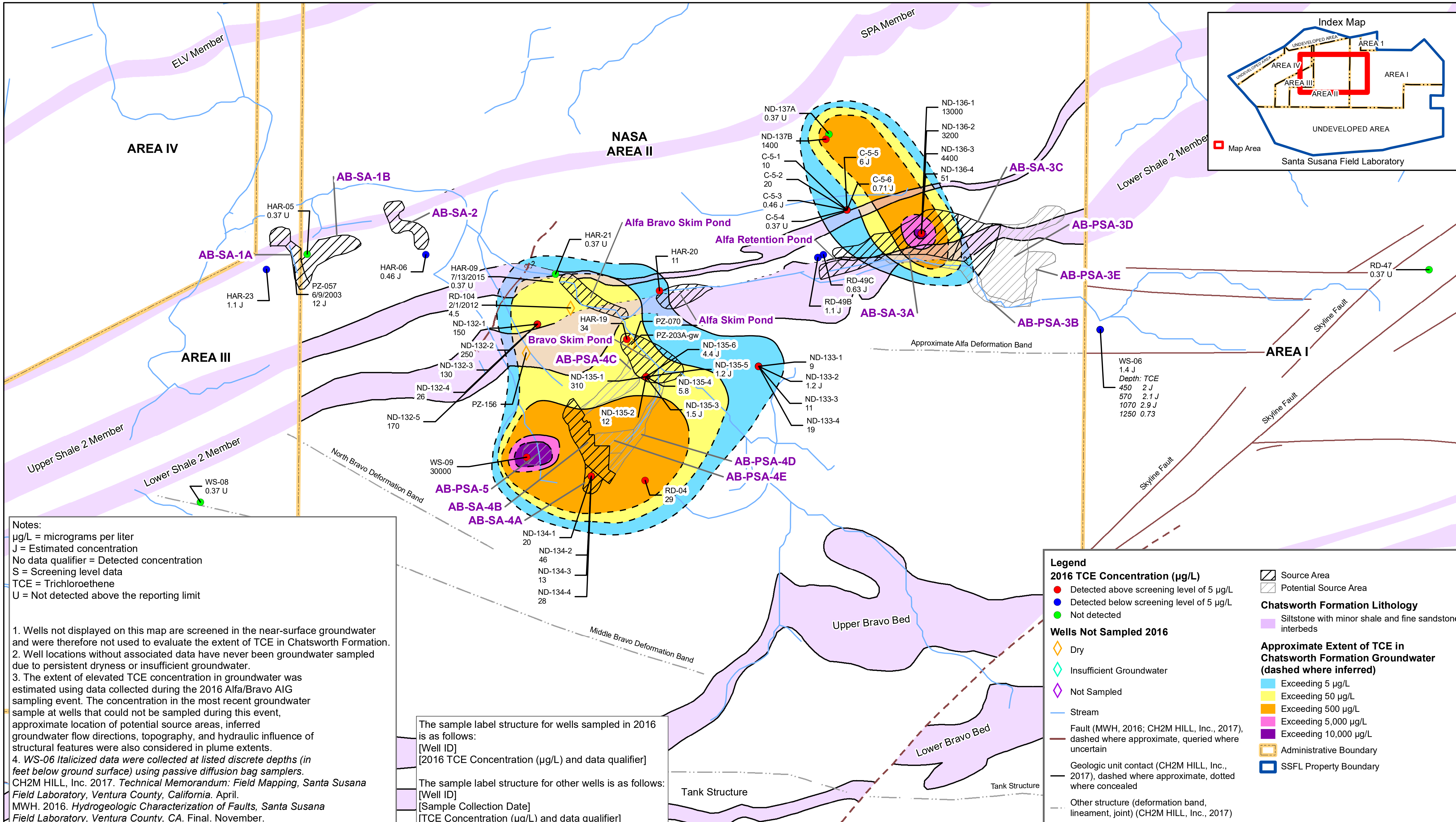
Figure 2-9
Extent of COCs in Groundwater, B204/ELV AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California



01-Sep-2020
Drawn By:
S. Stevens
A. Cooley

Figure 2-10
Conceptual Diagram of Possible Horizontal Migration Pathways, B204/ELV AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\B204_ELV_COCMigrationPath.mxd



Notes:
µg/L = micrograms per liter
J = Estimated concentration
No data qualifier = Detected concentration
S = Screening level data
TCE = Trichloroethene
U = Not detected above the reporting limit

1. Wells not displayed on this map are screened in the near-surface groundwater and were therefore not used to evaluate the extent of TCE in Chatsworth Formation.
2. Well locations without associated data have never been groundwater sampled due to persistent dryness or insufficient groundwater.
3. The extent of elevated TCE concentration in groundwater was estimated using data collected during the 2016 Alfa/Bravo AIG sampling event. The concentration in the most recent groundwater sample at wells that could not be sampled during this event, approximate location of potential source areas, inferred groundwater flow directions, topography, and hydraulic influence of structural features were also considered in plume extents.
4. *WS-06 Italicized data were collected at listed discrete depths (in feet below ground surface) using passive diffusion bag samplers.*

CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California*. April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA*. Final. November.

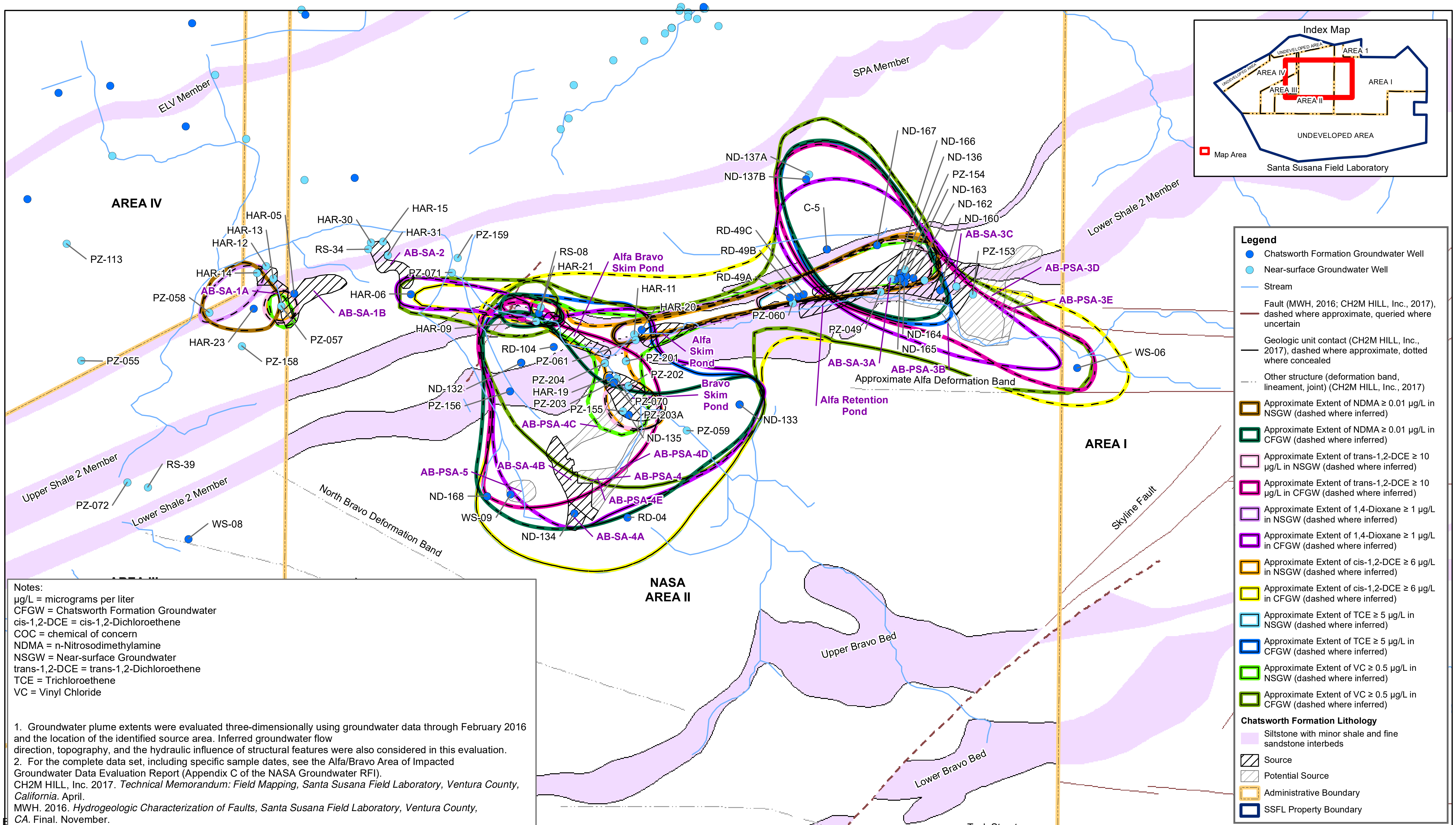
The sample label structure for wells sampled in 2016 is as follows:
[Well ID]
[2016 TCE Concentration (µg/L) and data qualifier]

The sample label structure for other wells is as follows:
[Well ID]
[Sample Collection Date]
[TCE Concentration (µg/L) and data qualifier]

07-Aug-2018
Drawn By:
A. Cooley

Figure 2-11
Extent of Trichloroethene in Chatsworth Formation Groundwater, Alfa/Bravo AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AB_TCE_Plumes.mxd



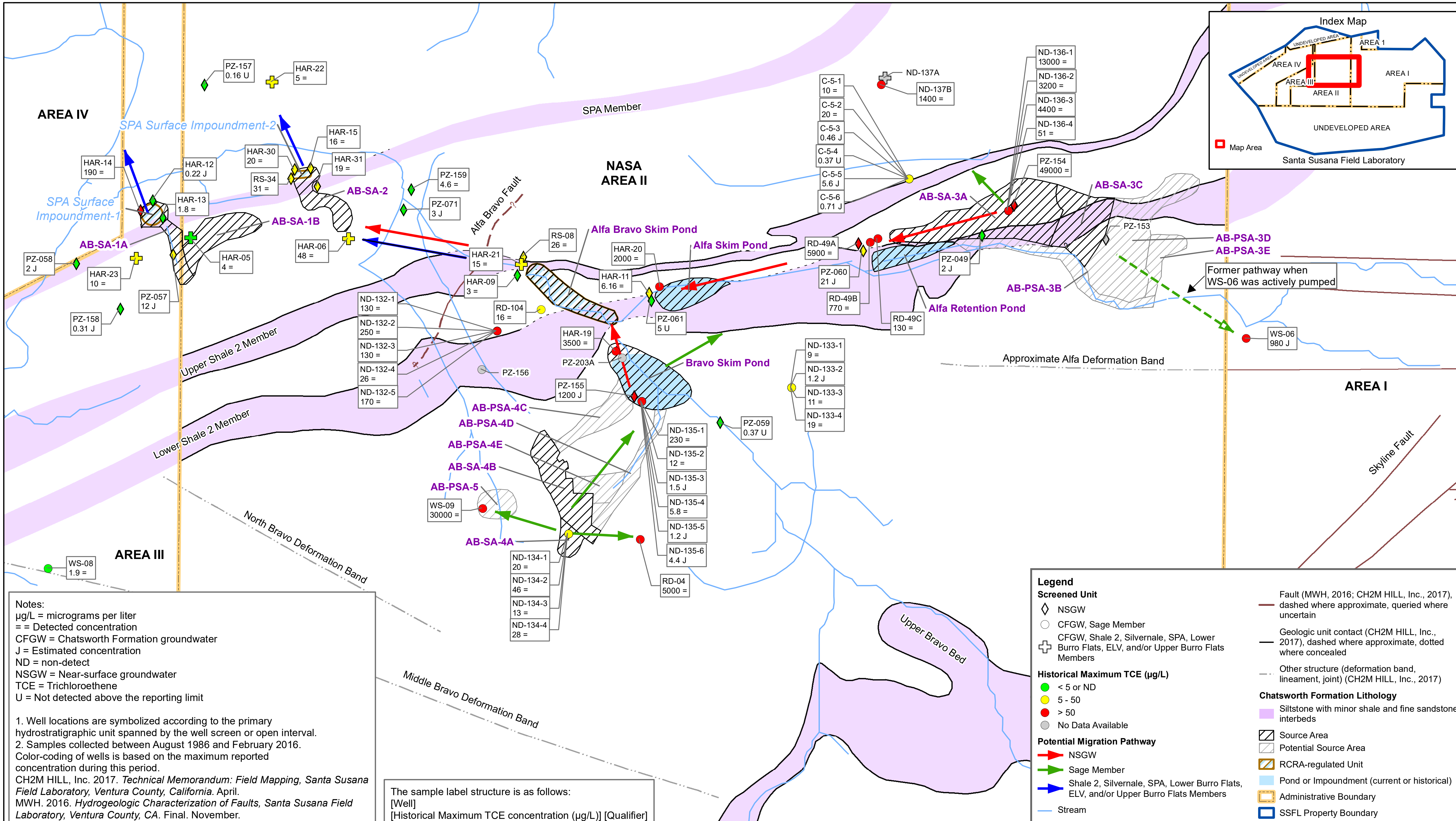
Notes:
µg/L = micrograms per liter
CFGW = Chatsworth Formation Groundwater
cis-1,2-DCE = cis-1,2-Dichloroethene
COC = chemical of concern
NDMA = n-Nitrosodimethylamine
NSGW = Near-surface Groundwater
trans-1,2-DCE = trans-1,2-Dichloroethene
TCE = Trichloroethene
VC = Vinyl Chloride

1. Groundwater plume extents were evaluated three-dimensionally using groundwater data through February 2016 and the location of the identified source area. Inferred groundwater flow direction, topography, and the hydraulic influence of structural features were also considered in this evaluation.
2. For the complete data set, including specific sample dates, see the Alfa/Bravo Area of Impacted Groundwater Data Evaluation Report (Appendix C of the NASA Groundwater RFI).
CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California*. April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA*. Final. November.

16-Oct-2023
Drawn By:
S. Stevens

Figure 2-12
Extent of COCs in Groundwater, Alfa/Bravo AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AB_GW_COCs.mxd



Notes:
µg/L = micrograms per liter
= = Detected concentration
CFGW = Chatsworth Formation groundwater
J = Estimated concentration
ND = non-detect
NSGW = Near-surface groundwater
TCE = Trichloroethene
U = Not detected above the reporting limit

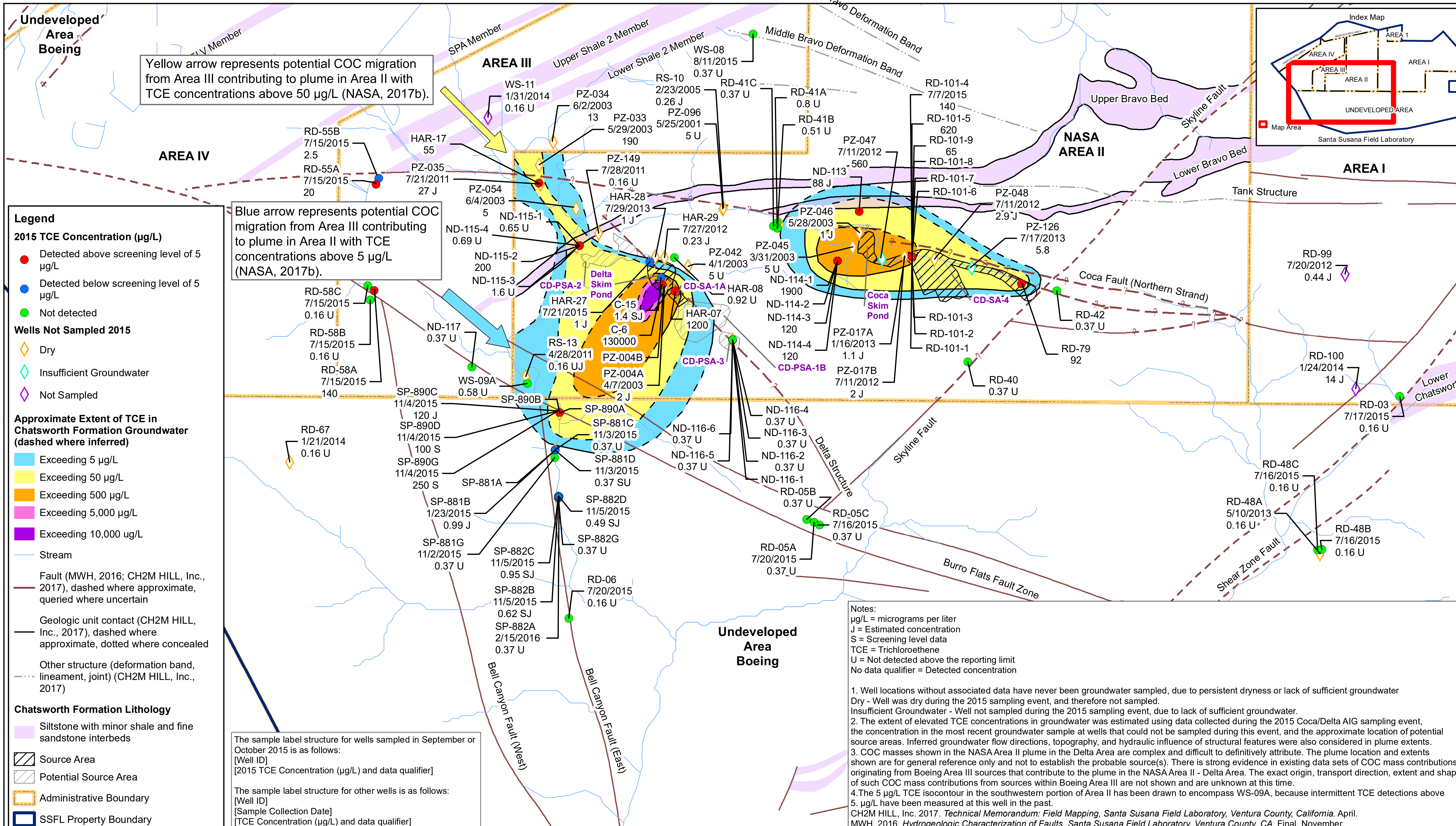
1. Well locations are symbolized according to the primary hydrostratigraphic unit spanned by the well screen or open interval.
2. Samples collected between August 1986 and February 2016. Color-coding of wells is based on the maximum reported concentration during this period.
CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California*. April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA*. Final. November.

The sample label structure is as follows:
[Well]
[Historical Maximum TCE concentration (µg/L)] [Qualifier]

07-Aug-2018
Drawn By:
A. Cooley

Figure 2-13
Conceptual Diagram of Possible Horizontal Migration Pathways, Alfa/Bravo AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

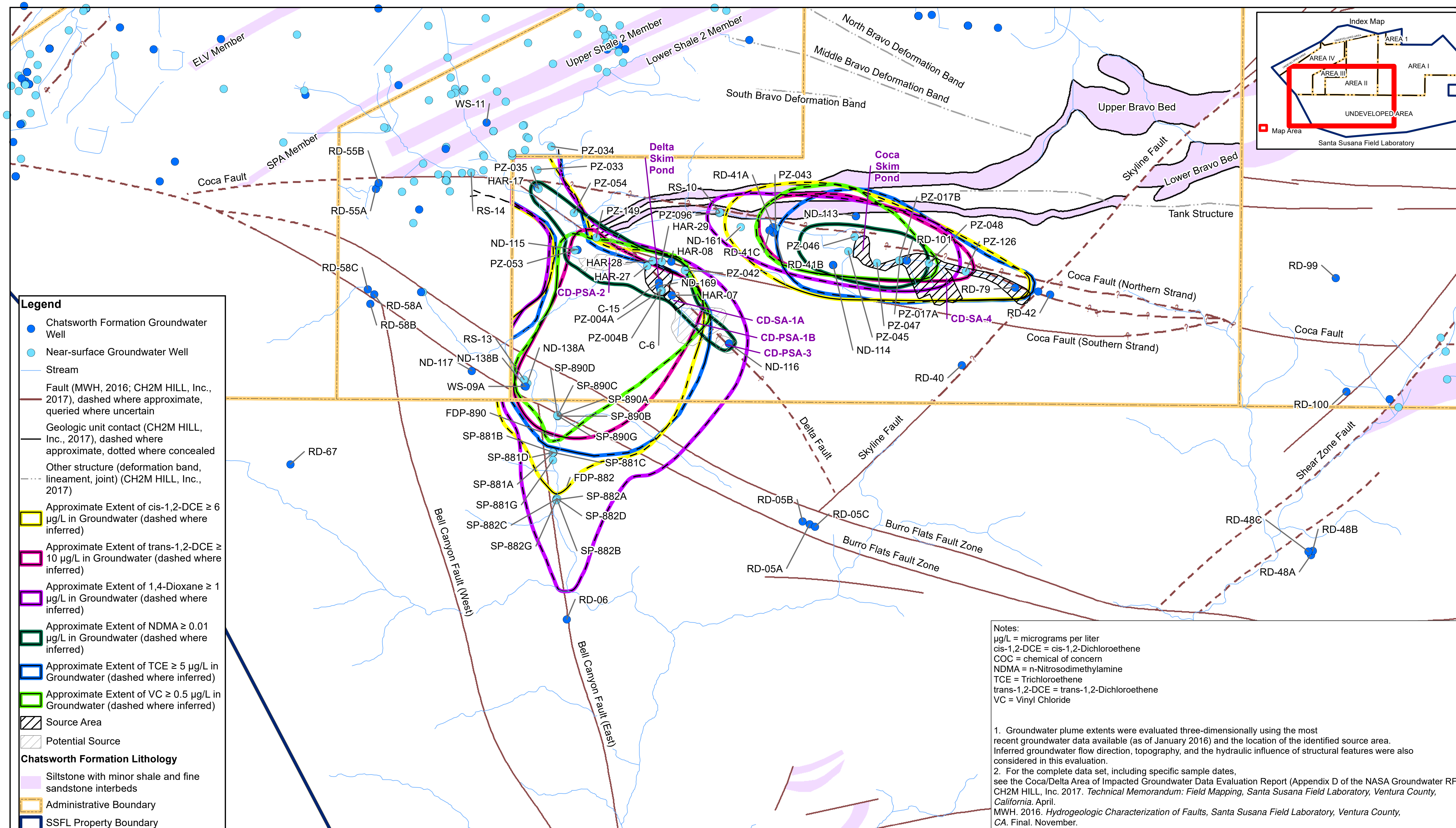
Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AB_RFI_GWCOCPathways.mxd *.ai 09-18-20



20-Jul-2018
Drawn By:
A. Cooley

Figure 2-14
Extent of Trichloroethene in Groundwater, Coca/Delta AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\CD_TCE_Plumes.mxd

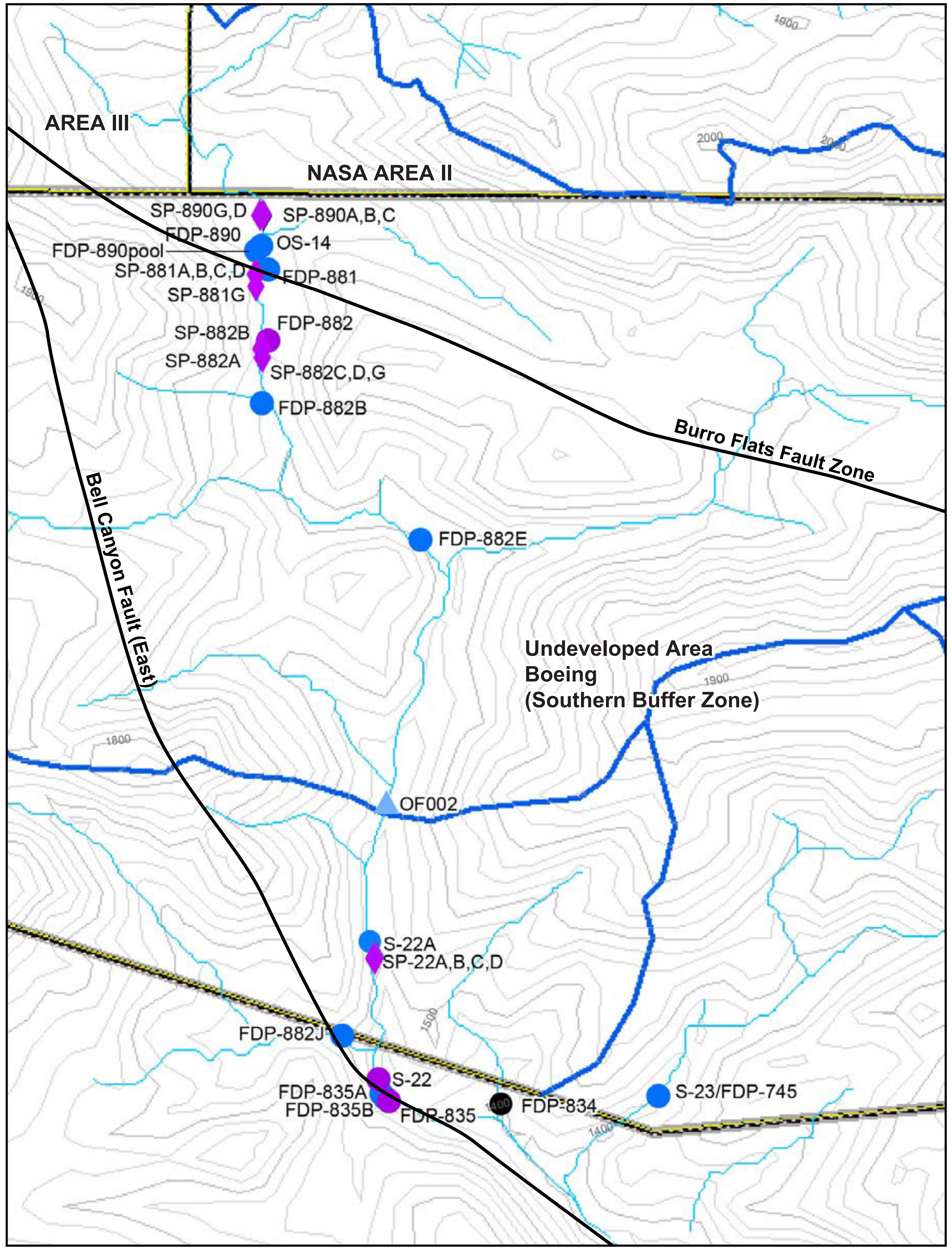


0 250 500 1,000 Feet
0 75 150 300 Meters

16-Oct-2023
Drawn By:
Erin Eppling

Figure 2-15
Extent of COCs in Groundwater, Coca/Delta AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\CD_GW_COCs.mxd



Legend

- Sampled prior to 2013 and sometime between 2013 and 2016
- Sampled sometime between 2013 and 2016
- Sampled prior to 2013
- Not sampled previously or insufficient flow for adequate sampling
- Seep Piezometer
- Drainage
- Drainage Basin Divide (if enclosed, shows extent of drainage basin)
- Topography (25 foot intervals)
- Ponds
- Administrative Boundary Areas
- SSFL Property Boundary

Notes:
Objects shown as sampled have been sampled one or more times for site related contaminants which include VOCs.

The occurrence of any seep varies in time and can be attributed to factors related to historical operational water use, the occurrence of vegetation, surface water collection features, and/or rainfall occurrence and intensity and runoff.

Modified from Figure 12 in The Boeing Company (Boeing). 2015. *Report on Seeps Investigation, Santa Susana Field Laboratory, Ventura County, California*. July.

Abbreviations:
SP - Seep Piezometer
S - Seep
OS - Off-site
FDP - Field Data Point
OF - Outfall

N

0 700 1,400 2,800 Feet

Figure 2-16
Seeps and Springs in the Vicinity of the Coca/Delta AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

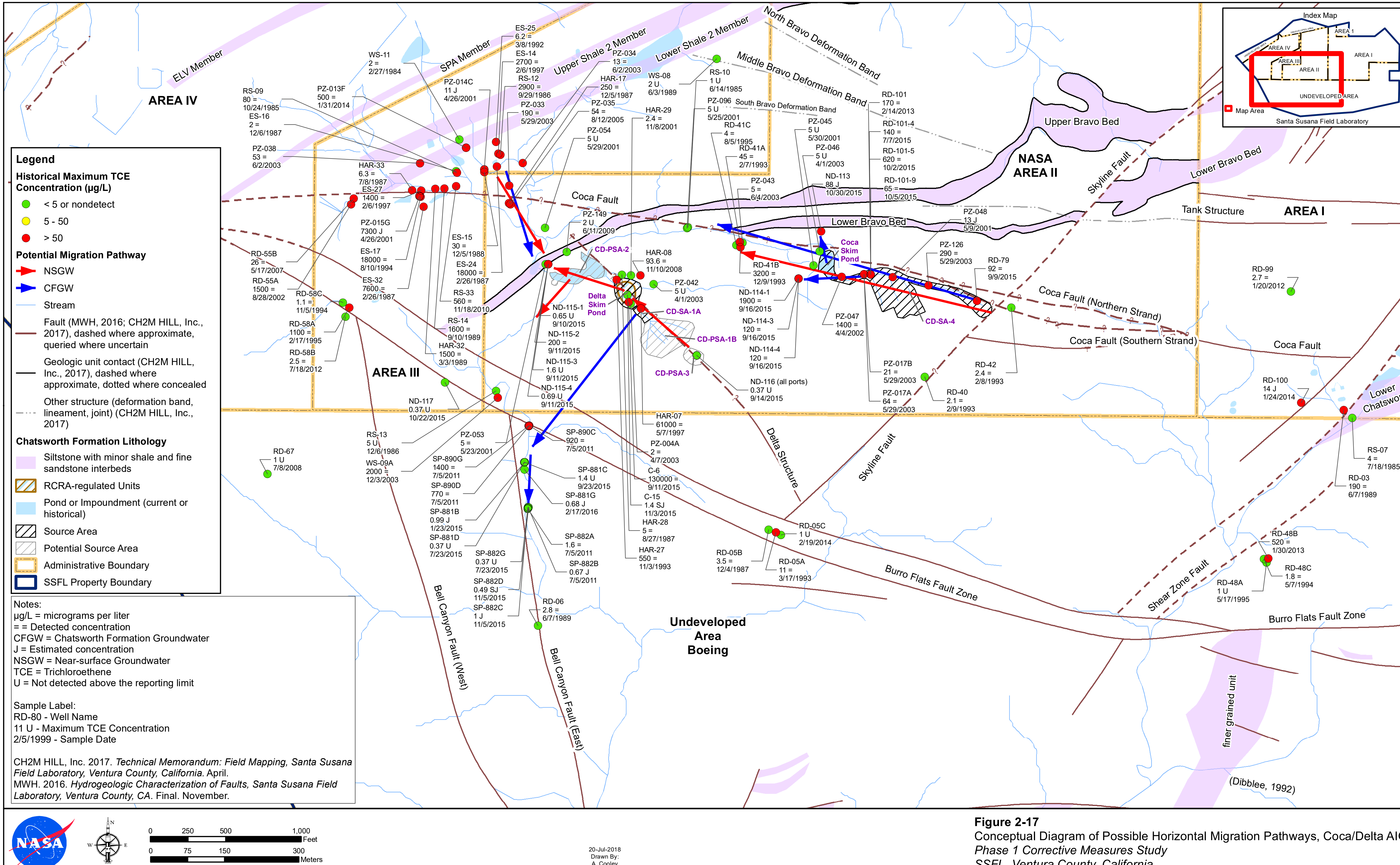


Figure 2-17
Conceptual Diagram of Possible Horizontal Migration Pathways, Coca/Delta AIG
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\CD_GW_COCMigration.mxd

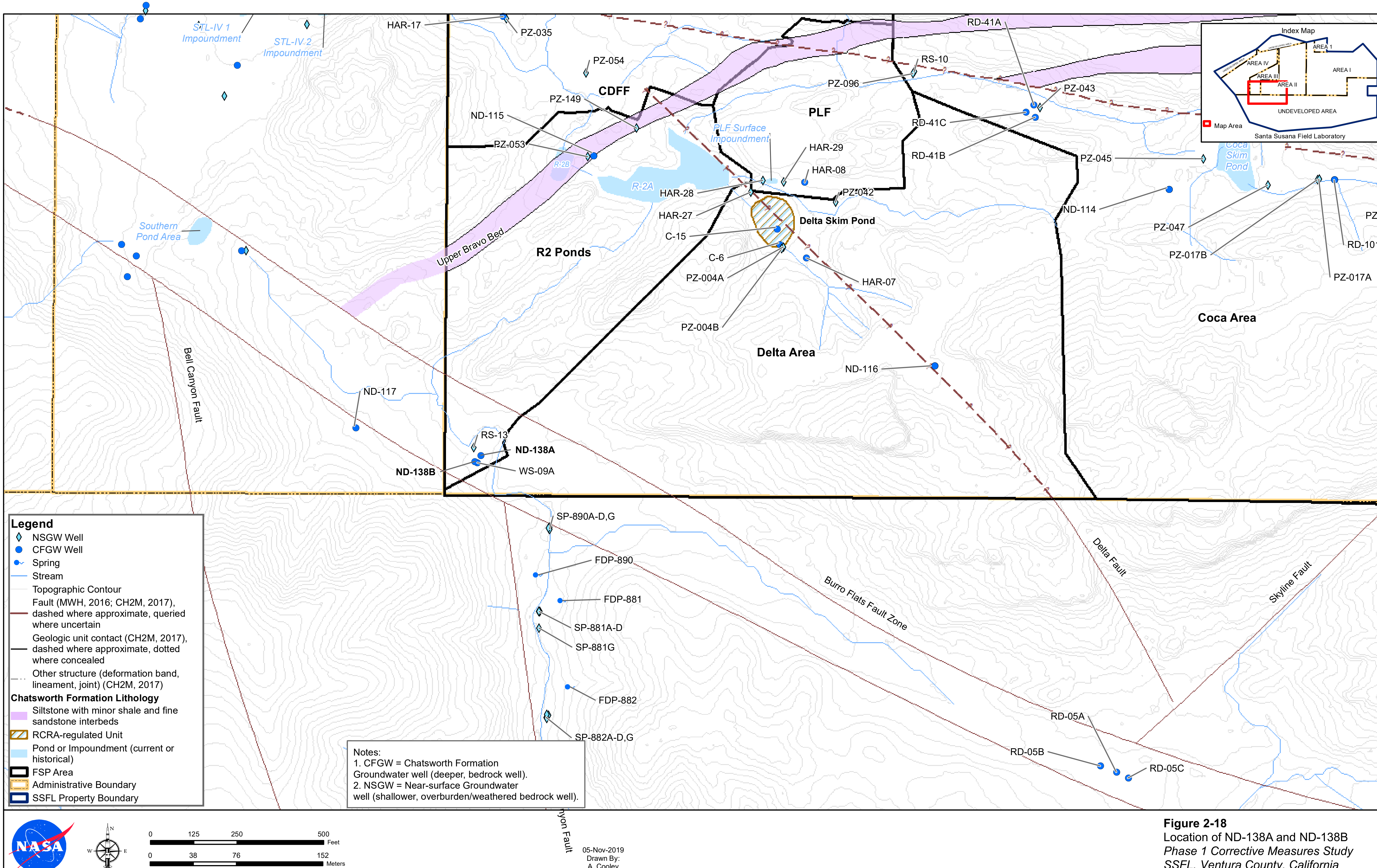


Figure 2-18
Location of ND-138A and ND-138B
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\GWIM_Summary_ND38A_138B_Loc.mxd

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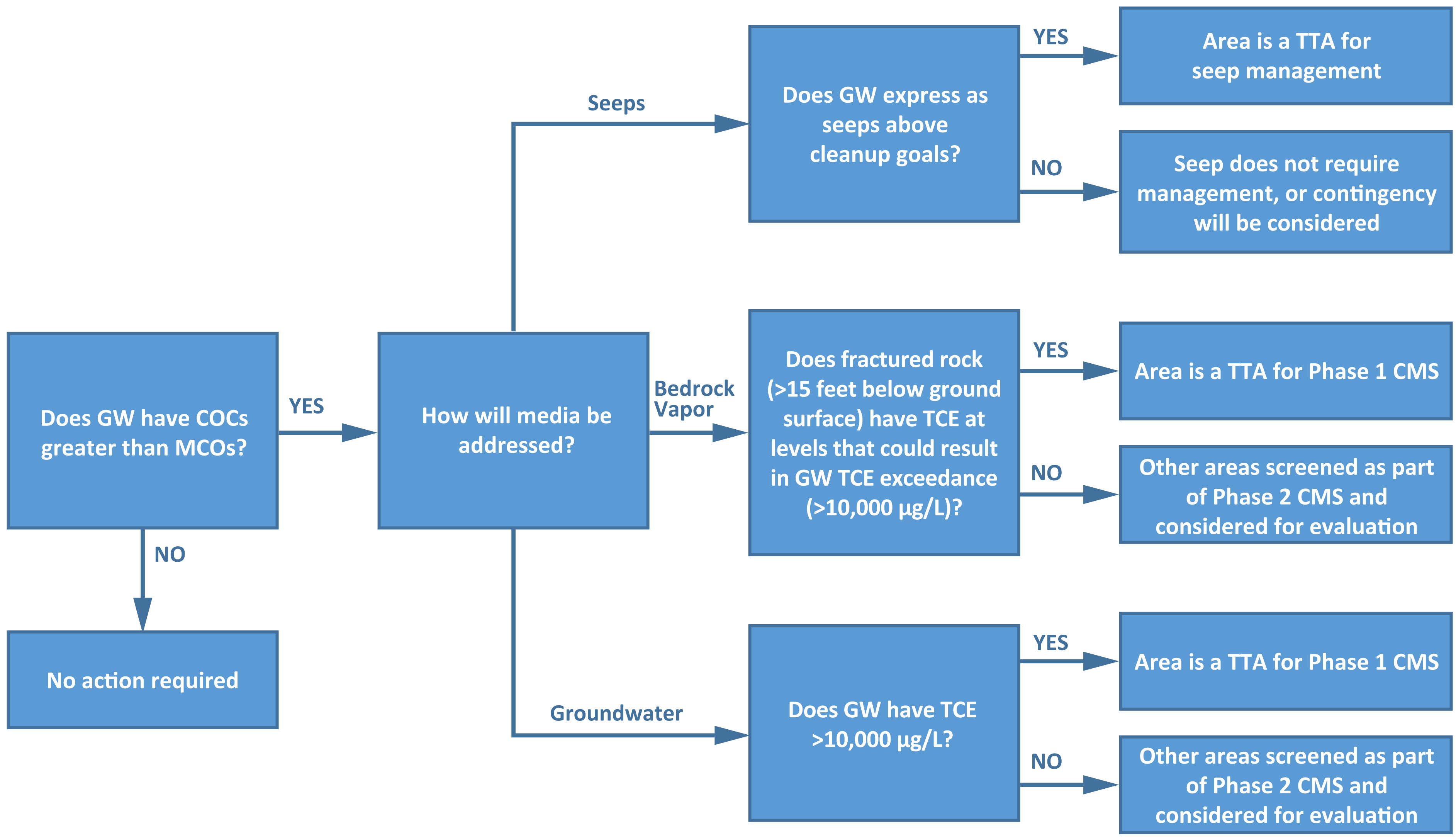

COC – chemical of concern
GW – groundwater
MCL – maximum contaminant level
MCO – media cleanup objective
MNA – monitored natural attenuation
TCE – trichloroethene
TTA – target treatment area
µg/L – micrograms per liter

Figure 4-1
Flowchart to Identify Target Treatment Areas for Groundwater
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

707597CH.01.PI 04-01 TTA flowchart groundwater.ai 10-27-23

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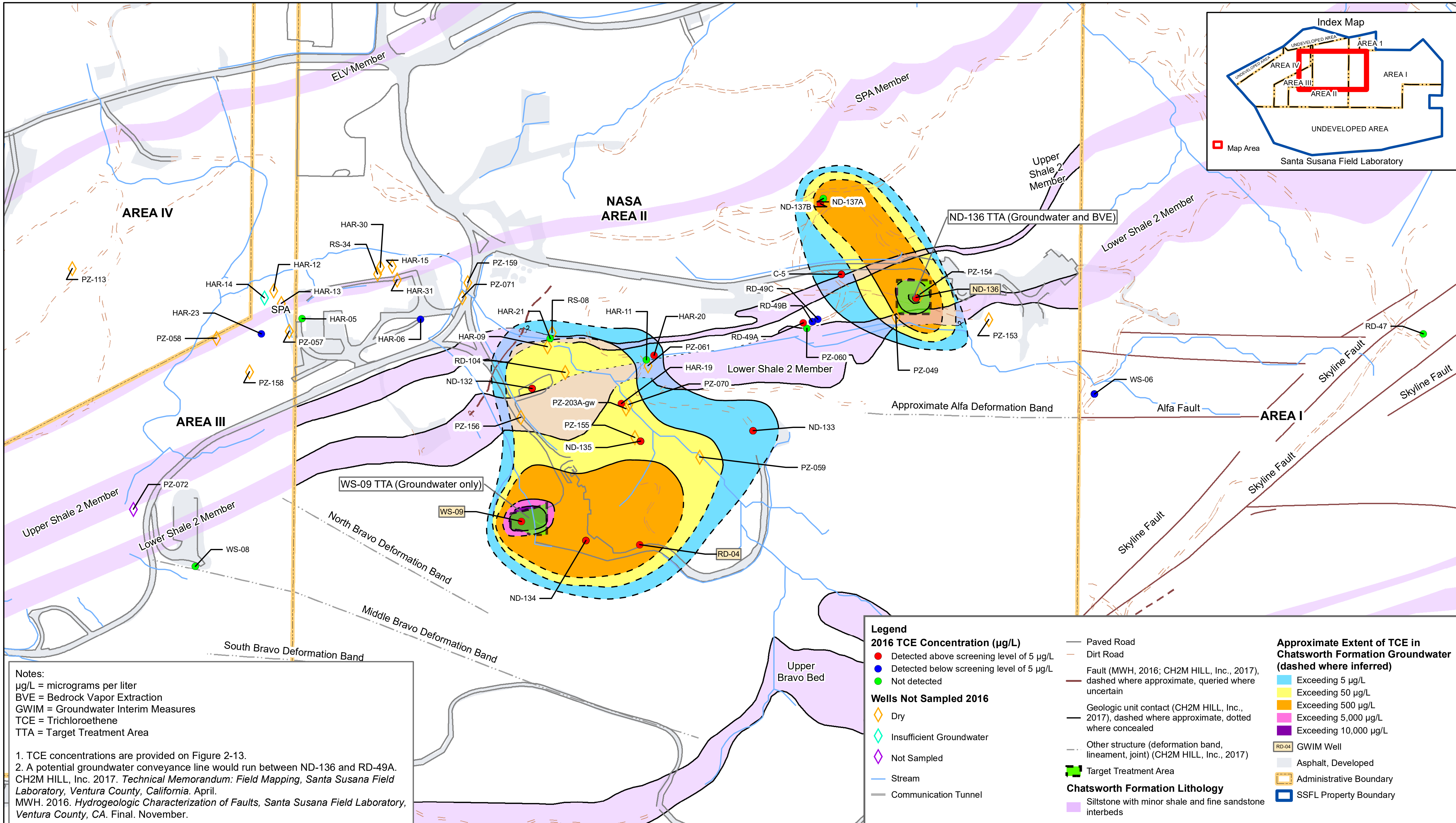


Notes:
µg/L = micrograms per liter
BVE = Bedrock Vapor Extraction
GWIM = Groundwater Interim Measures
TCE = Trichloroethene
TTA = Target Treatment Area

1. TCE concentrations are provided on Figure 2-13.
2. A potential groundwater conveyance line would run between ND-136 and RD-49A.

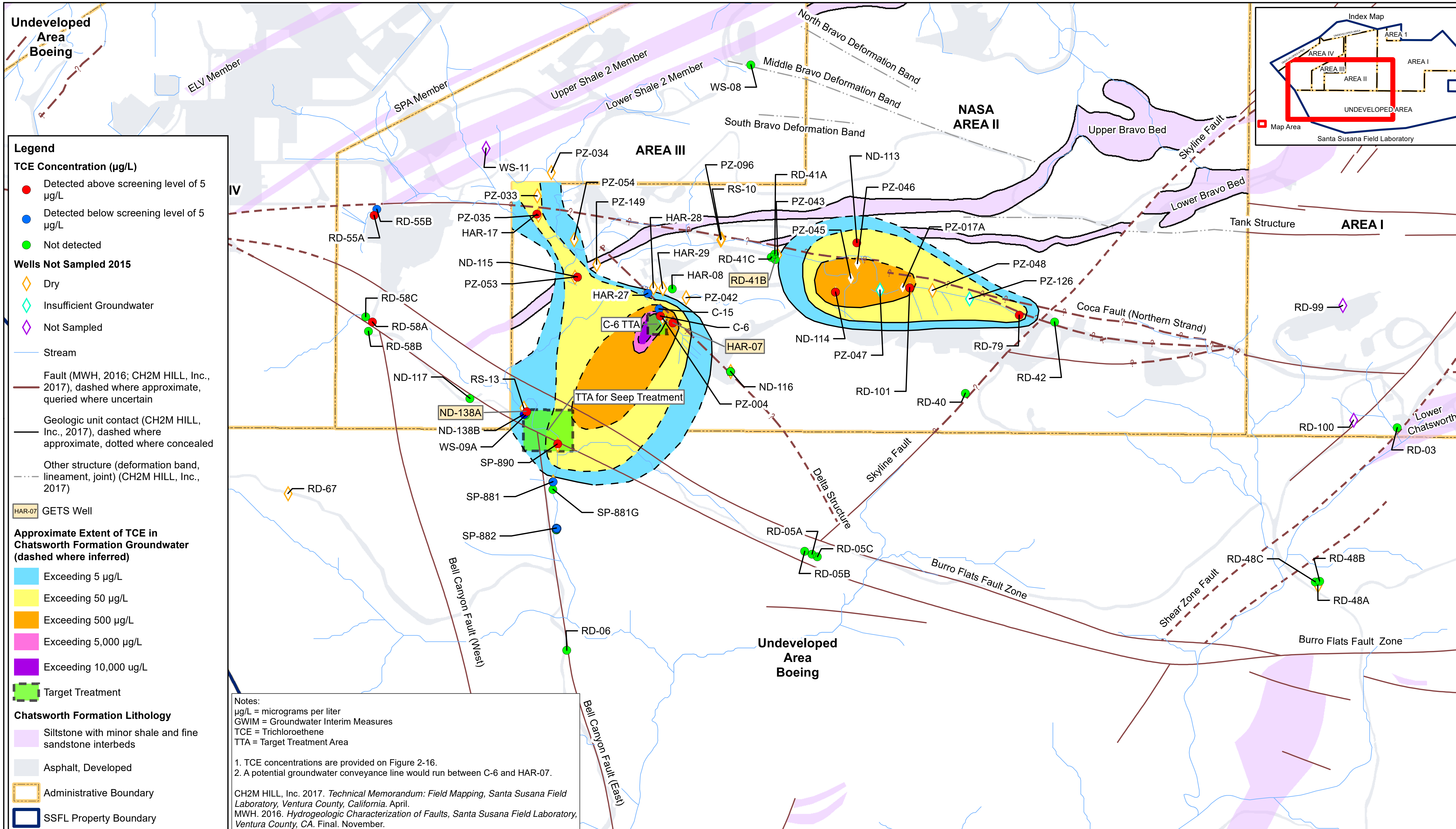
CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California*. April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA*. Final. November.

0 125 250 500 Feet
0 37.5 75 150 Meters

19-Jul-2018
Drawn By:
A. Cooley

Figure 4-2
Target Treatment Areas for Groundwater and Bedrock Vapor in ND-136 and WS-09 Areas
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AB_TargetTreatment.mxd



Notes:
µg/L = micrograms per liter
GWIM = Groundwater Interim Measures
TCE = Trichloroethene
TTA = Target Treatment Area

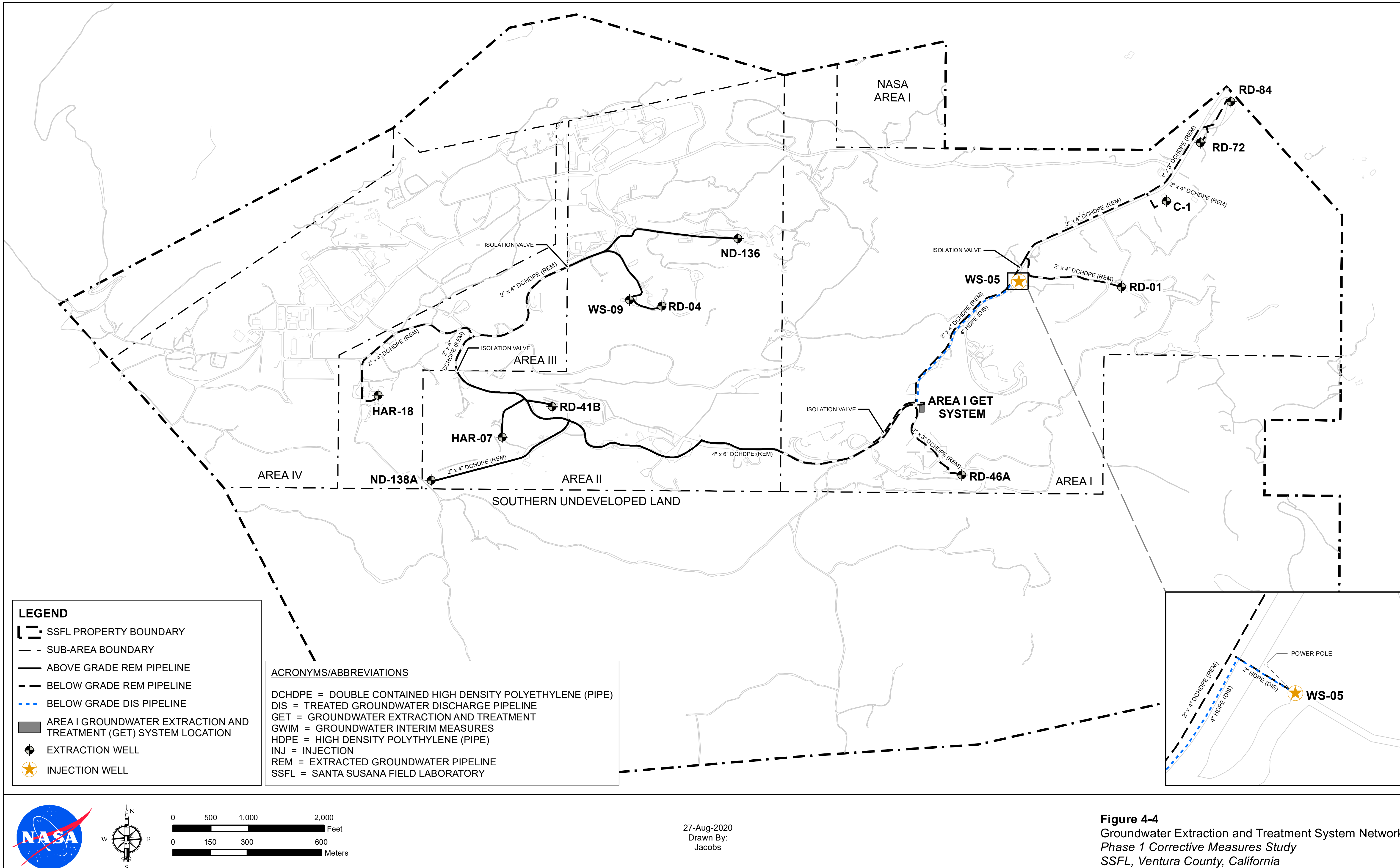
1. TCE concentrations are provided on Figure 2-16.
2. A potential groundwater conveyance line would run between C-6 and HAR-07.

CH2M HILL, Inc. 2017. *Technical Memorandum: Field Mapping, Santa Susana Field Laboratory, Ventura County, California*. April.
MWH. 2016. *Hydrogeologic Characterization of Faults, Santa Susana Field Laboratory, Ventura County, CA*. Final. November.

25-Aug-2020
Drawn By:
S. Stevens
A. Cooley

Figure 4-3
Target Treatment Area for Groundwater in Delta Area and Southern Seep Area
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

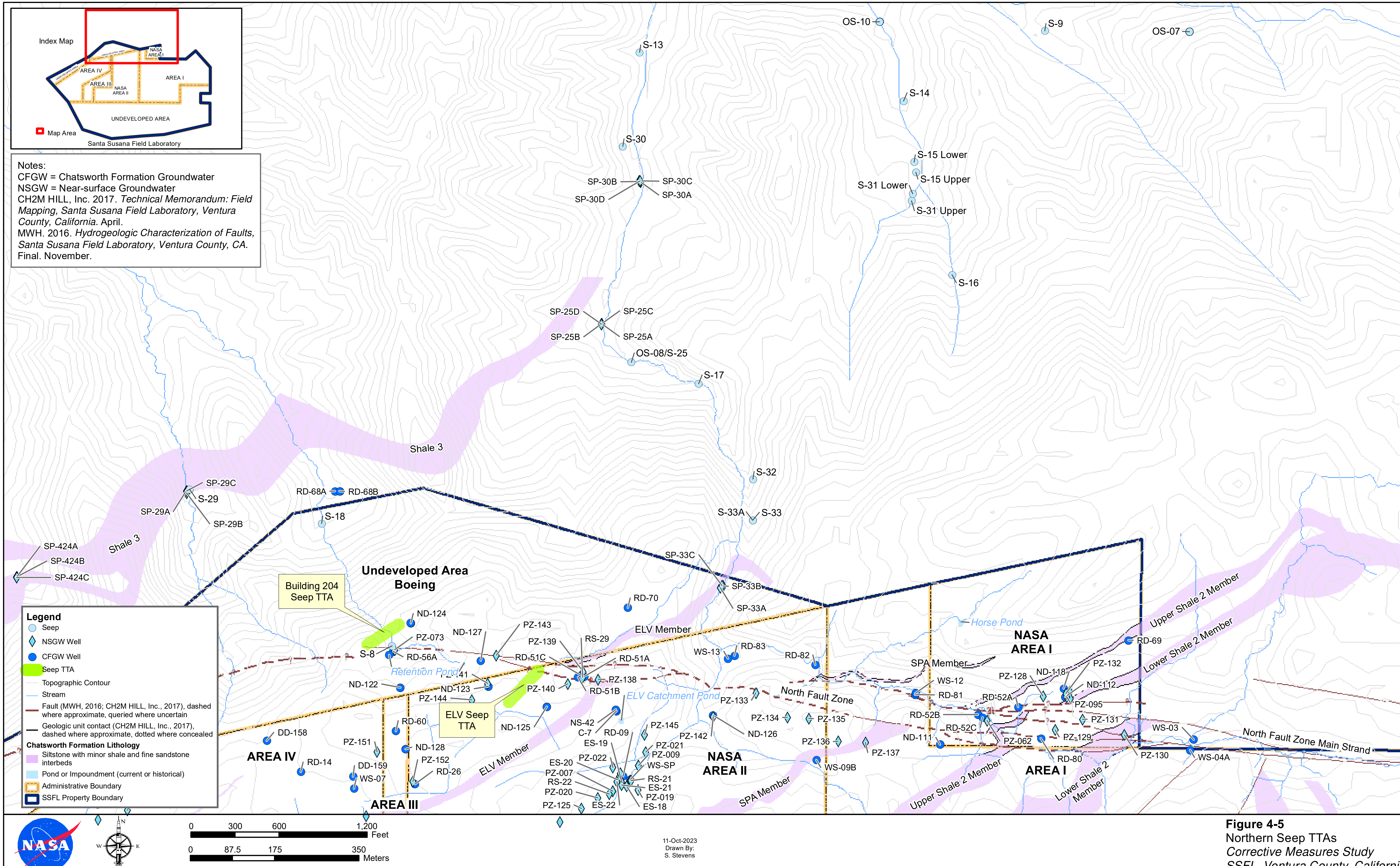
Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\CD_DeltaTargetTreatment.mxd



27-Aug-2020
Drawn By:
Jacobs

Figure 4-4
Groundwater Extraction and Treatment System Network
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: D:\GIS Projects\NASA\MXDs\CMS\CMS_GETS_Layout.mxd kremmen



11-Oct-2023
Drawn By:
S. Stevens

Figure 4-5
Northern Seep TTAs
Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\BE_LOX_SeepCMS.mxd

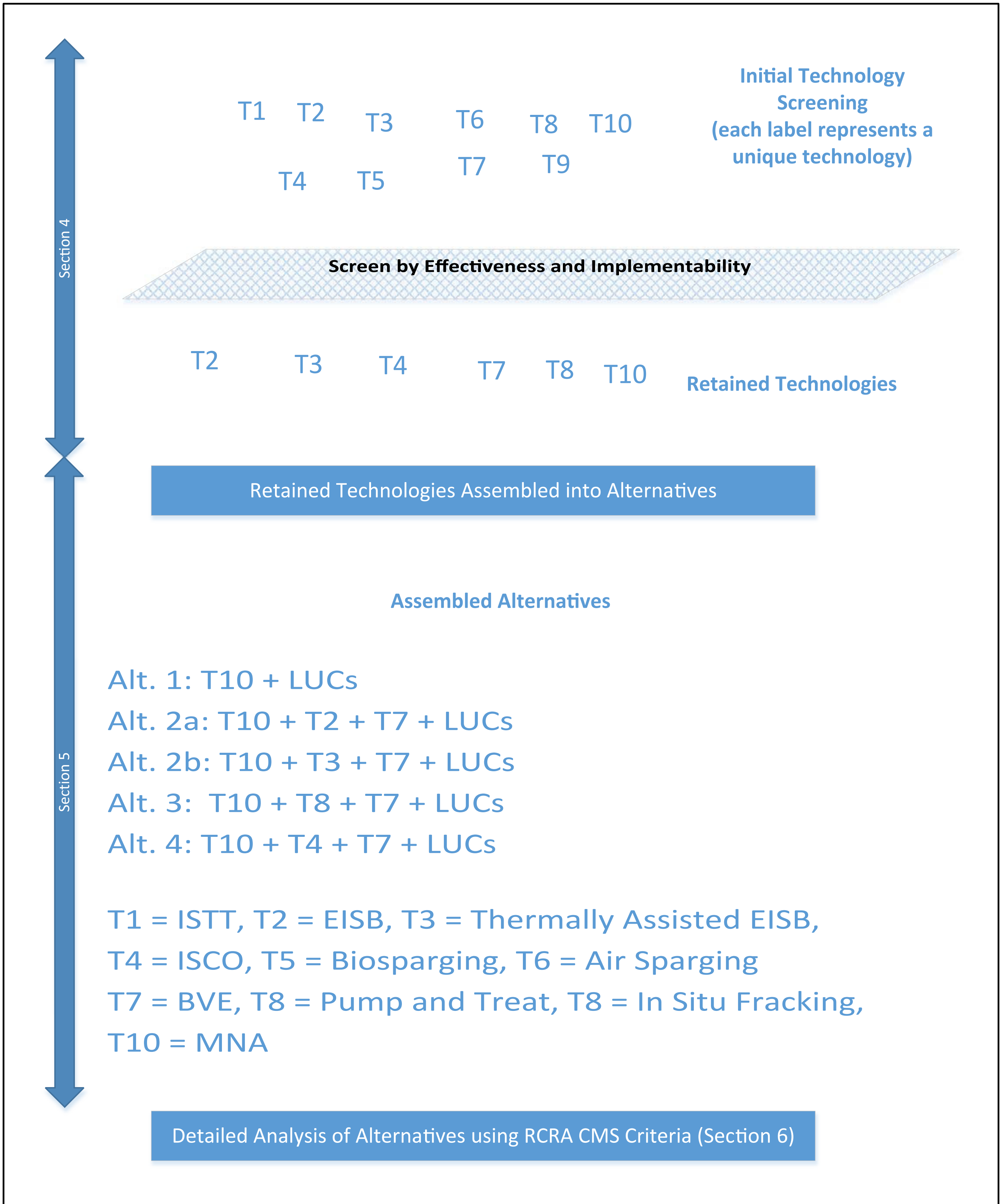


Figure 4-6
Technology Identification and Screening, and Alternative Development
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

707597CH.01.01 SSFL_tech_id_CMS_v2.ai 09-18-20

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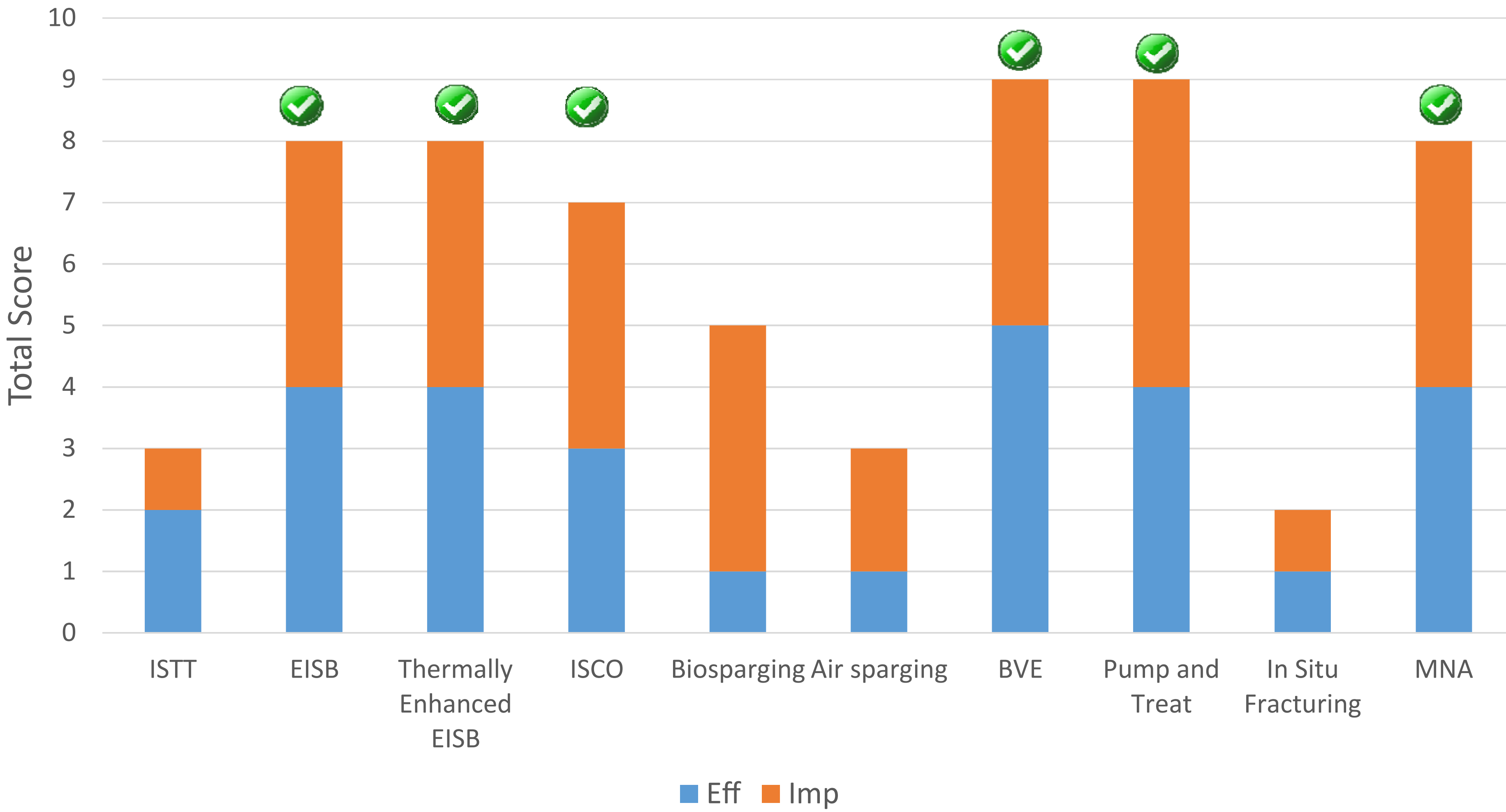


Figure 4-7
Summaries of Scores for Screened Technologies - Phase 1 Groundwater Areas
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

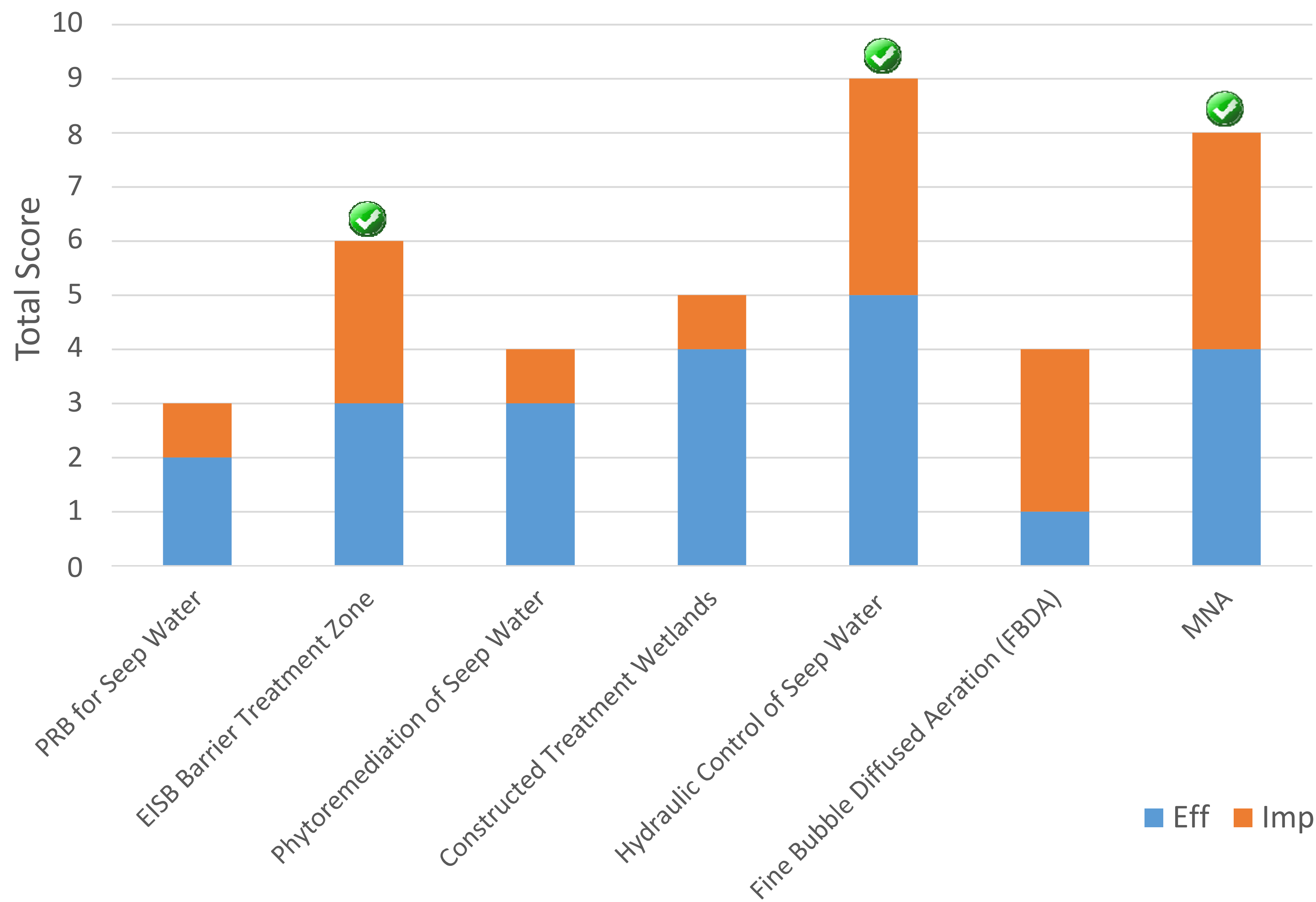
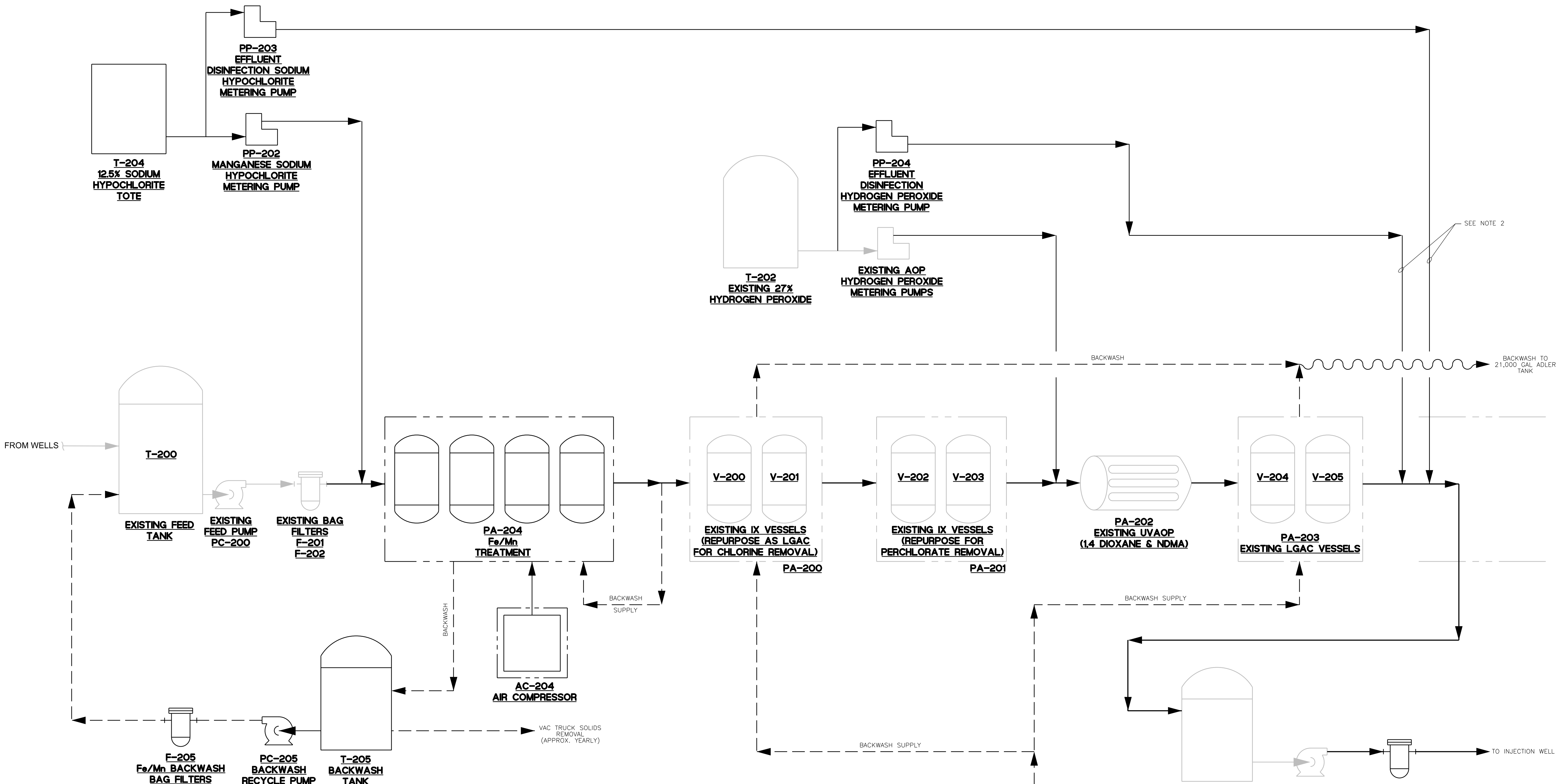


Figure 4-8
Summaries of Scores for Screened Technologies - Seep Areas
Phase 1 Corrective Measures Study
SSFL, Ventura County, California



RECORD DRAWINGS

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. THE ENGINEER WILL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS WHICH HAVE BEEN INCORPORATED INTO THE RECORD DRAWINGS.

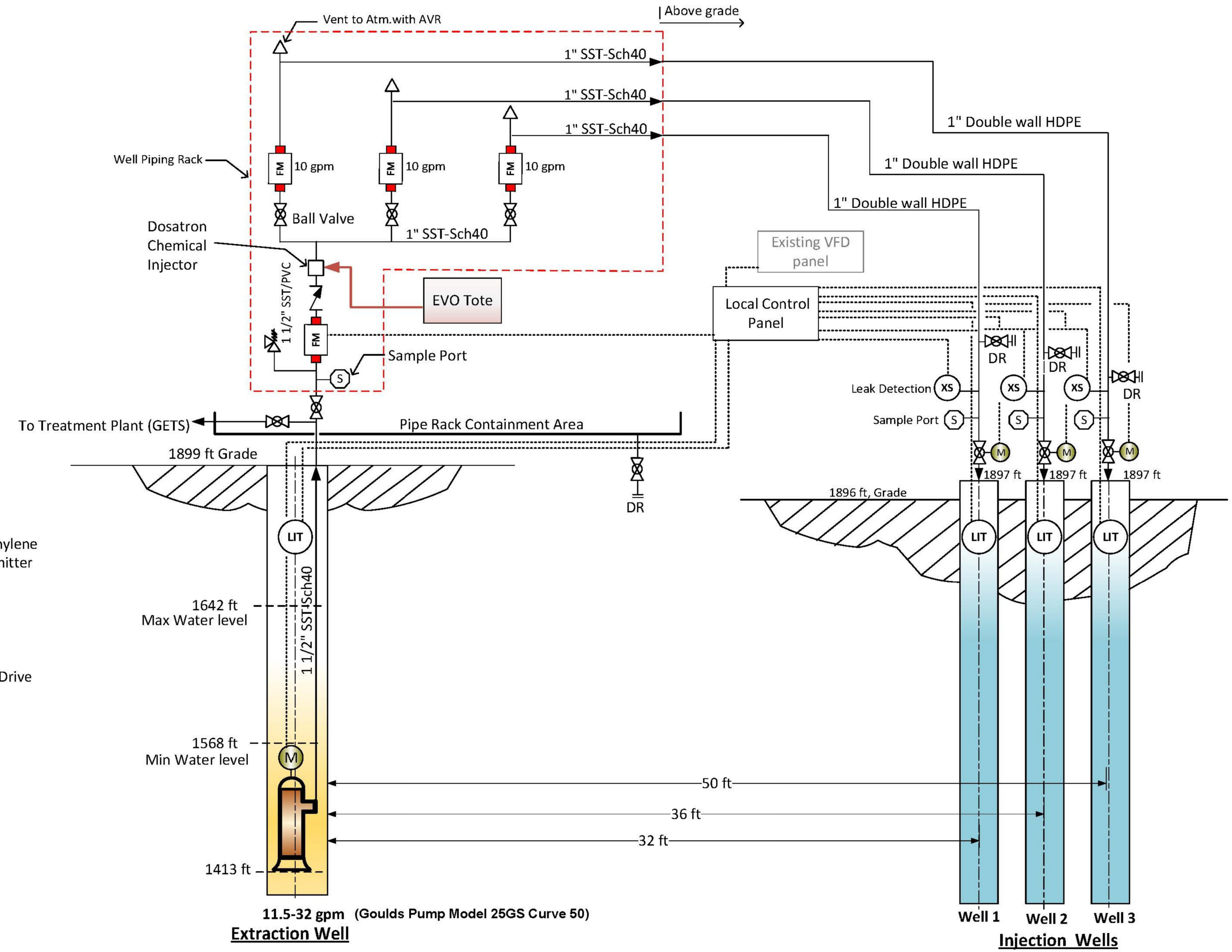
NOTES:

1. NEW EQUIPMENT SHOWN IN BOLD; EXISTING EQUIPMENT IS SCREENED BACK.
2. CAPABILITY TO DISINFECT FINAL EFFLUENT WITH EITHER HYDROGEN PEROXIDE OR SODIUM HYPOCHLORITE.
3. DASHED LINES INDICATE PERIODIC FLOWS.

Figure 6-1
Groundwater Extraction and Treatment System Process Flow Diagram
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Figure 6-2
Conceptual EISB Layout for ND-136 TTA
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\EISB_PilotStudy\AB_ND136_CMS_2408.mxd



Legend

ATM: Atmospheric
DR : Drain
Ft : feet
FM : Flowmeter
HDPE: High Density Polyethylene
LIT :Level Indictor Transmitter
PVC : Polyvinyl chloride
Sch : Schedule
S : Sample Port
SP : Set Point
SST : Stainless Steel
VFD : Variable Frequency Drive

Figure 6-3
EISB Process Flow Diagram
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

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	Alternative 1 - MNA and LUCs	Alternative 2a - EISB, BVE, MNA, and LUCs	Alternative 2b - Thermally Assisted EISB, BVE, MNA, and LUCs	Alt 3 - P&T, BVE, MNA, and LUCs	Alt 4 - ISCO, BVE, MNA, and LUCs
Protection of Human Health and Environment	3	4	4	4	3.5
Attain Media Cleanup Objectives	1	3	3	3	2
Control Source Releases	1	5	5	5	5
Long-term Effectiveness	1.7	5.0	5.0	5.0	4.7
Reliability	3	5	5	5	4
Assessment of Long-term Performance and Effectiveness	1	5	5	5	5
Residual Risks	1	5	5	5	5
Reduction in Toxicity, Mobility, and Volume	1.5	4.4	4.4	4.9	3.6
Toxicity	1	4	4	5	3
Mobility	1	4	4	5	3
Volume	1	5	5	5	4
Irreversibility of Treatment	3	5	5	5	4
Types of Treatment Residuals	2	3.5	3.5	4.5	3.5
Amount of Hazardous Constituents that will be Treated	1	5	5	5	4
Short-term Effectiveness	4.7	3.8	3.7	2.7	3.7
Community Protection	5	5	5	5	5
Worker Protection	4	3.5	3	2	3
Environmental Impacts	5	3	3	1	3
Implementability (ND-136 and WS-09)	4.0	4.8	4.6	5.0	4.8
Implementability (C-6)	4.0	4.5	4.4	5.0	4.5
Construction and Operation (ND-136 and WS-09)	5	4	3.5	5	4
Construction and Operation (C-6)	5	3	2.5	5	3
Administrative Feasibility	1	5	5	5	5
Availability of Services and Materials	5	5	5	5	5
Permitting	5	5	5	5	5
Cost	5.0	2.5	1.5	3.8	2.0
Capital Cost	5	2	1	4.5	2
Annual O&M Cost (first 30 years)	5	3	2	3	2
Total Score (ND-136 and WS-09)	**21.9**	**32.5**	**31.2**	**33.4**	**29.3**
Total Score (C-6)	**21.9**	**32.2**	**31.0**	**33.4**	**29.0**
Time to Achieve MCOs	**190 Yrs (ND-136) 360 Yrs (WS-09) 270 Yrs (C-6)**	**140 Yrs (ND-136) 275 Yrs (WS-09) 215 Yrs (C-6)**	**140 Yrs (ND-136) 275 Yrs (WS-09) 215 Yrs (C-6)**	**140 Yrs (ND-136) 275 Yrs (WS-09) 215 Yrs (C-6)**	**140 Yrs (ND-136) 275 Yrs (WS-09) 215 Yrs (C-6)**
Capital Cost	**$ 220,000**	**$ 11,374,940**	**$ 14,641,459**	**$ 1,442,177**	**$ 11,634,472**
Present Value (2%) O&M Costs (excluding monitoring and LUC mgmt)	**$ -**	**$ 12,067,640**	**$ 12,776,731**	**$ 11,642,387**	**$ 12,830,010**
Present Value (2%) O&M Costs (monitoring and LUC mgmt)	**$ 7,111,000**	**$ 7,111,000**	**$ 7,111,000**	**$ 7,111,000**	**$ 7,111,000**
Total 30 Year Present Value (2% Costs)	**$ 7,331,000**	**$ 30,553,580**	**$ 34,529,190**	**$ 20,195,564**	**$ 31,575,482**

Figure 6-4

Comparative Analysis of Groundwater Alternatives - Scores

Phase 1 Corrective Measures Study

SSFL, Ventura County, California

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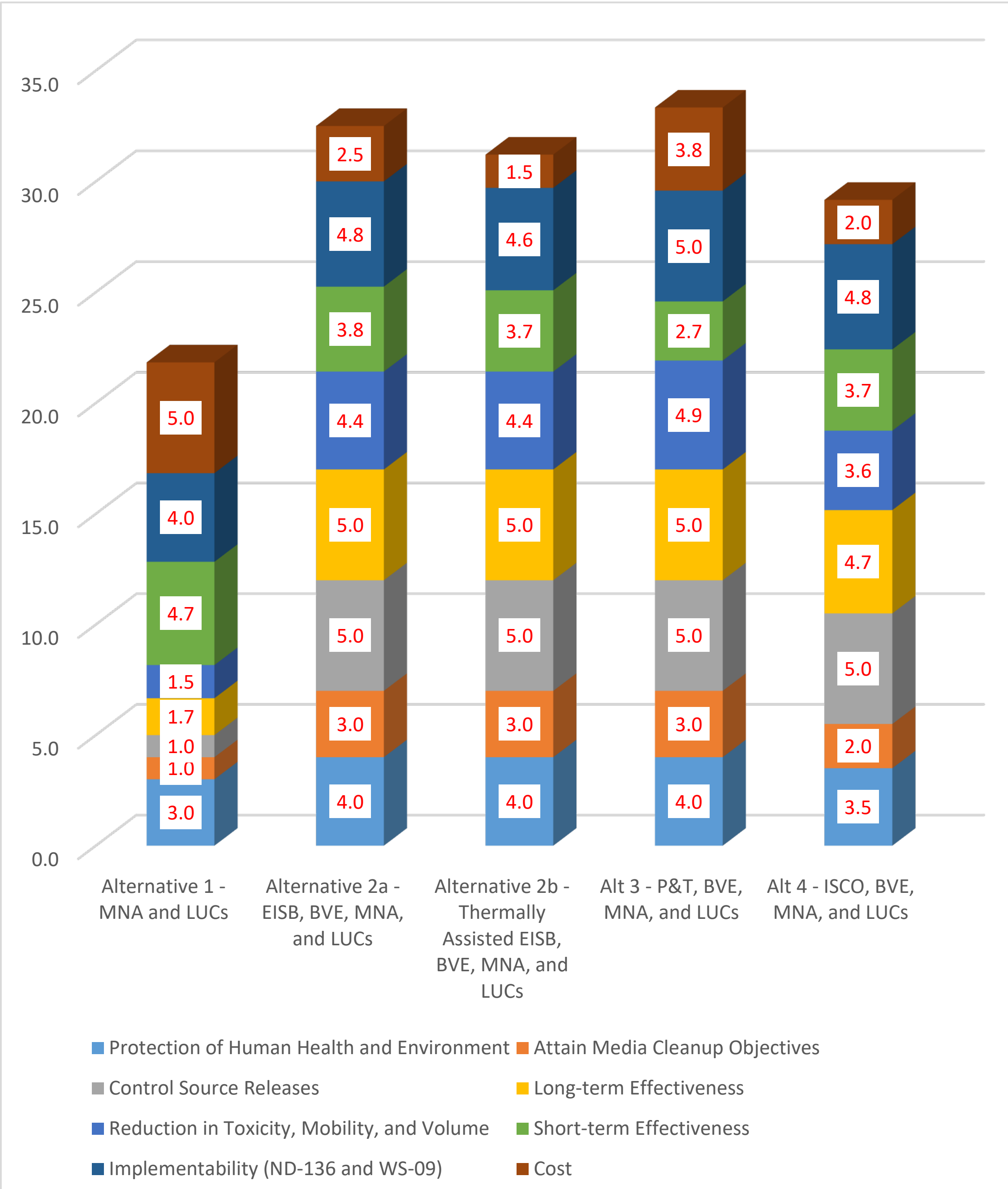

Figure 6-5A

Comparative Analysis of Groundwater Alternatives - Graphical Summary for ND-136 and WS-09 TTA

Phase 1 Corrective Measures Study

SSFL, Ventura County, California

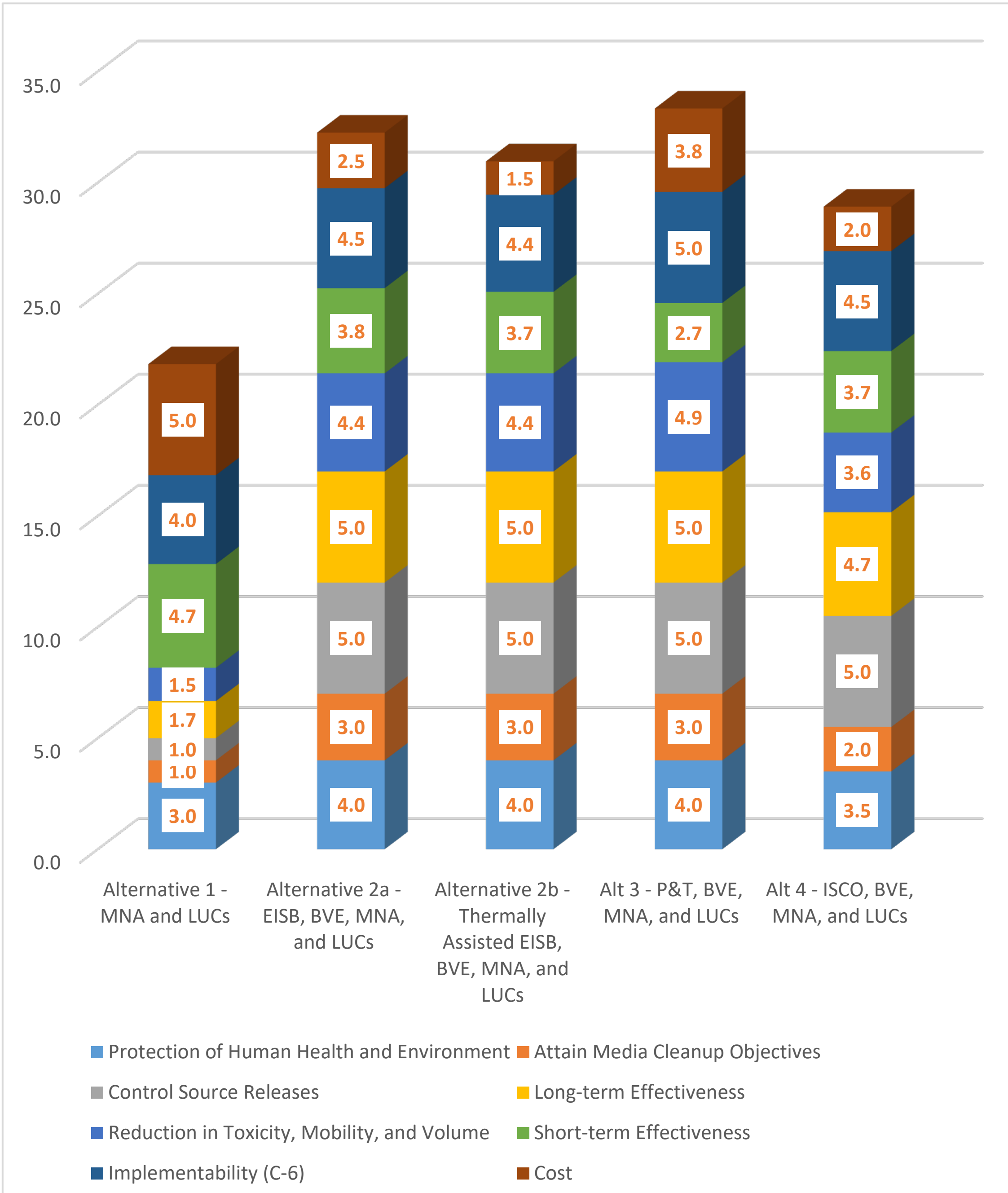

Figure 6-5B
Comparative Analysis of Groundwater Alternatives - Graphical Summary for C-6 TTA
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

	Alternative SP1 (North) - Contingency, MNA and LUCs	Alternative SP1 (South) - MNA and LUCs	Alternative SP2 (North) - Contingency, Hydraulic Containment and LUCs	Alternative SP2 (South) - Hydraulic Containment and LUCs	Alternative SP3 (North) - Contingency, EISB Treatment Zone and LUCs	Alternative SP3 (South) - EISB Treatment Zone and LUCs
Protection of Human Health and Environment	5	5	5	5	3	3
Attain Media Cleanup Objectives	1	1	3	3	2	2
Control Source Releases	NA	NA	NA	NA	NA	NA
Long-term Effectiveness	4.3	3.7	4.7	5.0	4.3	4.3
Reliability	3	1	4	5	3	3
Assessment of Long-term Performance and Effectiveness	5	5	5	5	5	5
Residual Risks	5	5	5	5	5	5
Reduction in Toxicity, Mobility, and Volume	2.0	2.0	4.8	4.9	4.0	4.2
Toxicity	1	1	5	5	4	4
Mobility	1	1	5	5	4	4
Volume	1	1	4	5	3	4
Irreversibility of Treatment	3	3	5	5	5	5
Types of Treatment Residuals	3	3	4.5	4.5	4	4
Amount of Hazardous Constituents that will be Treated	3	3	5	5	4	4
Short-term Effectiveness	4.7	4.7	2.7	2.7	3.7	3.7
Community Protection	5	5	5	5	5	5
Worker Protection	4	4	2	2	3	3
Environmental Impacts	5	5	1	1	3	3
Implementability	5.0	4.0	5.0	5.0	4.5	5.0
Construction and Operation	5	5	5	5	3	5
Administrative Feasibility	5	1	5	5	5	5
Availability of Services and Materials	5	5	5	5	5	5
Permitting	5	5	5	5	5	5
Cost	5.0	5.0	2.5	4.0	2.0	5.0
Capital Cost	5	5	2	5	1	5
Annual O&M Cost (10 years)	5	5	3	3	3	5
Total Score	**27.0**	**25.4**	**27.7**	**29.6**	**23.5**	**27.2**
Time to Achieve MCOs	**Uncertain**	**Uncertain**	**Uncertain**	**Uncertain**	**Uncertain**	**Uncertain**
Capital Cost	**$ 48,090**	**$ 48,090**	**$ 3,832,840**	**$ 48,090**	**$ 6,439,651**	**$ 230,944**
Present Value (2%) O&M Costs	**$ 1,144,000**	**$ 572,000**	**$ 1,968,000**	**$ 2,178,000**	**$ 2,228,400**	**$ 709,000**
Total 30 Year Present Value (2% Costs)	**$ 1,192,090**	**$ 620,090**	**$ 5,800,840**	**$ 2,226,090**	**$ 8,668,051**	**$ 939,944**

Figure 6-6
Comparative Analysis of Seep Alternative - Scores
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

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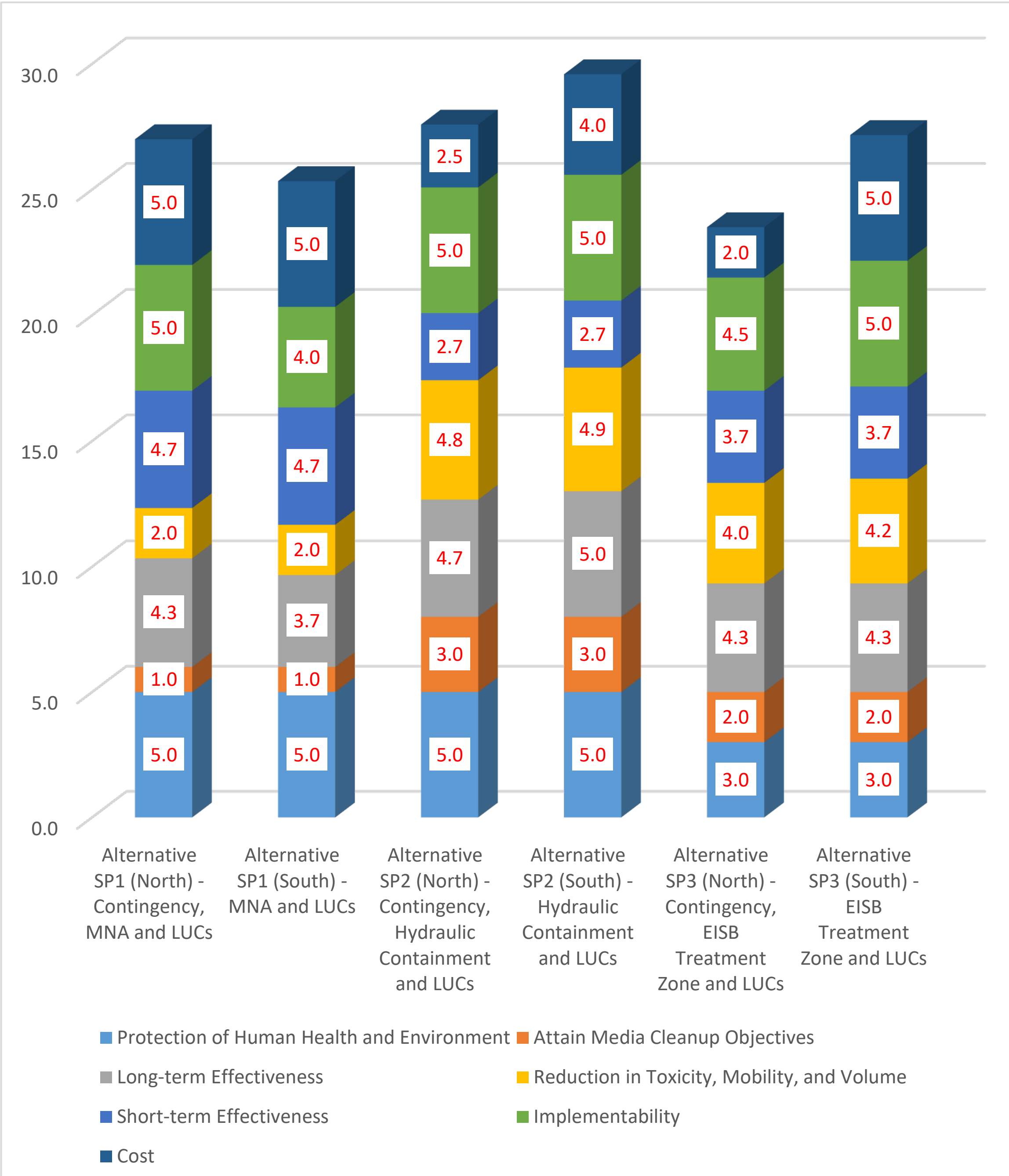

NASA

Figure 6-7
Comparative Analysis of Seep Alternatives - Graphical Summary
Phase 1 Corrective Measures Study
SSFL, Ventura County, California

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Appendix A
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets

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Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at Santa Susana Field Laboratory, Ventura County, California

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PREPARED BY:	Dan Dolmar/RDD
DATE:	August 24, 2020

This memorandum documents one-dimensional dual-domain vadose zone water and solute transport modeling calculations that were performed to determine whether existing volatile organic compound (VOC) source areas may require remedial actions to be protective of underlying groundwater quality at the National Aeronautics and Space Administration (NASA) Santa Susana Field Laboratory (SSFL) in Ventura County, California. These calculations were also used to estimate vadose zone trichloroethene (TCE) concentrations that may be left behind following bedrock vapor extraction (BVE) that will result in acceptable target porewater concentrations reaching saturated groundwater. These calculated remaining concentrations will thus contribute to the determination of when BVE systems may be shut off.

Method

The modeling for this effort was performed in HYDRUS-1D version 4.16 (Šimůnek et al., 2013). The domain of the simulations was the entire vadose zone, between ground surface and saturated groundwater, of Alfa/Bravo Area of Impacted Groundwater (AIG) monitoring well cluster ND-136. This location was chosen because it has some of the highest vadose zone concentrations of TCE found at SSFL. This domain is entirely within the Chatsworth Formation and is primarily located in the Sage Member of that formation (according to Figure 2.3-13 of the draft Alfa/Bravo AIG Data Evaluation Report [Appendix C of the NASA Groundwater RFI Report; NASA, 2017]).

The simulations of vadose zone water flow and dissolved TCE transport require the assignment of both initial conditions and boundary conditions. In addition, the groundwater flow simulation requires hydraulic parameters such as saturated hydraulic conductivity and parameters defining the relationship between saturation and pressure head. Similarly, TCE transport simulation requires parameters defining processes such as the transfer between phases (such as sorbed, aqueous, and vapor), and between the fracture and bulk matrix domains.

Previous Investigation of Transport in Fractures and Bulk Matrix

The *Site Conceptual Model for the Migration and Fate of Contaminants in Groundwater at the Santa Susana Field Laboratory* (The SSFL Groundwater Advisory Panel, et al., 2009) indicates that transport of chemicals of concern (COCs) through the Chatsworth Formation is limited because of the presence of rock matrix blocks between faults and fractures that have a relatively high porosity and low permeability. This rock matrix represents a large storage reservoir for COCs and limits their mobility through the process of matrix diffusion. Historically, matrix diffusion is the dominant mechanism that has temporarily removed COC mass from the more dynamic advective flow pathways, limiting the rate and extent of migration of COCs from the source area. Based on the matrix diffusion process, the Site Conceptual Model concludes that essentially all (greater than 99.9 percent) of the COC mass at SSFL resides in the low-permeability rock matrix and plumes have reached or nearly reached stationary positions. For this reason, the modeling assumes that >99 percent of the contamination resides in the rock matrix, although the actual amount is dependent on the water contents of the mobile and immobile phases, which are variables of the water flow calculation in the vadose zone.

Vadose Soil Water Flow Model Input

A soil profile was developed that reflects the hydrogeologic and contaminant conditions within the vadose zone of monitoring well ND-136 within the Alfa/Bravo AIG. This profile was 270 feet thick, consistent with the depth to groundwater at this location. The flow parameters that were used to populate this model are given in Table 1. These parameters were implemented uniformly in the HYDRUS soil profile, reflecting the general uniformity of subsurface material observed at this location (a relatively thin interval of shale that was observed near the surface was ignored for this analysis).

TABLE 1
Flow Parameters Used in Vadose Modeling
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

Parameter	Value	Units	Source/Reference
Residual water content, fractures	0	--	Assumed
Saturation water content, fractures	0.001	--	The SSFL Groundwater Advisory Panel et al., 2009
van Genuchten n, fractures and bulk matrix	3.6	--	Estimated from HYDRUS-supplied parameters for Sand
van Genuchten alpha, fractures and bulk matrix	1.56	$meters^{-1}$	Adapted from previous unpublished HYDRUS simulations for the Building 204 Area and Expendable Launch Vehicle
Saturated hydraulic conductivity, fractures	4.700	feet per day	NASA, 2017, Late-Time Recovery Cooper-Jacob K estimate from Alfa/Bravo AIG aquifer testing (maximum value)
van Genuchten l, fractures and bulk matrix	0.5	--	Assumed, recommended value
Spacing between fractures	5	feet	SSFL Groundwater Advisory Panel et al., 2009
Water exchange coefficient between matrix and fractures	0.0288	day^{-1}	Assumed that this should be approximately = Kmatrix/half-thickness = 7.2e-02/2.5 (feet/day/feet).
Residual water content, bulk matrix	0.053	--	HYDRUS-supplied (assumed).
Saturation water content, bulk matrix	0.136	--	Inferred from bulk density of 2.29 grams per cubic centimeter, measured as documented in the Site Conceptual Model (The SSFL Groundwater Advisory Panel et al., 2009)
Saturated hydraulic conductivity, bulk matrix	$7.2x10^{-2}$	feet per day	NASA, 2017

day^{-1} = per day
NASA = National Aeronautics and Space Administration
SSFL = Santa Susana Field Laboratory

The top flow boundary was determined using precipitation data from an onsite weather station. The average precipitation from the years 2005 through 2012 was 15.9 inches (these were the years for which the data was complete). The majority of the precipitation in those years (98.6 percent) was determined to occur from October through May. For this reason, the simulated groundwater recharge was applied 8 months on, 4 months off, to account for this seasonality. The total annual groundwater recharge was estimated by Manna et al. (2016) to be approximately 4.2 percent of the precipitation, so the recharge in the HYDRUS model was 0.67 inch per year. The bottom boundary condition was set to zero pressure head to indicate the water table condition there.

The initial condition was set by running a preliminary HYDRUS model with the above parameters and boundary conditions until the water content in the soil profile was in quasi-equilibrium with the water being applied to the top boundary. Once the water content stabilized, the corresponding pressure heads were copied into the main HYDRUS model for use in the transport modeling.

Vadose Solute Transport Model Input

The model simulates the transport of TCE in the soil profile at monitoring well ND-136. The transport parameters are indicated below in Table 2. Most of them were used in previous unpublished HYDRUS simulations used for the SSFL investigation.

TABLE 2
Parameters Used in the TCE Transport Model
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

Parameter	Value	Units	Source/Reference
Soil bulk density	2.29	g/cm^3	The SSFL Groundwater Advisory Panel, et al., 2009
Fractional organic carbon (Foc)	0.00028	--	Estimated from SSFL soil samples
Organic carbon-water partitioning coefficient (Koc)	166	cm^3/g	EPA, 2002
Dimensionless Henry's Constant	0.422	--	EPA, 2002
Soil water partitioning coefficient	0.04648	cm^3/g	Koc * Foc
Diffusion coefficient, air	0.68	m^2/d	DTSC, 1994
Diffusion coefficient, water	$9.00x10^{-5}$	m^2/d	DTSC, 1994
Mobile-immobile solute exchange coefficient	$1.13x10^{-5}$	day^{-1}	Methodology to compute the mass transfer coefficient provided by Dr. Matt Becker/California State University Long Beach (equations associated with this alternative method to estimate mass transfer coefficient based on free water diffusion, tortuosity, fracture spacing, and fracture aperture included in Appendix B of the Phase 1 Groundwater CMS)

cm^3/g = cubic centimeter(s) per gram
CMS = Corrective Measures Study
day^{-1} = per day
DTSC = California Department of Toxic Substances Control
EPA = U.S. Environmental Protection Agency
g/cm^3 = gram(s) per cubic centimeter
m^2/d = square meter(s) per day
SSFL = Santa Susana Field Laboratory
TCE = trichloroethene

The top boundary condition for the transport model was set to a zero-concentration boundary, under the assumption that no TCE would be introduced into the profile, nor would it be migrating to the surface from below. A zero concentration *gradient* (as distinct from zero concentration) was set at the bottom boundary. This boundary condition effectively assumes that the concentration in the uppermost saturated pores below the water table will always be the same as the concentration in the lowermost partially-saturated pores just above the water table.

The initial condition of concentration for the base transport scenario was adapted from the vapor phase concentrations measured at ND-136. These concentrations were up to 36,000,000 micrograms per cubic meter ($\mu g/m^3$). The measured vapor phase concentrations were translated into porewater concentrations using the transport parameters in Table 2 and assuming equilibrium TCE concentrations between the soil-sorbed, porewater, and vapor phases. Figure 1 indicates the base transport scenario initial porewater concentrations.

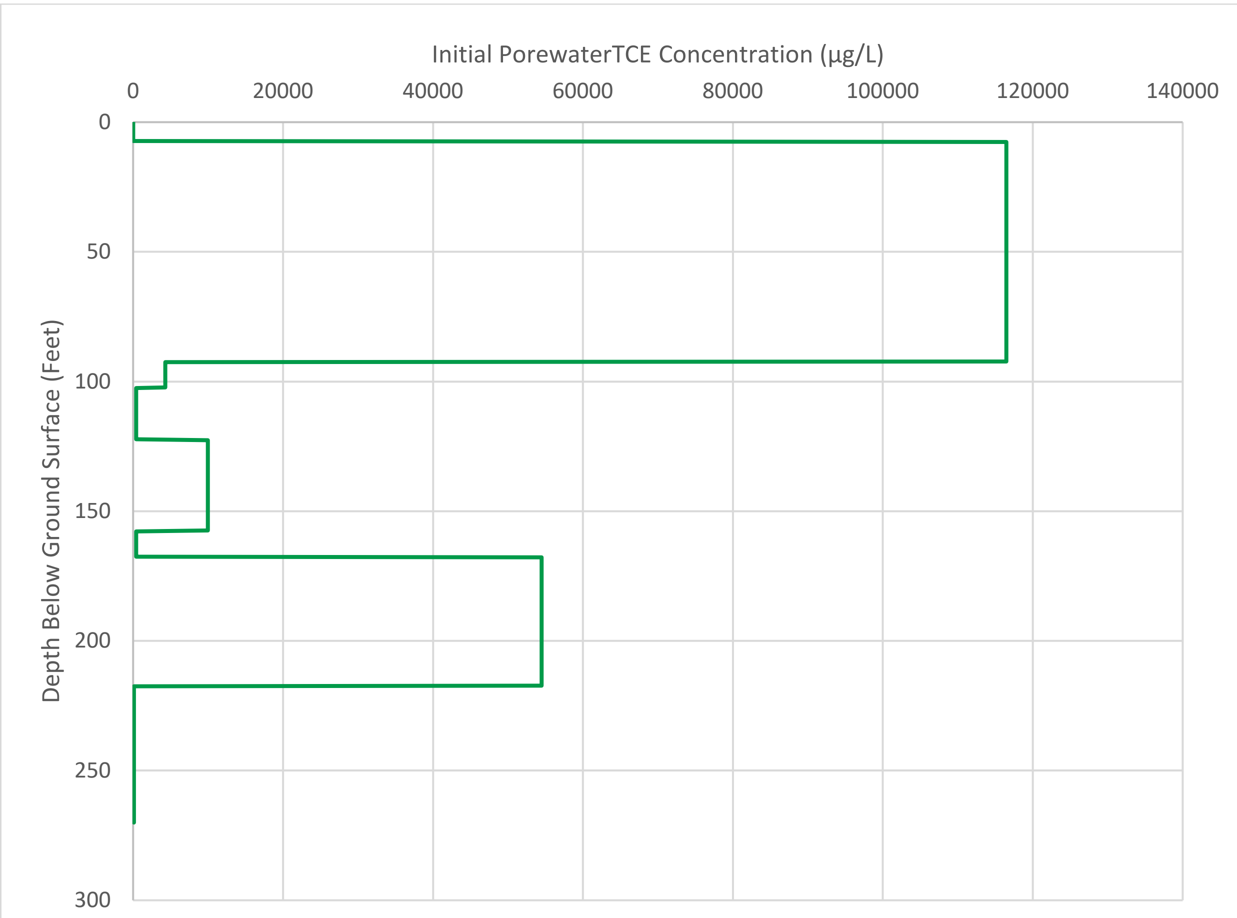

FIGURE 1
Base Scenario Initial Porewater TCE Concentrations in HYDRUS Vadose Zone Soil Profile Model
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

This concentration profile was scaled by simple multipliers (for example, a factor of 0.2 would be applied to all of the concentrations), in successive HYDRUS simulations, until the maximum concentration at the water table (the bottom of the profile) was equal to a target water table concentration. The maximum initial water phase concentration from that HYDRUS run (that resulted in the target concentration at the water table) was then used to calculate the vapor and sorbed phase concentrations that would be in equilibrium with it.

Results

The first simulation aimed for a water table porewater concentration of 5 micrograms per liter (µg/L) of TCE. Figure 2 indicates the water table porewater concentrations forecasted by the HYDRUS model over 100 years of simulation.

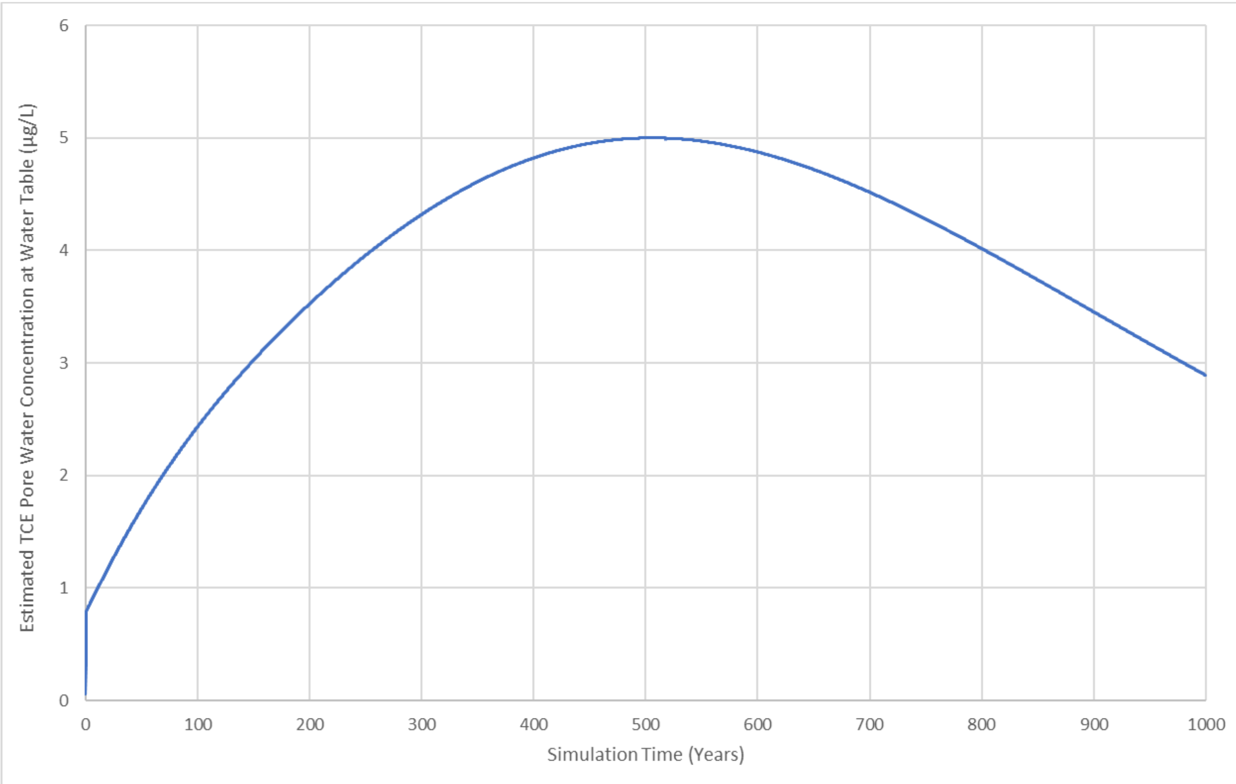

FIGURE 2
Estimated TCE Concentrations in Porewater at the Water Table with a Target Concentration of 5 µg/L
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

As Figure 2 indicates, the target maximum simulated TCE concentration of 5 µg/L at the water table was achieved. This concentration was forecasted to occur after 500 years. The scaled initial concentrations that resulted in this outcome included maximums of 14 µg/L in soil porewater, 1.2 micrograms per kilogram (µg/kg) (total) in soil, and 5,900 µg/m^3 in soil vapor. These concentrations correspond to the maximum porewater concentrations in Figure 1, which are between 10 and 90 feet below ground surface. This suggests a porewater concentration reduction required by the BVE system from 116,000 µg/L (Figure 1) to 14 µg/L, a factor of approximately 8,300, in order to achieve the target concentration at the water table.

The annual fluctuations of concentrations reaching the water table that are indicated in Figure 2 reflect the annual precipitation cycle.

A second scenario was run to estimate the TCE concentration that could be left remaining in the vadose zone at ND-136 if the target water table TCE concentration was 10,000 µg/L. Figure 3 indicates the resulting forecast of porewater TCE concentrations at the water table.

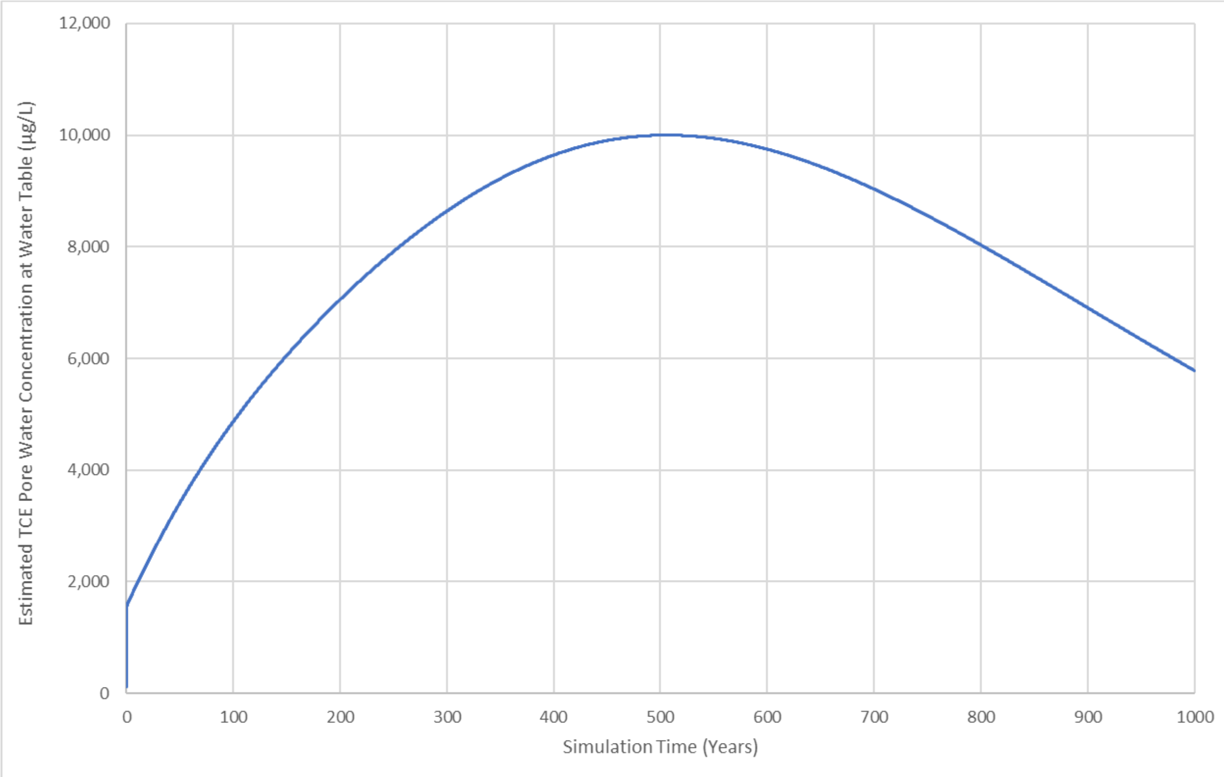

FIGURE 3
Estimated TCE Concentrations in Porewater at the Water Table with a Target Concentration of 10,000 µg/L
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

The target concentration was achieved in a model with maximum initial concentrations of 2,300 µg/kg (total) soil concentration, 28,000 µg/L porewater concentration, and 12,000,000 µg/m^3 vapor phase concentration. These initial concentrations would require a reduction in vadose zone concentrations from 116,000 µg/L (Figure 1) to 28,000 µg/L, a factor of 4.1.

A third scenario was run to estimate the TCE concentration that could be left remaining in the vadose zone at ND-136 if the target water table TCE concentration was 1,000 µg/L. Figure 4 indicates the resulting forecast of porewater TCE concentrations at the water table.

The information presented in this memorandum will be used as a screening value to identify the potential for bedrock vapor TCE concentrations to result in pore water greater than 10,000 µg/L in areas where TCE exceeds this same concentration of groundwater.

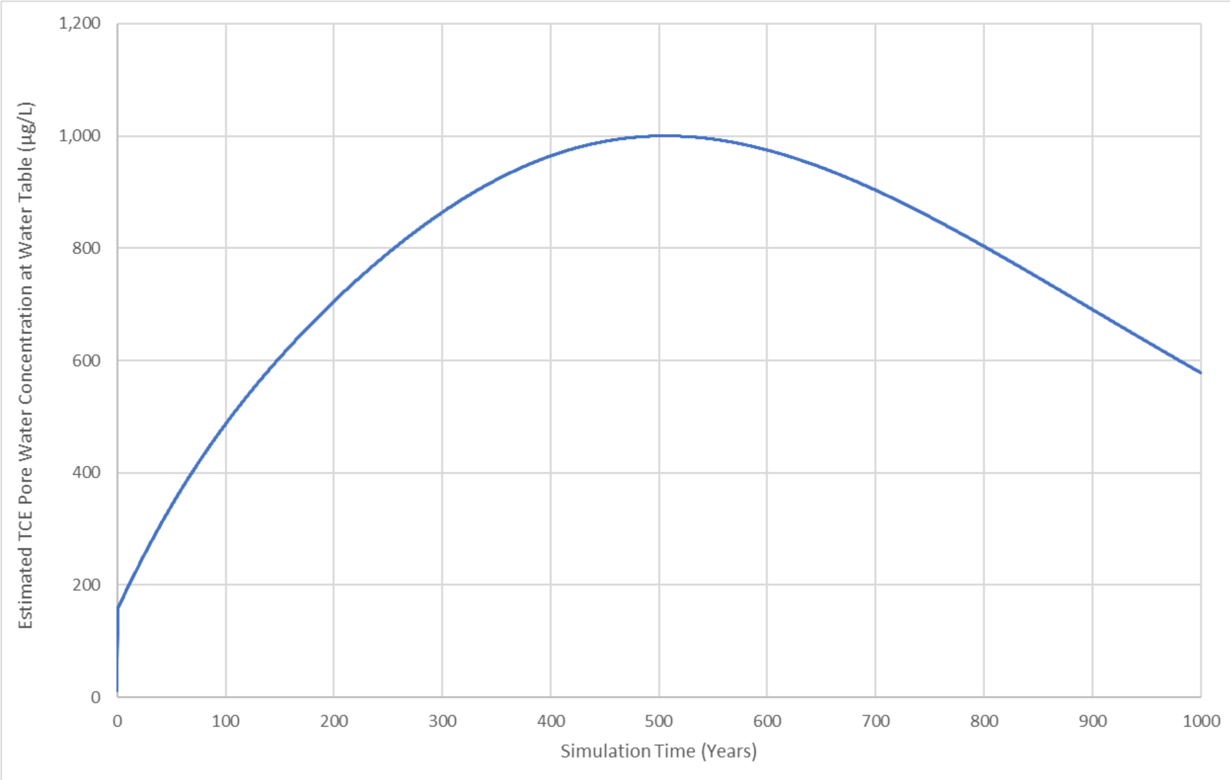

FIGURE 4
Estimated TCE Concentrations in Porewater at the Water Table with a Target Concentration of 1,000 µg/L
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

The target concentration was achieved in a model with maximum initial concentrations of 230 µg/kg (total) soil concentration, 2,800 µg/L porewater concentration, and 1,200,000 µg/m^3 vapor phase concentration. These initial concentrations would require a reduction in vadose zone concentrations from 116,000 µg/L (Figure 1) to 2,800 µg/L, a factor of 41.

Mass balances for both water and TCE were calculated semi-annually for all three simulations presented. In each simulation, the maximum mass balance error for TCE was 0.11 percent.

Table 3 summarizes the results of the three simulations.

TABLE 3
Summary of HYDRUS-1D Vadose Zone Modeling of TCE Transport in the Vadose Zone
Vadose Zone Flow and Transport Modeling to Assess Source Area Remediation Targets at SSFL, Ventura County, California

Simulation	**Porewater at Water Table (µg/L)**	**Total Soil Concentration (µg/kg)**	**Vadose Porewater Concentration (µg/L)**	**Vapor Maximum Concentration in Vadose Zone (µg/m^3)**	**Vadose Zone Vapor Concentration to Porewater Concentration Ratio**
1	5	1.2	14	5,900	1,200
2	10,000	2300	28,000	12,000,000	1,200
3	1,000	230	2,800	1,200,000	1,200

µg/kg = microgram(s) per kilogram
µg/L = microgram(s) per liter
µg/m^3 = microgram(s) per cubic meter

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Appendix B
Screening-level Solute Transport Modeling

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APPENDIX B
Screening-level Solute Transport Modeling

Introduction and Modeling Objectives

This appendix describes the application of a screening-level solute transport model to simulate the transport of trichloroethene (TCE) within the Chatsworth Formation Groundwater (CFGW) aquifer at the Alfa/Bravo and Coca/Delta Areas of Impacted Groundwater (AIGs) at the National Aeronautics and Space Administration (NASA) Santa Susana Field Laboratory (SSFL). The modeling described in this appendix pertains to the TCE plumes emanating from high-concentration source areas targeted for potential treatment as part of the Phase 1 Corrective Measures Study (CMS) in the Alfa Area (at well ND-136), in the Bravo Area (at well WS-09), and in the Delta Area (at well C-6). The objectives of this modeling are:

- To estimate a set of groundwater flow and solute transport parameters that are consistent with observed field data regarding the current length of TCE plumes exceeding the maximum contaminant level (MCL) of 5 micrograms per liter (µg/L).
- To use the model to forecast the remediation time frame (RTF) in the absence of remedial actions (that is, monitored natural attenuation [MNA]).
- To use the model to forecast the RTF with source area and/or plume-wide remedial actions.

Screening level solute transport modeling at lower concentration source areas as well as evaluation of constituents of concern other than TCE will be included in the forthcoming Phase 2 CMS Report.

Groundwater Flow and Contaminant Transport Modeling

The analysis was performed using HYDRUS-1D for groundwater flow and solute transport (Šimůnek et al., 2008, 2009). The HYDRUS-1D code was selected for the following reasons:

- Project scope required use of a model to forecast the effectiveness of current and proposed remedial action scenarios. The forecasts of the RTF and maximum plume migration distance provide the opportunity to compare results between the modeled remedial scenarios.
- Given the project scope and limited data associated with TCE transport mechanisms, a screening-level modeling approach was considered appropriate.
- HYDRUS-1D provides more flexibility in how source terms and initial concentration conditions are simulated, as compared with other screening-level solute transport codes (e.g., BIOSCREEN and 3DADE).
- HYDRUS-1D provides the option of simulating dual-domain transport processes. This provides the opportunity to consider back-diffusion of contaminant mass from less permeable mass storage zones in the subsurface, which tends to prolong RTFs.
- HYDRUS-1D is in the public domain, a product of more than 10 years of development, in wide use, and well supported and documented.

HYDRUS-1D numerically solves the Richards equation for variably saturated flow in one dimension (1D). For the current application, HYDRUS-1D was set up so that the modeled system remained fully saturated along the 1D model domains developed along the inferred longitudinal centerline (herein referred to as the longsect) of each of the TCE plumes as shown on Figures B-1 and B-2. HYDRUS-1D was set up to solve the advection-dispersion-biodegradation transport equation with dual-domain mass transfer to simulate TCE transport along the modeled longsect. The dual-domain transport formulation was implemented to more accurately account for transport processes with the goal of improving the predictive capabilities over what could have been achieved with a traditional single-domain transport formulation. With the dual-domain transport formulation, the transport equations account for 1D TCE transport in the aqueous phase undergoing first-order biodegradation and first-order TCE mass transfer between the mobile and immobile domains in the subsurface, in addition to advection and dispersion in the mobile domain. Additionally, the HYDRUS-1D models, as formulated for this particular application, include the assumption of steady-state groundwater flow conditions along the modeled longsects.

The overall approach to the modeling analysis involved establishing a steady-state groundwater flow field, based on hydraulic gradients estimated from data collected as part of AIG characterization field efforts (Figures B-3 and B-4) followed by transient solute transport modeling of the plumes from emplacement forward in time. The groundwater flow and solute transport models were parameterized with initial estimates (described further in the subsequent section) based on site data and literature values. Parameters were then adjusted in order to match the current estimates of TCE plume lengths exceeding 5 µg/L (Figures B-1 and B-2) as well as current TCE concentrations within each source area of interest.

The following list summarizes important points related to the modeling effort common to all of the models:

- The modeled longsects for each of the plumes were started at the associated source area wells: C-6 in the Delta Area, ND-136 in the Alfa Area, and WS-09 in the Bravo Area. The total model domain for each of the longsects extend 10,000 feet downgradient from the associated source area wells.
- The emplacement time was assumed to be 60 years for each of the plumes (time of plume initiation, relative to current time).
- A dual-domain transport formulation was implemented in the simulations to account for matrix diffusion, in addition to advection, dispersion, adsorption, and degradation.

Groundwater Flow Model Parameterization

The following describes the parameterization of the Hydrus-1D models. Final groundwater flow and solute transport model parameters are summarized in Table B-1.

Saturated Hydraulic Conductivity

The Alfa and Bravo Area models were assigned saturated hydraulic conductivity values of 1.3 feet per day (ft/day) (4.6×10^{-4} centimeters per second [cm/s]) over their entire longsects. This value represents the average hydraulic conductivity estimated from recent injection aquifer testing at the Alfa/Bravo AIG (Appendix C of *NASA Groundwater RFI Report, Santa Susana Field Laboratory, Ventura County, California* [NASA Groundwater RFI Report]; NASA, 2020).

The Delta Area model was assigned a saturated hydraulic conductivity value of 0.85 ft/day (3.0×10^{-4} cm/s) over the majority of the longsect. Although this value is at the higher end of the range of estimated permeabilities from recent hydraulic packer testing, it is within the range of historical single well aquifer testing estimates (Appendix D of the NASA Groundwater RFI Report; NASA, 2020). A value of 0.085 ft/day was assigned to a 10-foot length of the longsect at a distance of approximately 1,250 feet to represent the Burro Flats Fault, which acts as a partial barrier to groundwater flow.

Hydraulic Gradient

Groundwater elevations and hydraulic gradients assigned to establish the steady-state groundwater flow field were obtained from data collected during AIG field characterization activities and presented in the *NASA Groundwater RFI Report* (NASA, 2020) (Figures B-3 and B-4). Constant head boundary conditions were assigned at the upgradient end of each longsect based on the groundwater elevation at the associated source area well. The hydraulic gradient inferred from the groundwater elevation contour maps were then used to establish the constant head boundary condition for the downgradient end of the longsects. As discussed in the *NASA Groundwater RFI Report* (NASA, 2020), the inferred direction of migration of the Alfa Area plume is in the down-dip direction of the regional bedding (to the northwest [Figure B-1] instead of following the current northeast hydraulic gradient [Figure B-3]). Dense non-aqueous phase liquid (DNAPL) from the Alfa Test Stand sources areas may have followed the northwest down-dip migration of the bedding planes, and/or have been influenced by historical pumping at WS-13. TCE concentrations exceeding the GSL also are observed at well C-5, but at levels that are several orders of magnitude lower than that measured at ND-137B; this suggests that ND-137B is along a more direct migration pathway from the Alfa Test Stand source area than C-5. The Lower Shale 2 Member is thought to act as a barrier to limit the northern extent of the Alfa Area plume at depth (NASA, 2020). As such, the hydraulic gradient for the Alfa Area model was computed based on the groundwater elevation difference between ND-136-4 and ND-137B (Figure B-3). As will be discussed further below, the hydraulic gradients were modified, if necessary, during model calibration. The final horizontal hydraulic gradients assigned to the models are presented in Table B-1.

Solute Transport Model Parameterization

The following describes the parameterization of the Hydrus-1D solute transport models. Final groundwater flow and solute transport model parameters are summarized in Table B-1.

Bulk Density and Porosity

The aquifer system at SSFL is comprised of relatively highly fractured/faulted sandstone of varying grain size. As such, the aquifer is characterized as a dual porosity system, with the sandstone matrix providing the primary porosity and the fracture system(s) representing the secondary porosity. The conceptual model for the dual-porosity aquifer system at SSFL is such that the primary (matrix) porosity acts primarily as a reservoir for storage while the secondary (fracture networks) porosity acts primarily as a conduit for flow. It should be noted; however, that the matrix porosity can transmit fluid and that portions of the fracture network can act as reservoirs for storage.

Analyses completed in support of the draft *Site-Wide Groundwater Remedial Investigation Report* (MWH, 2009) concluded that the effective and total matrix porosity of the CFGW sandstone units were essentially the same, approximately 14 percent. This suggests that the entire pore space of the sandstone matrix is interconnected. These investigations further concluded that the secondary (fracture) porosity is approximately 0.01 percent.

The relationship between total porosity, and bulk density is defined by the following equation:

$$\theta = 1 - \frac{\rho_b}{\rho_s} \qquad (1)$$

Where:

θ = Total porosity
ρ_b = Bulk density
ρ_s = Particle density

Given an assigned total porosity value of 14 percent and a particle density of 2.65 grams per cubic centimeter (g/cm^3), bulk density assigned to the solute transport models was 2.279 g/cm^3 (Table B-1).

Longitudinal Dispersivity

A longitudinal dispersivity of 10 feet was used for each of the solute transport models (Table B-1).

Distribution Coefficient

The distribution coefficient (K_d), a product of the fraction of organic carbon (f_{oc}) and soil organic carbon-water partitioning coefficient (K_{oc}), used in the solute transport models was 0.035 cubic centimeters per gram (cm^3/g). K_{oc} value for TCE used in the solute transport modeling, 126 cm^3/g, was estimated from literature values (Pankow and Cherry, 1996). An f_{oc} value of 0.028 percent was used to calculate K_d and was based on site-specific data (MWH, 2009) (Table B-1).

Mass-transfer Coefficient

The mass-transfer coefficient is a first-order rate coefficient that scales the rate of solute exchange between the mobile and immobile domains according to the simulated TCE concentrations between these domains at each model node through time. Although it is acknowledged that mass transfer rate is variably both spatially and temporally, single rate mass transfer was considered appropriate for this screening level analysis. When an advecting solute undergoes first-order mass transfer between the mobile and immobile porosity domains, the reciprocal of the mass transfer coefficient provides an approximation of the mean residence time (or mass transfer time) of the solute in the immobile domain (t_α). Using a diffusion model, t_α can be approximated by (Haggarty, et. al., 2004):

$$t_\alpha = \frac{a^2}{k_g \quad D_a} \qquad (2)$$

Where:

t_α = Mean residence time
a = Radius of a sphere or half distance of a layer
k_g = Geometry-dependent coefficient (3 for layers and 15 for spheres)
D_a = Apparent diffusivity

The single-rate mass transfer coefficient (α) can be estimated from the mean residence time as:

$$\alpha = \frac{1}{t_\alpha} \qquad (3)$$

Given the geometry of the fracture networks at SSFL, a slab (or layered) model was used for this analysis (k_g = 3). The half-distance between layers for the Alfa, Bravo, and Delta source areas was estimated based on the fracture spacing identified during geophysical logging at the source area wells. The spacing of fractures below the water table greater than rank 0 was estimated based on optical televiewer logging at ND-136 (Alfa). Because optical televiewer logging was not performed at WS-09 or C-6 (corehole was partially logged), nearby wells ND-134 and C-15 were used as surrogates for the Bravo and Delta areas. Table B-1 provides the estimated half-distance of the fracture spacing. Apparent diffusivity of TCE was estimated as the open water diffusivity of TCE accounting for tortuosity in the aquifer and retardation of the solute. As shown in Table B-1, estimated single-rate mass transfer coefficients ranged from 0.0041 to 0.049 per year (1.13×10^{-5} to 1.34×10^{-4} per day).

First-order Biodegradation Half-Life

The first-order biodegradation half-life (BHL) represents the decay of a solute via biological mechanisms. This parameter has a significant impact on solute transport forecasts. Numerically, the BHL removes solute mass from the modeled system, or in the case of TCE, degrades a parent contaminant into its daughter product. The BHLs for TCE were estimated to range from 1 to 3 years, during the model calibration process (Table B-1).

Initial Concentrations

Because the modeling objective focused on growing the plumes from the time of emplacement, initial TCE concentrations in both the mobile and immobile domains were set to zero along each of the modeled longsects.

Source Area Concentrations

Specified mass flux boundary conditions were assigned at the upgradient end of each of the longsects in order to simulate the TCE source areas. The initial TCE source concentration at the time of emplacement for the Alfa Area and Bravo Area plumes was assumed to be approximately equal to 10 percent of the solubility limit for TCE (128,000 µg/L) (Table B-1). Because the current TCE concentration measured in C-6 is approximately equal to 10 percent of the solubility limit (Figure B-2), the initial TCE source concentration at the time of emplacement for the Delta Area plume was assumed to be approximately equal to the solubility limit (1,280,000 µg/L). Plume-specific attenuation half-life values were assigned to the source areas

(Table B-1) to simulate a decrease in the source strength over time. The source area half-life values were computed by Equations 4 and 5 as follows:

$$\frac{C}{C_0} = e^{-kt}, rearranged\ to\ k = {-\ln\left(\frac{C}{C_0}\right)} \Big/ {t} \qquad (4)$$

Where:

C = Current TCE concentration at the source area well (µg/L)
C_0 = TCE concentration at the time of emplacement (µg/L)
k = decay constant (years^{-1})
t = emplacement time (years)

$$t_{½} = \frac{\ln(2)}{k} \qquad (5)$$

Where:

$t_{½}$ = TCE half-life (years)
ln = natural log
k = decay constant (years^{-1})

The source area attenuation half-life values were applied to the source area concentrations, beginning with the emplacement concentration at time = 0 years, to develop a time series of source area concentrations that result in forecasts of TCE concentrations at year 60 (present day) that match the currently observed TCE concentrations within each source area.

For simulations involving source area treatment, the following process applied to the source area boundary conditions:

- Simulation years 0 through 60 represented plume emplacement and development through present day and were assigned specified concentration boundary conditions as described above.
- Simulation years 60 through 70 represented the time frame for source area treatment. It was assumed that the applied remedy would provide complete hydraulic containment of the source area during treatment; therefore, a concentration of 0 µg/L was assumed to leave the source area during this 10-year period.
- Simulation years 70 and forward represented the post-treatment timeframe. It was assumed that the source area would resume contribution to the plume; however, the initial concentration was based on a concentration equal to 10 percent of that immediately prior to the onset of treatment (that is, it is assumed that source treatment reduces source concentrations by 90 percent over a 10-year period). The source area attenuation half-lives estimated during simulation years 0 through 60 (and presented in Table B-1) were applied during this period.

Model Calibration

The calibration process involved running a groundwater flow and solute transport model, evaluating the simulated plume length after 60 years of transport (current day) and adjusting model parameters. The plume length at 60 years represents the estimated length of plume with concentrations of 5 µg/L or greater for the Alfa and Bravo Areas and concentrations of 250 µg/L (the concentration at SP-890G) or greater for the Delta Area. Due to the high degree of complexity and associated uncertainty in the detailed hydraulics of groundwater and COCs moving through the Burro Flats Fault Zone, along with the limitations of the simplified screening-level modeling performed to support this analysis, it was decided to focus the calibration to the plume current length to the area north of the fault zone.

The BHL was the primary calibration parameter and was adjusted, if needed, during the iterative calibration process. The BHL values were constrained within reasonable literature values (Anderson and McCarthy, 1997; Suarez and Rifai, 1999; EPA, 1998; and Aziz and Gonzales, 2002) and professional judgement. The lower range of BHL assigned to the Hydrus-1D models was 1 year. If necessary, the horizontal hydraulic gradient of the models was adjusted during calibration to achieve that simulated plume length after 60 years of transport. This was considered appropriate as there is a high degree of uncertainty associated with the variability in hydraulic gradients over time since plume emplacement. The calibration process was continued until a suite of parameters was identified that adequately replicated the present day TCE plume lengths with reasonable assumed model input parameter values.

Model Results

Transient solute transport models were run for each of the TCE plumes described above, starting at emplacement, forward in time for up to 500 years. Simulations that include the source area boundary condition with only the attenuation half-life applied represent plume development and degradation under existing conditions. The RTF estimated from these simulations represents those that would occur with a remedy of MNA only. For the purposes of this analysis, RTF is defined as the time at which all portions of a given plume are below the MCL for TCE of 5 µg/L. The second set of simulations represent RTF estimates associated with source treatment followed by MNA. Table B-2 summarizes the results for each of the plumes. The data presented in Table B-2 suggest that implementation of source area treatment could reduce the RTF between 20 and 25 percent.

Figures B-5 through B-7 present a graphical depiction of the MNA and source area treatment simulations. These plots were developed by identifying the length of each TCE plume exceeding 5 µg/L at 5-year intervals and dividing by the current length of the plume (simulation year 60 – current year, vertical line on plots). Periods of time when the relative plume lengths are greater than 100 percent represent periods of plume growth, when the plume is forecast to be longer than present day. Periods of time when the relative plume lengths are less than 100 percent represent periods of plume recession, when the plumes are forecast to be shorter than present day.

As shown on Figure B-5, model simulations suggest that the Alfa Area TCE plume reached maximum length approximately 55 years ago and is in a phase of recession. It is acknowledged that such rapid propagation of the plume is unlikely; however, the inherent assumption included in the simplified tool is that advective transport occurs only in the fractures. The combination of mobile porosity and other input parameters included in Table B-1 result in a rapid mobile velocity. The steep decline in the relative length of the plume with source area treatment represents the time when the source area mass is removed by treatment activities and relatively clean water from upgradient is flushed through the dissolved phase plume. Following treatment, flux from the source area resumes and the plume enters another phase of growth. The later time portions of the curves, where the MNA only and source treatment curves are parallel, represent times where the plumes have equilibrated and are recessing at a rate defined by the source area attenuation half-life and the plume-scale BHL.

Figures B-6 and B-7 present similar plots of simulated relative plume lengths for the Bravo and Delta Area TCE plumes. These plots suggest that the plumes reached maximum length 35 to 50 years ago and are in a phase of recession. The MNA and source area treatment plots for the Bravo and Delta Areas show similar patterns as those for the Alfa Area. As shown on Figure B-6, the reduction in length and subsequent secondary growth stage of the Bravo Area plume following source area treatment is of smaller magnitude than that of the Alfa plume. This is likely related to the longer assigned BHL within the dissolved phase plume in the Bravo Area (that is, there is less reduction in the concentrations in the dissolved phase plume during source area treatment due to the longer BHL). As shown on Figure B-7, an additional simulation was performed for the Delta Area plume to evaluate the potential benefit of treatment within the dissolved phase plume. This simulation was implemented similarly to the Delta source area treatment simulation plume with respect to the source area boundary condition. However, an additional treatment action within the dissolved plume between simulation years 60 through 80 (representing 20 years of plume treatment) was included. To reflect the effects of plume treatment in the transport model, any model cells within the longsect where the simulated TCE concentrations exceeded 500 µg/L within the mobile domain at year 80 were reduced to 500 µg/L. Simulated concentrations within the immobile domain were unchanged as it was assumed that the plume treatment would act primarily on the mobile domain. The simulation then proceeded as described previously for the other simulations. As shown on Figure B-7, the model output suggests that the RTF with source area and plume treatment was essentially identical to source area treatment only.

The results of the modeling effort were also used to estimate the rate of remediation in the target treatment area (TTA) source areas both under active remediation and MNA scenarios. These results are summarized in Table B-3. The model results were evaluated to estimate the time required for each TTA source area to undergo a 10-fold, 100-fold, and 1,000-fold reduction in the initial assumed source concentration. Results suggest that for the Alfa Source Area, under MNA conditions, 57, 113, and 169 years are required to reduce source concentrations by a factor of 10-fold, 100-fold and 1,000-fold, respectively. Under active remediation, those estimates drop to 10, 67, and 123 years, respectively. For the Bravo source area, under MNA conditions, 95, 190, and 285 years are required to reduce source concentrations by a factor of 10-fold, 100-fold and 1,000-fold, respectively. Under active remediation, those estimates drop to 10, 105, and 285 years, respectively. Finally, for the Delta source area under MNA conditions, 60, 121, and 181 years are required to reduce source concentrations by a factor of 10-fold, 100-fold and 1,000-fold, respectively. Under active remediation, those estimates drop to 10, 70, and 131 years, respectively.

Comments received from a subcontractor to DTSC on the 2018 version of this memorandum required substantial modifications to the original approach used to compute the first-order mass transfer coefficient between the mobile and immobile domains within the aquifer system. Based on subsequent discussions with DTSC and their subcontractor, a mutually agreed upon revised methodology was developed, and the results of the analysis provided herein reflect the implementation of that approach.

Limitations

Mathematical models can only approximate processes of physical systems. Models are inherently inexact because the mathematical description of the physical system is imperfect, the understanding of interrelated physical processes is incomplete, and many of the model input parameters (such as the source area terms) are not well constrained. Limitations associated with this screening level analysis include:

- The screening level modeling assumed 1D groundwater flow and solute transport; however, the SSFL system is strongly three dimensional.
- The steady-state groundwater flow model assumes one horizontal hydraulic gradient; however, the hydraulic gradient is variable both spatially and temporally.
- A single-rate mass transfer coefficient was assumed; however, the mass transfer coefficient is a time-variable parameter.
- The screening level analyses do not incorporate variable diffusion rates with distance from fracture face.

Although the model simulations are non-unique, the models described in this appendix represent screening-level tools that can provide useful insight into transport processes within the physical system and the relative benefits of potential remedial actions. However, such models are no substitute for continued monitoring of COC trends at available wells over the next several years to confirm the stage of plume evolution (that is, advancing, stable, or retracting) and to continually refine conceptual site models. Additionally, more complex groundwater flow and solute transport modeling is planned to support corrective measures implementation.

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Tables

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TABLE B-1
Summary of Physical and Chemical Parameters Used in Groundwater Flow and Transport Modeling
Screening Level Solute Transport Modeling

Parameter	Alfa Area	Bravo Area	Delta Area	Source
Source Area Well	ND-136	WS-09	C-6	N/A
TCE Concentration (µg/L)	11,000	30,000	130,000	NASA, 2020
Saturated Hydraulic Conductivity (foot/day)	1.3	1.3	0.085 to 0.85	AIG Aquifer Testing (NASA, 2020)
Hydraulic Gradient (foot/foot)	0.0006	0.0037	0.019	NASA, 2020 Calibration Parameter
Total Porosity, θ_t	0.14	0.14	0.14	MWH, 2009
Mobile Porosity, θ_m	0.0001	0.0001	0.0001	MWH, 2009
Immobile Porosity, θ_{im}	0.1399	0.1399	0.1399	N/A
Dry Bulk Density, ρb (g/cm^3)	2.279	2.279	2.279	Computed, Equation 1
Longitudinal Dispersivity (foot)	10	10	10	Assumed
Partition Coefficient, K_{oc} (cm^3/g)	126	126	126	Pankow and Cherry, 1996
Fraction Organic Carbon, *foc*	0.00028	0.00028	0.00028	MWH, 2009
Distribution Coefficient, K_d (cm^3/g)	0.035	0.035	0.035	Computed K_{oc} * foc
Retardation Factor, R	1.57	1.57	1.57	Computed 1 + ((⍰b* K_d)/ ⍰t)
Typical Diffusion Length, a (foot)	4.6	1.7	1.25	Estimated based on fracture spacing from geophysical logging (NASA, 2020)
Water Diffusivity, D (cm^2/s)	9.10 x 10-6	9.10 x 10-6	9.10 x 10-6	USEPA, Table 37a
Tortuosity, τ	0.13	0.13	0.13	MWH, 2009
Apparent Porewater Diffusivity, D_a (cm^2/s)	7.51 x 10-7	7.51 x 10-7	7.51 x 10-7	Computed: (D * ⍰)/R
Mass-Transfer Coefficient (days^{-1})	1.13 x 10-5	7.25 x 10-5	1.34 x 10-4	Computed, Equations 2 and 3
First-Order Biodegradation Half-Life (years)	1	3	1	Calibration Parameter
Assumed Source Area Emplacement Concentration (µg/L)	128,000	128,000	1,280,000	N/A

TABLE B-1
Summary of Physical and Chemical Parameters Used in Groundwater Flow and Transport Modeling
Screening Level Solute Transport Modeling

Parameter	Alfa Area	Bravo Area	Delta Area	Source
Source Area Attenuation Half-Life (years)	17	28.7	18.2	N/A

[a] https://semspub.epa.gov/work/HQ/175235.pdf
µg/L = microgram(s) per liter
AIG = area of impacted groundwater
cm^3/g = cubic centimeter(s) per gram
cm^2/s = square centimeter(s) per second
g/cm^3 = gram(s) per cubic centimeter
mL/g = milliliter(s) per gram
N/A = not applicable
NASA = National Aeronautics and Space Administration
TCE = trichloroethene

TABLE B-2
Summary of Estimated Remediation Time Frames
Screening Level Solute Transport Modeling

Source Area	**RTF[a] with MNA (years)**	**Maximum Plume Migration Distance with MNA (feet)**	**RTF[a] with Source Area Treatment and MNA (years)**	**Maximum Plume Migration Distance with Source Area Treatment and MNA (feet)**
Alfa Area	190	770	140	770
Bravo Area	360	1,060	275	1,060
Delta Area	270	2,040	215	2,040

[a] RFT in years from present day (add 60 years to estimate RTF from time of assumed plume emplacement)
MNA = monitored natural attenuation
RTF = remediation time frame

TABLE B-3
Summary of Estimated Time Required for Source Area Concentrations to be Reduced by a Factor of 10, 100, and 1,000
Screening Level Solute Transport Modeling

Parameter	Alfa Area		Bravo Area		Delta Area	
Source Area Well	ND-136		WS-09		C-6	
Baseline Source Area TCE Concentration (µg/L)	11,000		30,000		130,000	
Simulation	**MNA**	**Source Treatment**	**MNA**	**Source Treatment**	**MNA**	**Source Treatment**
Source Area TCE Concentration 10-fold Reduction	1,100		3,000		13,000	
Simulation Time (years from baseline)	57	10	95	10	60	10
TCE Concentration 100-fold Reduction	110		300		1,300	
Simulation Time (years from baseline)	113	67	190	105	121	70
TCE Concentration 1,000-fold Reduction	11		30		130	
Simulation Time (years from baseline)	169	123	285	200	181	131

µg/L = microgram(s) per liter
MNA = monitored natural attenuation
TCE = trichloroethene

Figures

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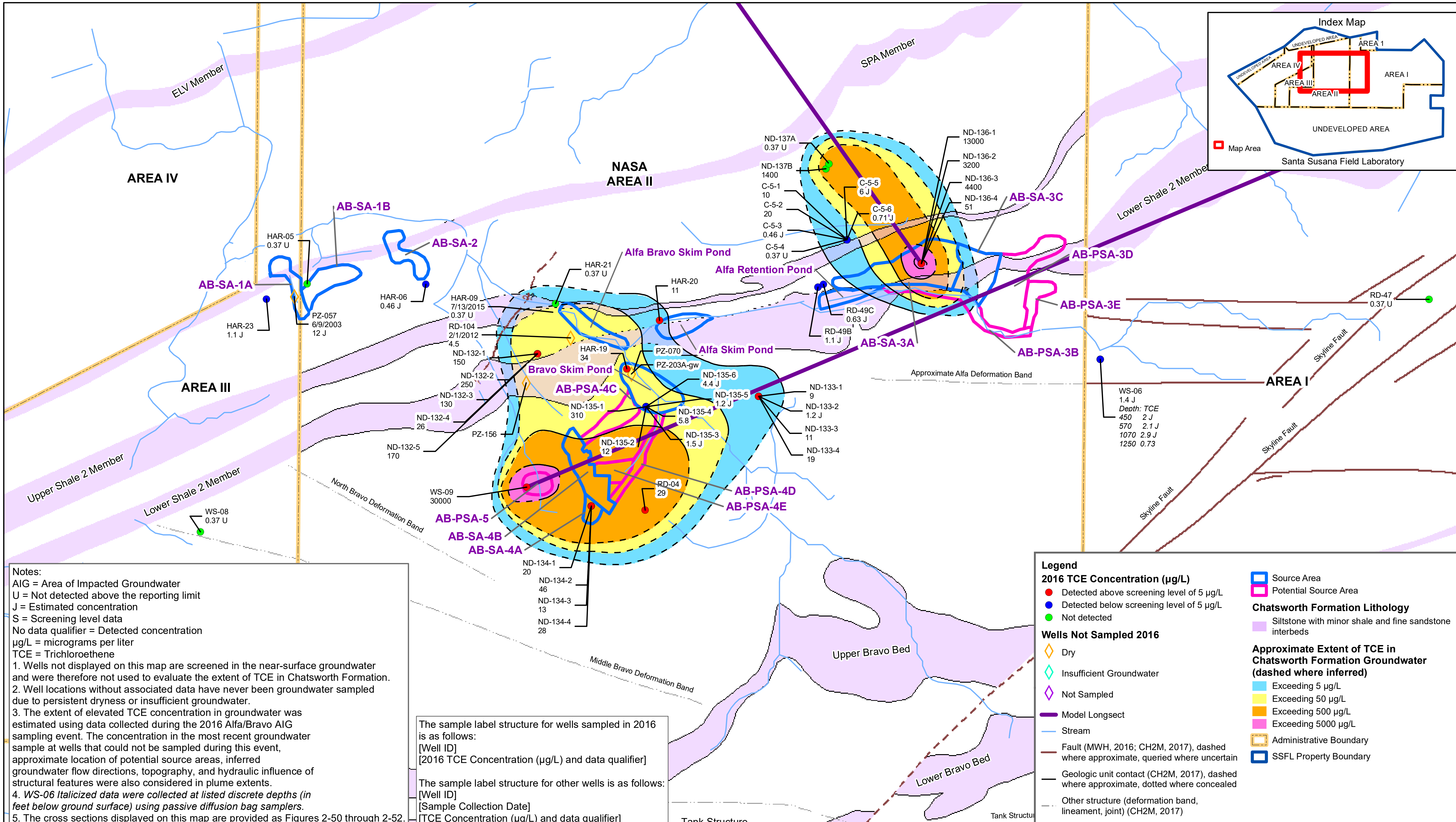


Notes:
AIG = Area of Impacted Groundwater
U = Not detected above the reporting limit
J = Estimated concentration
S = Screening level data
No data qualifier = Detected concentration
µg/L = micrograms per liter
TCE = Trichloroethene
1. Wells not displayed on this map are screened in the near-surface groundwater and were therefore not used to evaluate the extent of TCE in Chatsworth Formation.
2. Well locations without associated data have never been groundwater sampled due to persistent dryness or insufficient groundwater.
3. The extent of elevated TCE concentration in groundwater was estimated using data collected during the 2016 Alfa/Bravo AIG sampling event. The concentration in the most recent groundwater sample at wells that could not be sampled during this event, approximate location of potential source areas, inferred groundwater flow directions, topography, and hydraulic influence of structural features were also considered in plume extents.
4. *WS-06 Italicized data were collected at listed discrete depths (in feet below ground surface) using passive diffusion bag samplers.*
5. The cross sections displayed on this map are provided as Figures 2-50 through 2-52.

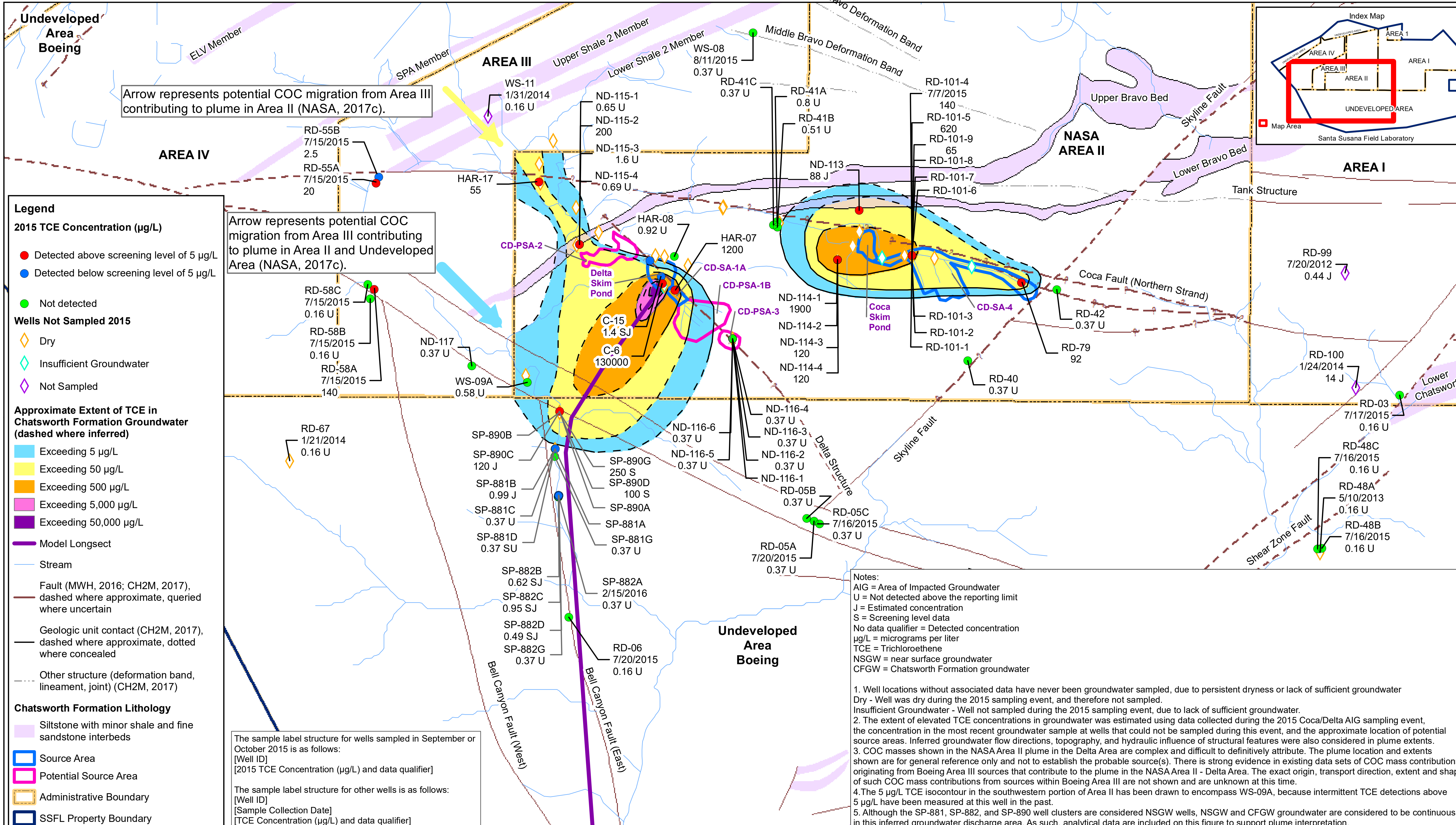
The sample label structure for wells sampled in 2016 is as follows:
[Well ID]
[2016 TCE Concentration (µg/L) and data qualifier]

The sample label structure for other wells is as follows:
[Well ID]
[Sample Collection Date]
[TCE Concentration (µg/L) and data qualifier]

21-May-2020
Drawn By:
A. Cooley

Figure B-1
Extent of Trichloroethene in Chatsworth Formation Groundwater, Alfa/Bravo AIG
Corrective Measures Study
NASA SSFL, Ventura County, California

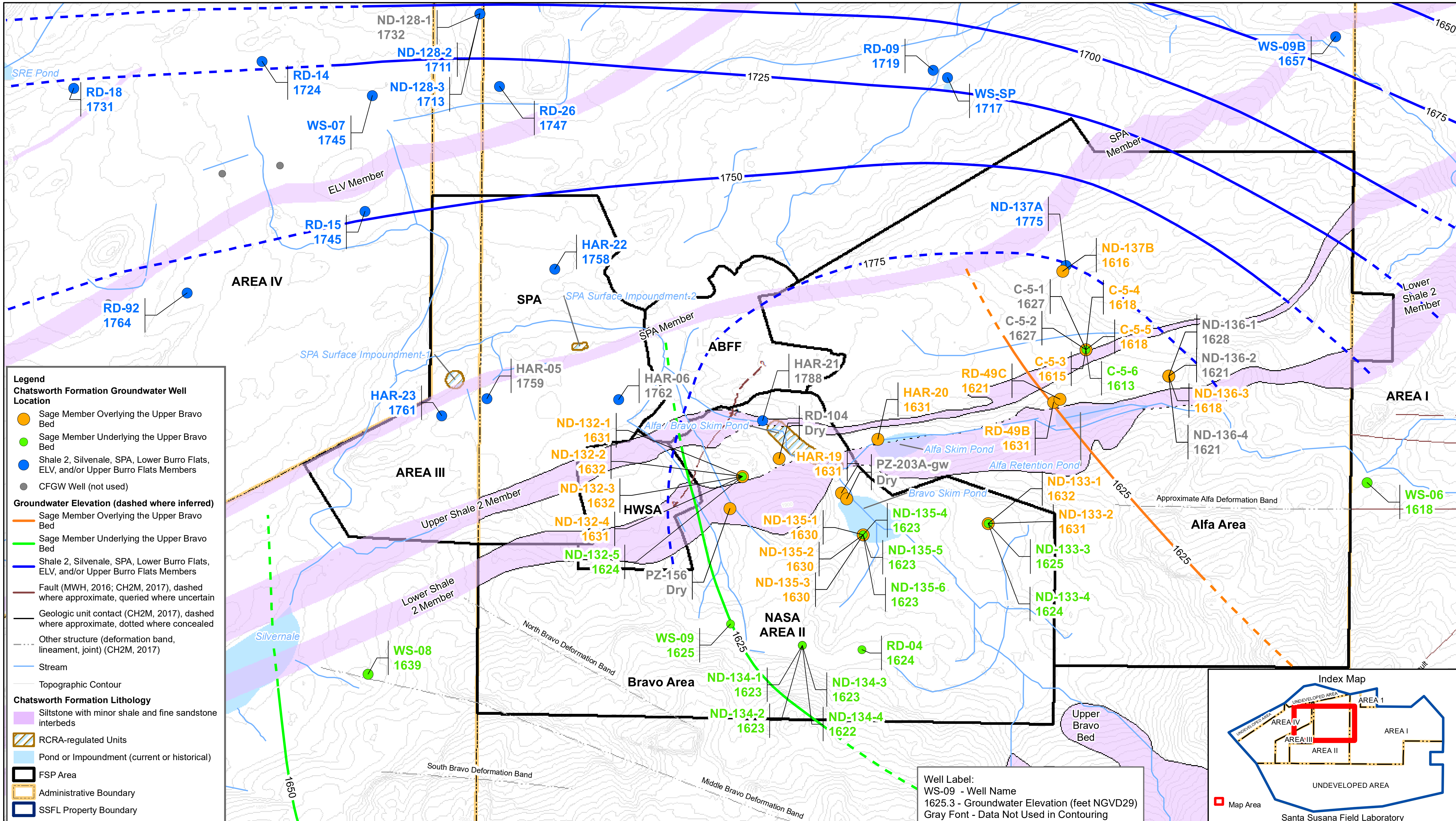
Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\AB_BE_CFGW_XSect_CMS.mxd



22-May-2020
Drawn By:
A. Cooley

Figure B-2
Extent of Trichloroethene in Chatsworth Formation Groundwater, Coca/Delta AIG
Corrective Measures Study
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\COCA_DELTA_AIG-TCE_CFGW_CMS.mxd



0 125 250 500 Feet

0 37.5 75 150 Meters

22-May-2020
Drawn By:
A. Cooley

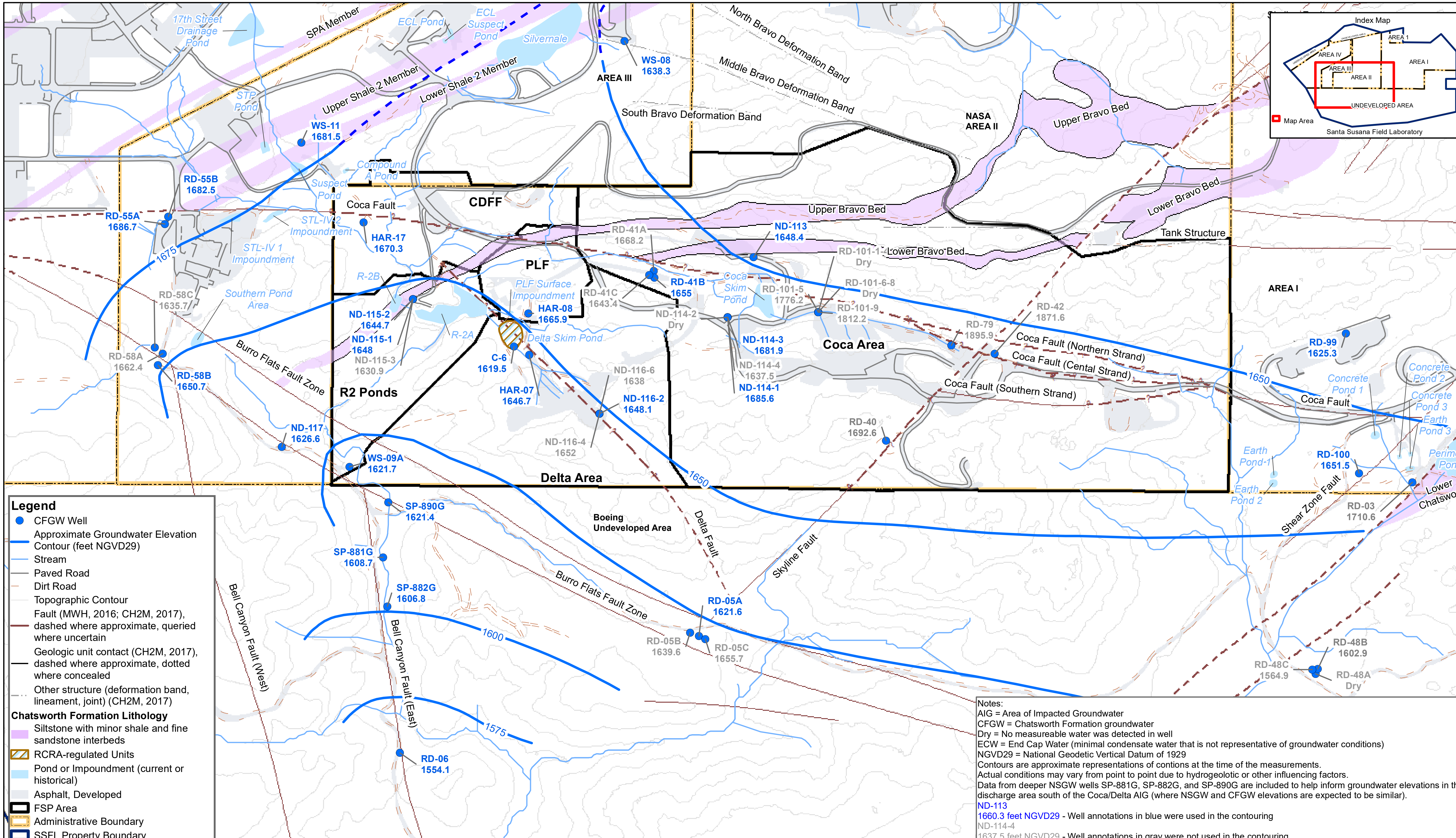
Figure B-3

Chatsworth Formation Groundwater Elevations, January 2016, Alfa/Bravo AIG

Corrective Measures Study

NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\ALFA_BRAVO_DER_Chatsworth16_CMS.mxd



20-May-2020
Drawn By:
A. Cooley

Figure B-4
Chatsworth Formation Groundwater Elevation Contour Map, Fall 2015, Coca/Delta AIG
Corrective Measure Study
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\CMS\Coca-Delta_CFGW_Elev.mxd

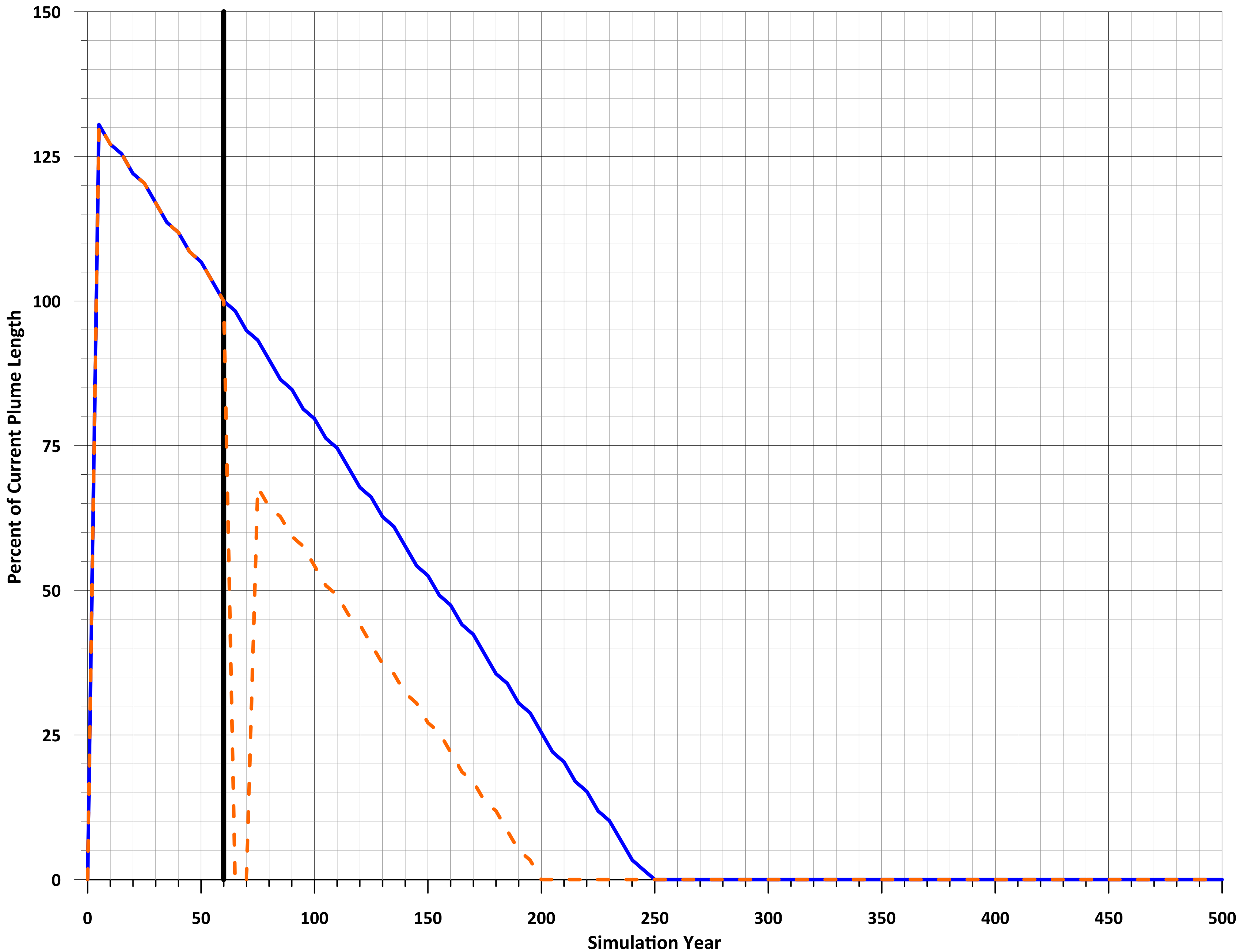


Figure B-5
Simulated Relative TCE Plume Length Versus Time; Alfa Area
Corrective Measures Study
SSFL, Ventura County, California

FES0528201002MGM 695738CH.69.SM Figure_B-5_v2_AlfaAreaPlume.ai 5/26/20

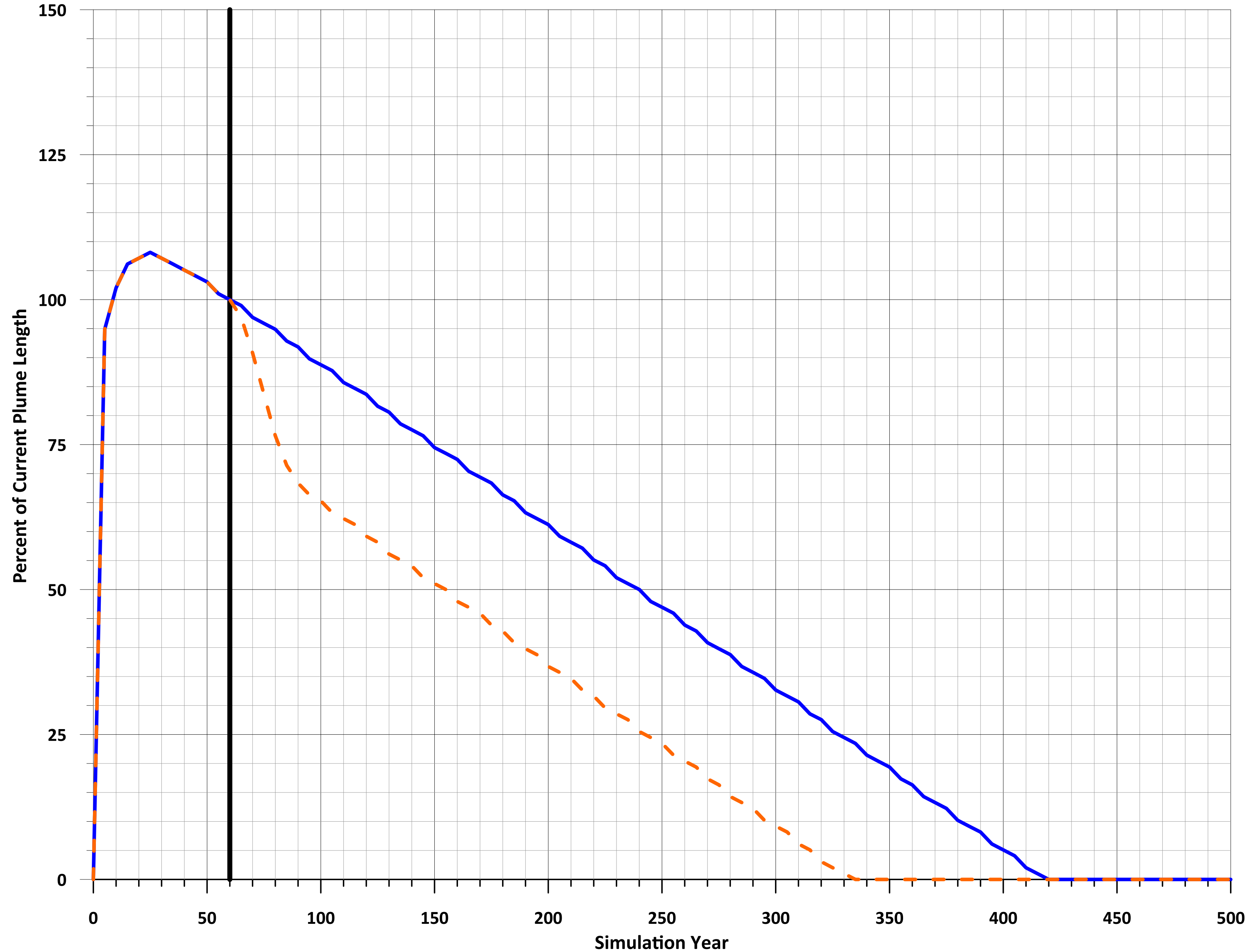


Figure B-6
Simulated Relative TCE Plume Length Versus Time; Bravo Area
Corrective Measures Study
SSFL, Ventura County, California

FES0528201002MGM 695738CH.69.SM_Figure_BC-6_v2_BravoAreaPlume.ai 5/26/20

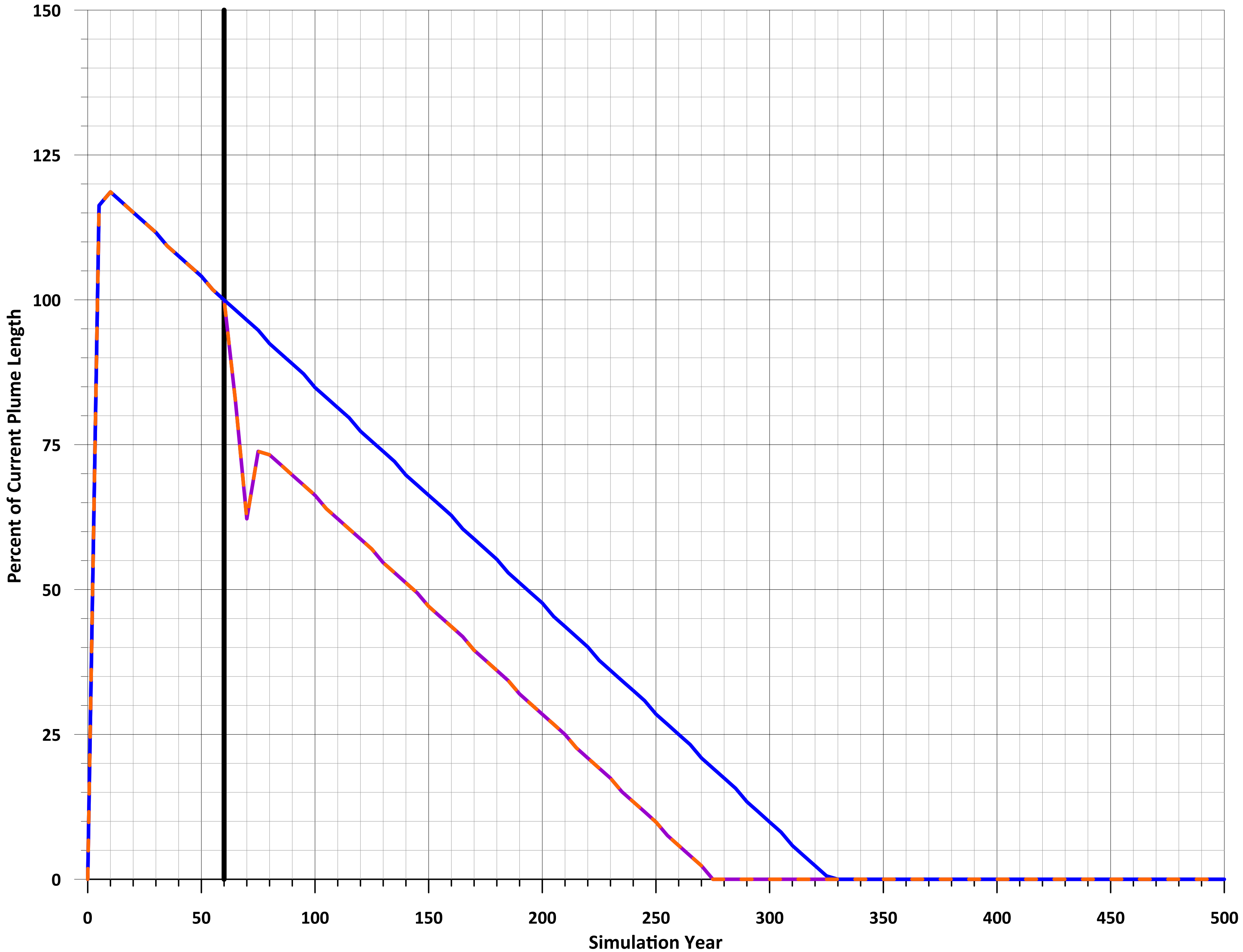


Figure B-7
Simulated Relative TCE Plume Length Versus Time; Delta Area
Corrective Measures Study
SSFL, Ventura County, California

FES0528201002MGM 695738CH.69.SM Figure_B-7_v2_DeltaAreaPlume.ai 5/26/20

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Appendix C
Groundwater Extraction and Treatment System Letter from Los Angeles Regional Water Quality Control Board

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Los Angeles Regional Water Quality Control Board

November 12, 2019

Mr. Roger Paulson, PE, Chief
Santa Susana Field Laboratory Unit
Department of Toxic Substances Control
8800 Cal Center Drive
Sacramento, CA 95826
roger.paulson@dtsc.ca.gov

AUTHORIZATION TO REPLACE EXTRACTION FROM GROUNDWATER INTERIM MEASURES WELLS HAR-20 AND RD-49A WITH EXTRACTION FROM WELL ND-136 – SANTA SUSANA FIELD LABORATORY, THE BOEING COMPANY, 5800 WOOLSEY CANYON ROAD, CANOGA PARK, CALIFORNIA 91304 (ORDER NO. R4-2014-0187, SERIES NO. 095, FILE NO. 16-137, CI No. 10310, GLOBAL ID WDR100039573)

Dear Mr. Paulson:

On October 2, 2017, the Los Angeles Regional Water Quality Control Board (Regional Water Board) enrolled The Boeing Company (Discharger) under General Waste Discharge Requirements (WDR) Order No. R4-2014-0187 with a Monitoring and Reporting Program (MRP) No. CI-10310 for the injection of treated groundwater from multiple extraction wells into well WS-5 at the site referenced above (Site). The extraction and injection are components of the Groundwater Interim Measures (GWIM) approved by the Department of Toxic Substances Control (DTSC). DTSC is the lead agency overseeing environmental remediation activities at the Santa Susana Field Laboratory (SSFL). DTSC approved the GWIM on March 12, 2013. The Discharger treats groundwater extracted from multiple administrative areas at SSFL and injects it at well WS-5. The National Aeronautics and Space Administration (NASA) oversees certain administrative areas.

On October 17, 2019, DTSC submitted a letter to the Regional Water Board with the subject Groundwater Interim Measures Pumping at NASA'S Alfa Area, Santa Susana Field Laboratory, Ventura County, California (Letter). The Letter indicates that NASA proposes to pump from a new NASA well (ND-136) instead of wells currently planned for pumping (HAR-20 and RD-49A). The requested change is based on data obtained during environmental assessment work conducted since the original GWIM approval.

The new data indicate the chemicals of concern (COC) mass removal rate from pumping at ND-136 will be significantly greater than the combined mass removal rate from simultaneous pumping at both HAR-20 and RD-49A. Using the new well will enhance GWIM effectiveness.

Based on the review of the information submitted, the Discharger is authorized to replace extraction from GWIM wells HAR-20 and RD-49A with extraction from well ND-136 and to continue the existing monitoring and reporting program. All requirements in WDR Order No. R4-2014-0187 and MRP No. CI-10310 remain in effect.

If you have any questions, please contact the Project Manager, Mr. Peter Raftery at (213) 620-6156 (Peter.Raftery@waterboards.ca.gov), or the Chief of the Groundwater Permitting Unit, Dr. Eric Wu at (213) 576-6683 (Eric.Wu@waterboards.ca.gov).

Sincerely,

Renee Purdy
Executive Officer

cc (via email): Steven Becker, DTSC, steven.becker@dtsc.ca.gov
Paul Carpenter, DTSC, paul.carpenter@dtsc.ca.gov
Tom Seckington, DTSC, tom.seckington@dtsc.ca.gov
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Steven Reiners, Stantec, steven.reiners@stantec.com

Appendix D
Depth of Target Treatment Areas: Alfa, Bravo, and Northern and Southern Seep Areas

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APPENDIX D

Depth of Target Treatment Areas: Alfa, Bravo, and Northern and Southern Seep Areas

The rationale for the depth of the Phase 1 Groundwater Corrective Measures Study (CMS) Target Treatment Areas (TTAs) is included in this appendix.

1.1 Alfa ND-136 Target Treatment Area

ND-136 is the well that has qualified the Alfa TTA to be included in the Phase 1 CMS remedial alternative analysis. Figure D-1 shows the rock core sample analytical results for ND-136 from the Area of Impacted Groundwater (AIG) Data Evaluation Report included in the NASA Groundwater RFI Report (NASA, 2020). In this well, trichloroethene (TCE) is the dominant compound, and two clusters of detections are noted: 65 to 190 feet below ground surface (bgs), designated for bedrock vapor extraction in the Phase 1 CMS for the vadose zone (depth to groundwater is approximately 280 feet bgs) and 475 feet bgs in the saturated zone. Figure D-2 presents a summary of depth-discrete groundwater sampling and hydraulic testing, which shows mostly low permeability layers, with one significant interval with high flow: 445 to 475 feet bgs. Figure D-3 shows the location of cross-section C-C' that is presented on Figure D-4. This cross-section is from the NASA Groundwater RFI Report and includes well ND-136 and its depth-discrete TCE concentration data. The Flexible Liner Underground Technology (FLUTe) sample concentrations at ND-136 are elevated in the upper three ports, corresponding to the zones from 307 to 460 feet bgs. The one FLUTe port beneath this interval, at 515 to 530 feet bgs, had concentrations about 100-fold lower, in what is also a lower permeability zone. Because the high permeability zone at 445 to 475 feet bgs is also a high contaminant flux zone, 475 feet bgs was chosen as the total depth for the ND-136 TTA. The assumed footprint of the treatment area (width and length at the ground surface) is 150 feet by 150 feet as described in Section 4.2.1 of the Phase 1 Groundwater CMS. If the depth to groundwater is assumed at 275 feet bgs the saturated thickness of the TTA is 200 feet. Therefore, the Alfa ND-136 TTA volume calculation is as follows:

$$150\ x\ 150\ x\ (475-275)/27\ for\ TTA\ volume\ (\ about\ 166{,}700\ cubic\ yards)$$

1.2 Bravo WS-09 Target Treatment Area

WS-09 is the location believed to represent the center of the Bravo TTA. This is an old rock core water-supply well, and stability problems of its sidewalls has led to irregular side wall profile and an inability to safely perform downhole geophysics and depth-discrete packer testing. Therefore, detailed rock core and depth-specific water concentration data are unavailable at WS-09. Besides a high groundwater concentration (30,000 micrograms per liter [µg/L]), the total depth of treatment for this location is indicated by a fracture zone that appears to be a source of high concentrations to WS-09 at 1,510 feet above mean sea level. This pattern is illustrated on Figure D-6, which is a time graph spanning decades, showing the water table variation during times of extreme pumping and recovery and the corresponding concentrations of TCE. The fracture interval identified is at a depth of 372 feet bgs in WS-09, which represents the zone believed to contain at least moderate flow and the highest TCE concentrations in this well. Figure D-3 shows the location of cross-section B-B' that is presented on Figure D-5. This cross-section is from the NASA Groundwater RFI Report (NASA, 2020) and includes well WS-09 and TCE concentration data from nearby wells. The Bravo WS-09 TTA depth is rounded to 400 feet bgs (depth to groundwater is approximately 250 feet bgs, so the saturated thickness of the TTA is 150 feet). The assumed footprint of the treatment area (width and length at the ground surface) is 150 feet by 150 feet, as described in Section 4.2.1 of the Phase 1 Groundwater CMS. The Bravo WS-09 TTA volume calculation is as follows:

$$150\ x\ 150\ x(400-250)/27\ for\ TTA\ volume\ (about\ 125{,}000\ cubic\ yards)$$

1.3 Delta C-6 Target Treatment Area

C-6 is a deep core hole in the Delta Skim Pond that has been converted to a deep conventional monitoring well (screened from 735 to 885 feet bgs). This location provided historically significant rock core concentration data at close intervals. These data were collected by the team at the University of Guelph[1].

A chart showing the C-6 pore water concentrations, converted to equivalent rock core concentrations with depth, is presented on Figure D-7. On this chart, there is a clear block of the highest concentrations from just below the ground surface to approximately 280 feet bgs, with an additional stringer of very high concentrations at 300 feet bgs. This zone would be an efficient zone in which to target treatment, but high concentrations are also present from approximately 400 feet bgs to approximately 480 feet bgs, after a concentration gap between 300 feet and 400 feet bgs. A Coca/Delta AIG plume map and cross-section from the NASA Groundwater RFI report (NASA, 2020) is included for reference on Figures D-8 and D-9.

An additional Delta Skim Pond source area well, ND-169, was drilled adjacent to C-6 to a depth of 500 feet bgs to support further characterization of the C-6 TTA and to provide a potential remedial extraction well. Depth-discrete groundwater TCE concentrations from this new well ranged from 6,200 to 98,000 µg/L, with an open borehole concentration of 53,000 µg/L (NASA, 2022).

A strategy requiring containment and source reduction should include the total depth to 500 feet bgs (depth to groundwater in this area is approximately 100 feet bgs, so the saturated thickness of the TTA is 400 feet). The assumed footprint of the treatment area (width and length at the ground surface) is 150 feet by 150 feet as described in Section 4.2.1 of the Phase 1 Groundwater CMS. The Delta C-6 TTA volume calculation is as follows:

$$150\ x\ 150\ x\ (500 - 100)/27\ for\ TTA\ volume\ (about\ 333{,}300\ cubic\ yards)$$

1.4 Northern Seep Area

Seeps discharge to the hillside slopes north of the Building 204/Expendable Launch Vehicle (B204/ELV) AIG in Area II. This is called the Northern Seep Area for the Phase 1 groundwater CMS. At the time this document was developed, only trace detections in historic sampling, with recent sampling confirming nondetects, have been found in these seep sampling clusters. If a detection of a chemical of concern (COC), with a trend to approach a water quality limit were to occur, upgradient wells would be considered to either pump or provide in situ treatment to remove mass from a possible source of the COCs and intercept groundwater possibly flowing to these seeps from the B204/ELV AIG source areas. In contrast to the three source area TTAs previously discussed, these seep control wells would be used to contribute to containment of a distal plume that otherwise may continue migrating to the north.

For the Building 204 Area, the closest downgradient seep wells (SP-25 seep well cluster) are about 0.25 mile away, and there is no recent groundwater COC detection at this location. The depth of the plume is about 450 feet bgs in this area. Depth to water is about 300 feet bgs; therefore, the ELV seep TTA has a saturated thickness of 150 feet. If downgradient seep detections are present and approaching water quality limits in the future, groundwater extraction from a series of wells along a 250-foot-long transect, with each well at a depth of about 450 feet bgs, would address the plume zone by exerting hydraulic control on the leading edge of the Building 204 Area Chatsworth Formation groundwater (CFGW) plume. The location of this transect north of Building 204 is shown on Figure D-10. The B204/ELV AIG TCE plumes are shown on Figure D-11, along with cross-section locations. As depicted on the cross-section for the Building 204 Area plume (Figure D-12), there is uncertainty as to the nature of the ELV member/North Fault Zone intersection

[1] Hurley, Jennifer C., Beth L. Parker, and John A. Cherry. 2003. *Source Zone Characterization at the Santa Susana Field Laboratory: Rock Core VOC Results for Core Holes C1 through C7*. Santa Susana Field Laboratory, Ventura County, California. December.

in terms of geometry, permeability, and contaminant extent. Upgradient of this contact, the plume appears to be below the ELV member; downgradient of this contact, the plume is detected only above the ELV member. Locations both upgradient and/or downgradient of this contact would be explored as part of the Corrective Measures Implementation (CMI) if it were necessary to install and operate a remedial well for hydraulic control. An extended cross-section of the Building 204 Area to the north includes seep and seep well cluster locations and is depicted on Figure D-13.

For the ELV, there are two wells that serve to define the ELV CFGW plume: C-7 and ND-125. Both of these wells are completed multi-level FLUTe wells. The plume footprint inferred by data from these two wells suggests that the ELV CFGW plume flows to the northwest (Figure D-11), while groundwater flow based on hydraulic gradients appears to be toward true north. The depth of the plume is about 400 feet bgs in this area (Figure D-14). Depth to water is about 180 feet bgs; therefore, the ELV seep TTA has a saturated thickness of 220 feet. If downgradient seep detections are present and approaching water quality limits, groundwater extraction from a series of wells along a 250-foot-long transect (Figure D-10) with each well at a depth of about 400 feet bgs would address the plume zone by exerting hydraulic control on the leading edge of the ELV CFGW plume. The well transect would be expected to intercept groundwater and capture COC mass that may be contributing to COC flux at the SP-25 cluster, located approximately 700 feet lower in elevation and about 0.5 mile away. An extended cross-section of the ELV to the north includes seep and seep well cluster locations and is depicted on Figure D-15. Considerable uncertainty remains as to the flow path for the ELV plume to the known seep discharges, so it is likely that the CMI would initially be focused on tracer work to better establish the appropriate location for a remedial pumping well, considering access constraints.

1.5 Southern Seep Area

For the Southern Seep Area associated with the Coca/Delta AIG, the seep cluster completion SP-890-G (50-foot depth) has exceedances of several chlorinated ethenes (Figures D-8 and D-9). This seep cluster is upgradient of the Burro Flats Fault Zone, which is considered an impediment to groundwater flow. Data collected during a recent series of aquifer tests conducted at wells ND-138A and ND-138B (45 feet and 200 feet bgs) and subsequent analysis suggest that pumping of either of these wells at rates exceeding 5 gallons per minute (gpm) would create drawdown at SP-890-G (300 feet away). At this location, the depth of treatment would be 45 feet bgs, the depth of ND-138A (20 feet bgs to groundwater for 25 feet saturated thickness), to address contaminated groundwater at the SP-890 cluster (refer to Figure D-16).

1.6 References

National Aeronautics and Space Administration (NASA). 2020. *NASA Groundwater RFI Report, Santa Susana Field Laboratory, Ventura County, California*. Final. November.

National Aeronautics and Space Administration (NASA). 2022. *Installation of Phase 1 Corrective Measures Implementation Design, Delta Data Gap Well ND-169, Santa Susana Field Laboratory, Ventura County, California*. August.

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Figures

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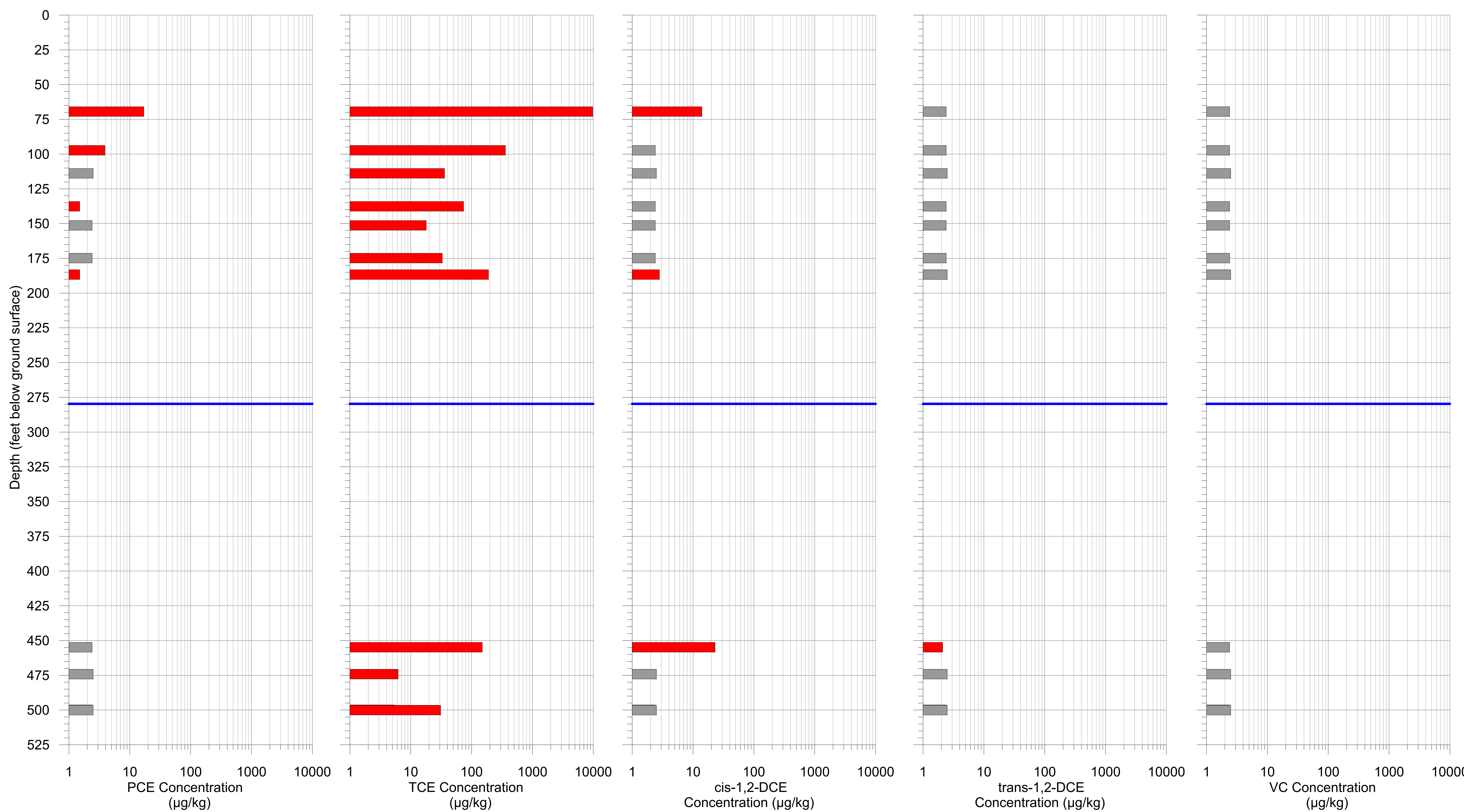
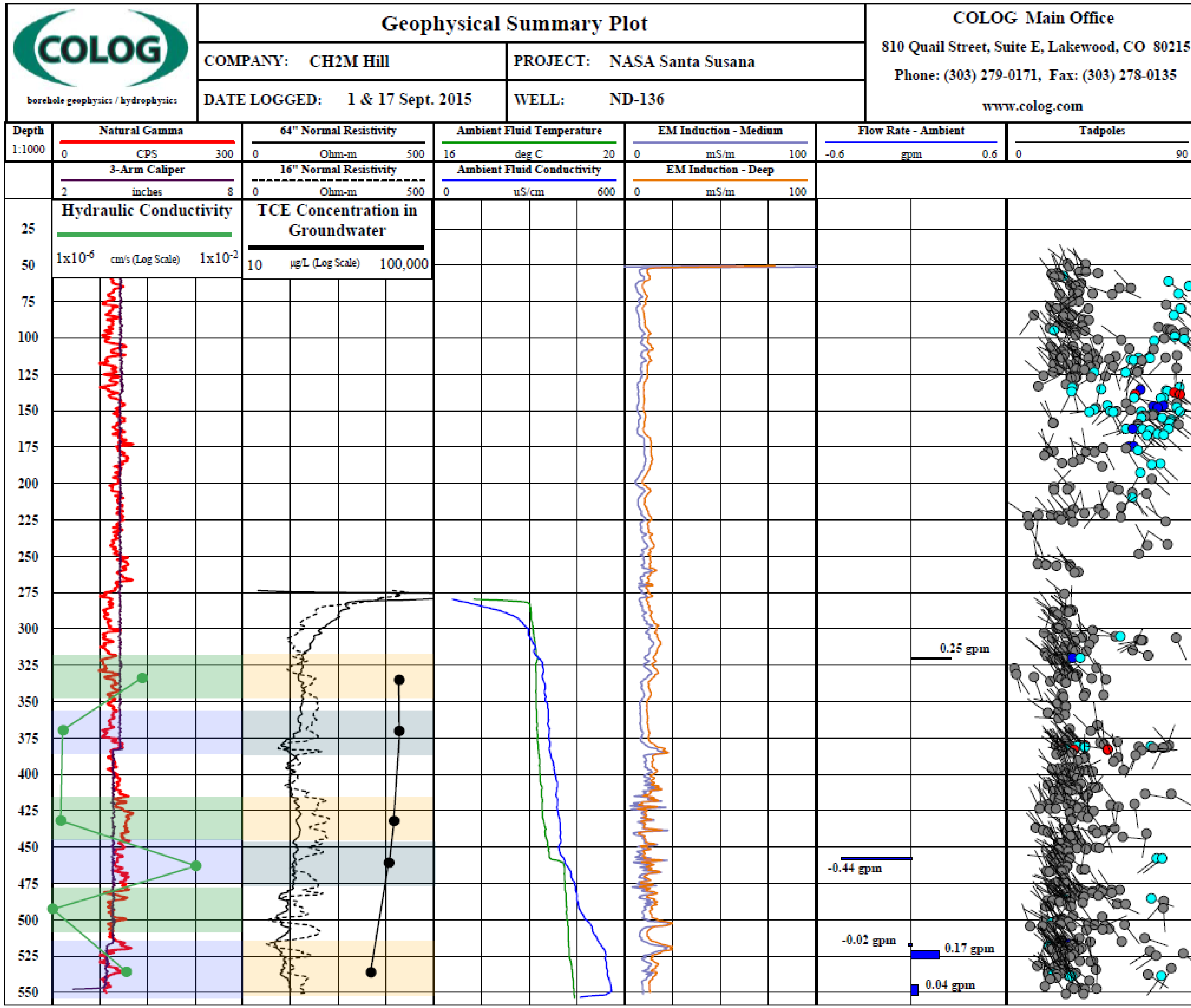


Detected Result
Nondetect Result
Groundwater Level (approximate)

Notes:
1. PCE = tetrachloroethene
2. TCE = trichloroethene
3. DCE = dichloroethene
4. VC = vinyl chloride
5. µg/kg = micrograms per kilogram
6. All samples deeper than 450 feet below ground surface are "screening level" samples.

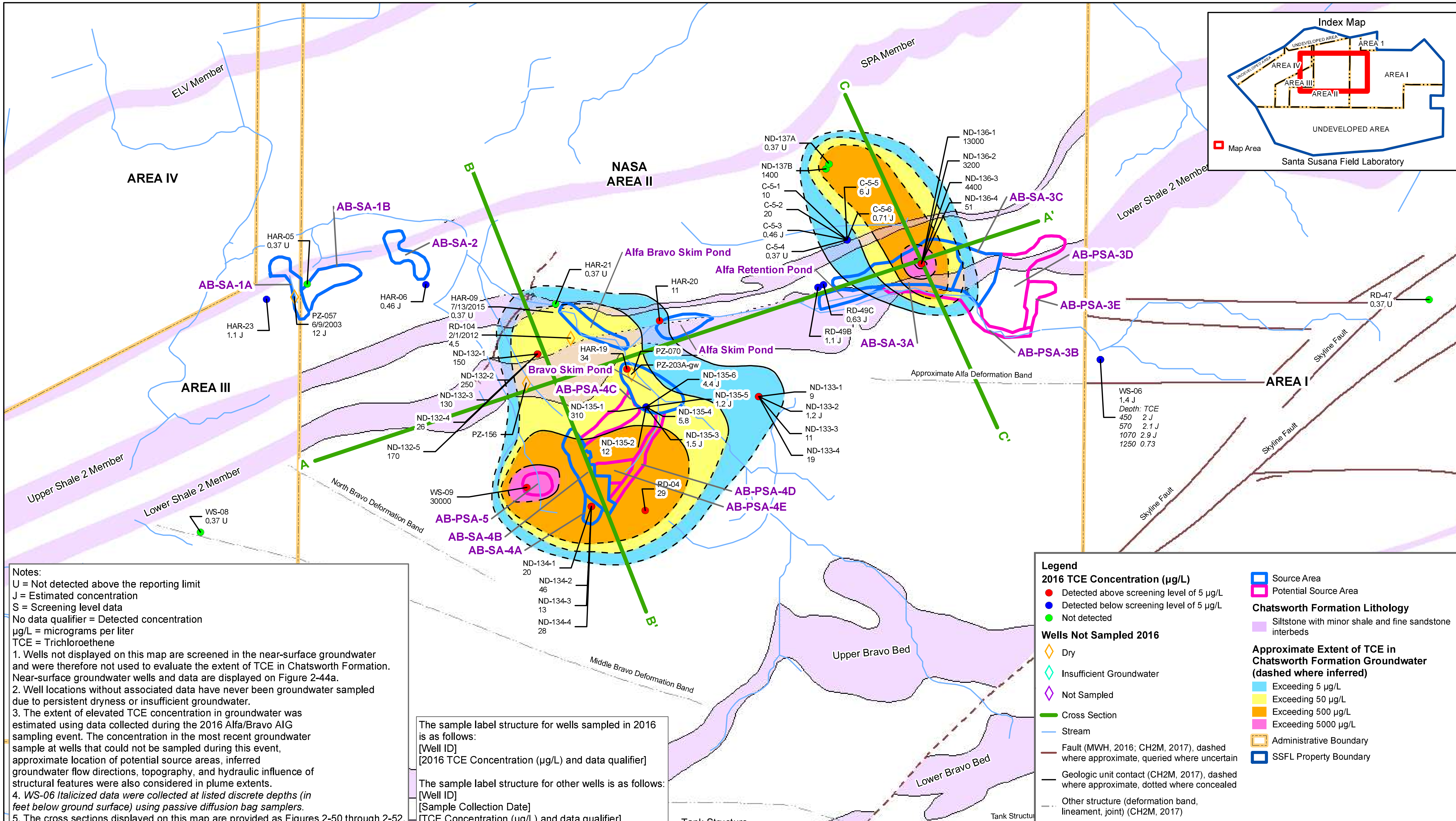
Figure D-1
Alfa ND-136 Target Treatment Area
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California

SCO654377.82.TM SSFL_alpha_bravo_nd136_rock_core.ai 11/15



- ND-136 Packer Test Data
  - Interval 1 (317–347 feet bgs) K=8.9E-5 cm/s (0.4–1.9 gpm)
  - Interval 2 (355–385 feet bgs) K=1.9E-6 cm/s (0.25 gpm)
  - Interval 3 (415–445 feet bgs) K=1.5E-6 cm/s (0.19 gpm)
  - Interval 4 (445–475 feet bgs) K=1.0E-3 cm/s (9–21 gpm)
  - Interval 5 (478–508 feet bgs) K=1.8E-7 cm/s (0.2–0.26 gpm)
  - Interval 6 (514–553 feet bgs) K=5.6E-5 cm/s (1.4–2 gpm)
- ND-136 FLUTe Sample Results (2016–2018)
  - Port 1 (307–322 feet bgs) TCE: 13,000–14,000 µg/L
  - Port 2 (376–386 feet bgs) TCE: 5,000–8,800 µg/L
  - Port 3 (445–460 feet bgs) TCE: 4,000–5,000 µg/L
  - Port 4 (515–530 feet bgs) TCE: 50–60 µg/L

FIGURE D-2
Alfa ND-136 TTA Depth-discrete Data Summary
NASA Phase 1 Groundwater CMS, SSFL, Ventura County, California



Notes:
U = Not detected above the reporting limit
J = Estimated concentration
S = Screening level data
No data qualifier = Detected concentration
µg/L = micrograms per liter
TCE = Trichloroethene

1. Wells not displayed on this map are screened in the near-surface groundwater and were therefore not used to evaluate the extent of TCE in Chatsworth Formation. Near-surface groundwater wells and data are displayed on Figure 2-44a.
2. Well locations without associated data have never been groundwater sampled due to persistent dryness or insufficient groundwater.
3. The extent of elevated TCE concentration in groundwater was estimated using data collected during the 2016 Alfa/Bravo AIG sampling event. The concentration in the most recent groundwater sample at wells that could not be sampled during this event, approximate location of potential source areas, inferred groundwater flow directions, topography, and hydraulic influence of structural features were also considered in plume extents.
4. *WS-06 Italicized data were collected at listed discrete depths (in feet below ground surface) using passive diffusion bag samplers.*
5. The cross sections displayed on this map are provided as Figures 2-50 through 2-52.

The sample label structure for wells sampled in 2016 is as follows:
[Well ID]
[2016 TCE Concentration (µg/L) and data qualifier]

The sample label structure for other wells is as follows:
[Well ID]
[Sample Collection Date]
[TCE Concentration (µg/L) and data qualifier]

Legend

2016 TCE Concentration (µg/L)
- Detected above screening level of 5 µg/L
- Detected below screening level of 5 µg/L
- Not detected

Wells Not Sampled 2016
- Dry
- Insufficient Groundwater
- Not Sampled

- Cross Section
- Stream
- Fault (MWH, 2016; CH2M, 2017), dashed where approximate, queried where uncertain
- Geologic unit contact (CH2M, 2017), dashed where approximate, dotted where concealed
- Other structure (deformation band, lineament, joint) (CH2M, 2017)

- Source Area
- Potential Source Area

Chatsworth Formation Lithology
- Siltstone with minor shale and fine sandstone interbeds

Approximate Extent of TCE in Chatsworth Formation Groundwater (dashed where inferred)
- Exceeding 5 µg/L
- Exceeding 50 µg/L
- Exceeding 500 µg/L
- Exceeding 5000 µg/L

- Administrative Boundary
- SSFL Property Boundary

NASA

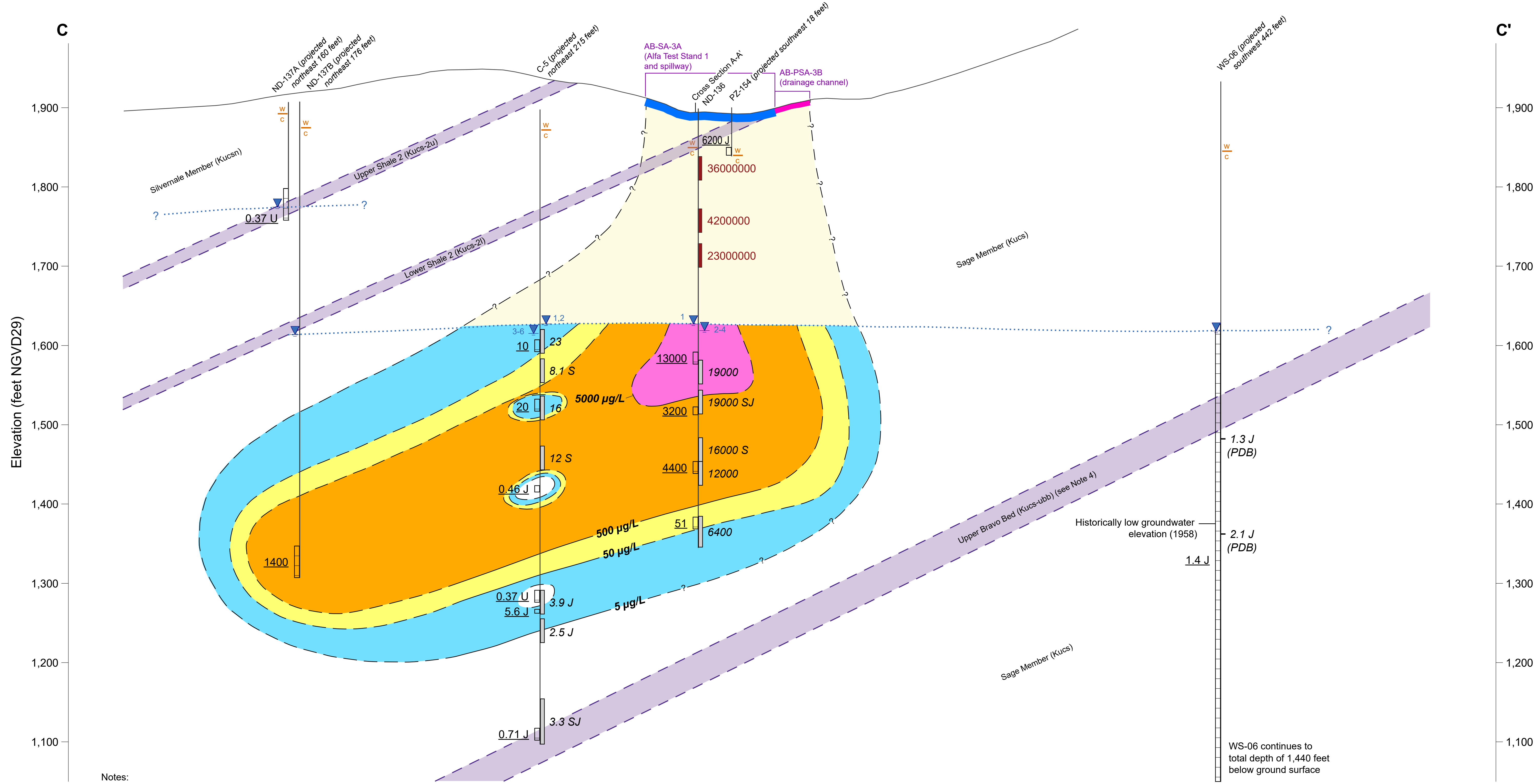
N W E S

0 125 250 500 Feet
0 37.5 75 150 Meters

19-May-2020
Drawn By:
A. Cooley

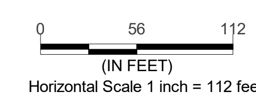
Figure 2-44b
Extent of Trichloroethene in Chatsworth Formation Groundwater
Alfa/Bravo AIG Data Evaluation Report
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\RFI\AB_BE_CFGW_XSect.mxd



Notes:
1. Posted TCE data are the latest reliable data available as of April 2016.
2. Source areas, bedrock vapor data, and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown in this document.
3. The 5 µg/L TCE contour is based on the highest detected concentration, regardless of sample type. Internal TCE contours (50 µg/L and above) are based on traditional groundwater sample data only (not packer or PDB sample data) and sometimes exclude projected wells.
4. The Upper Bravo Bed is drawn based on its location within projected well C-5 and is therefore not representative of its location in the plane of the cross section. Otherwise, depicted bedding inclinations represent apparent dips.
5. The location and orientation of this cross section can be viewed on Figure 2-44b.

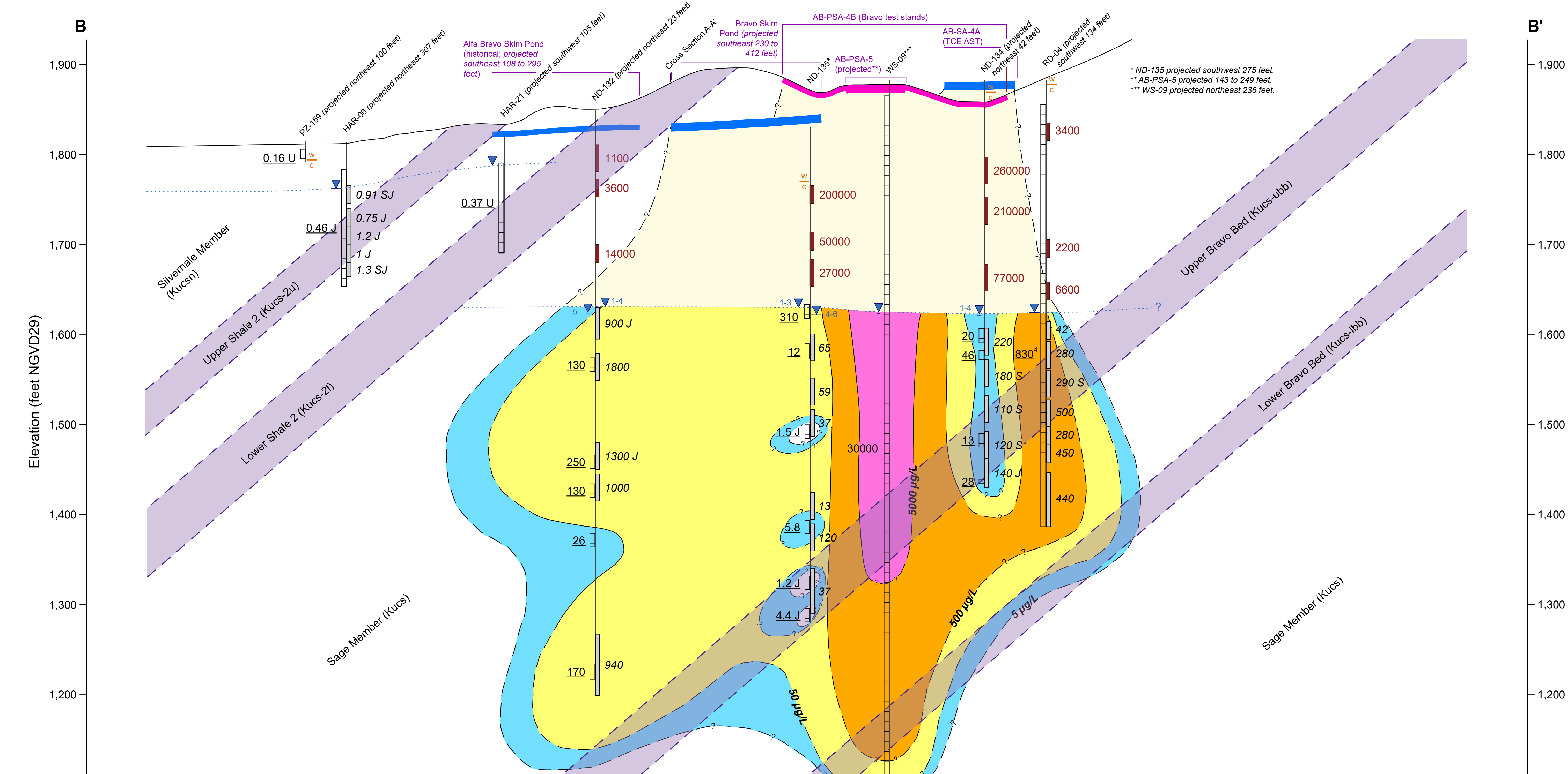
J - Concentration is estimated
NGVD29 - National Geodetic Vertical Datum of 1929
PDB - Passive Diffusion Bag
S - Data is appropriate for screening purposes only
TCE - Trichloroethene
U - Concentration is below detection limit
µg/L - micrograms per liter
µg/m³ - micrograms per cubic meter



Screen Interval
Packer Interval
Bedrock Vapor Sample Interval
Location of Source Area or Potential Source Area
Approximate Weathered/Competent Bedrock Interface
Groundwater Elevation (and FLUTe port number, where applicable) and approximate water table, Winter 2016
Approximate Extent of TCE in Chatsworth Formation Groundwater (dashed where inferred)
Inferred Extent of TCE in Vadose Zone (see note 2)
Siltstone with Minor Shale and Fine Sandstone Interbeds

TCE Concentrations
2.5 - Traditional Groundwater Sample (µg/L)
2.5 - Packer Groundwater Sample (µg/L)
2.5 - Bedrock Vapor Sample (µg/m³)

Figure D-4
Alfa/Bravo AIG Hydrogeologic Cross Section C-C'
NASA *Phase 1 Groundwater CMS*
NASA SSFL, Ventura County, California



Notes:
1. Posted TCE data are the latest reliable data available as of April 2016.
2. Source areas, bedrock vapor data, and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown in this document.
3. The 5 µg/L TCE contour is based on the highest detected concentration, regardless of sample type. Internal TCE contours (50 µg/L and above) are based on traditional groundwater sample data only (not packer or PDB sample data) and sometimes exclude projected wells.
4. Data from the January 2016 traditional groundwater sample at RD-04 were anamolous. The TCE result from the sample collected on August 9, 2016 is displayed instead.
5. The location and orientation of this cross section can be viewed on Figure 2-44b.
6. Depicted bedding inclinations represent apparent dips.

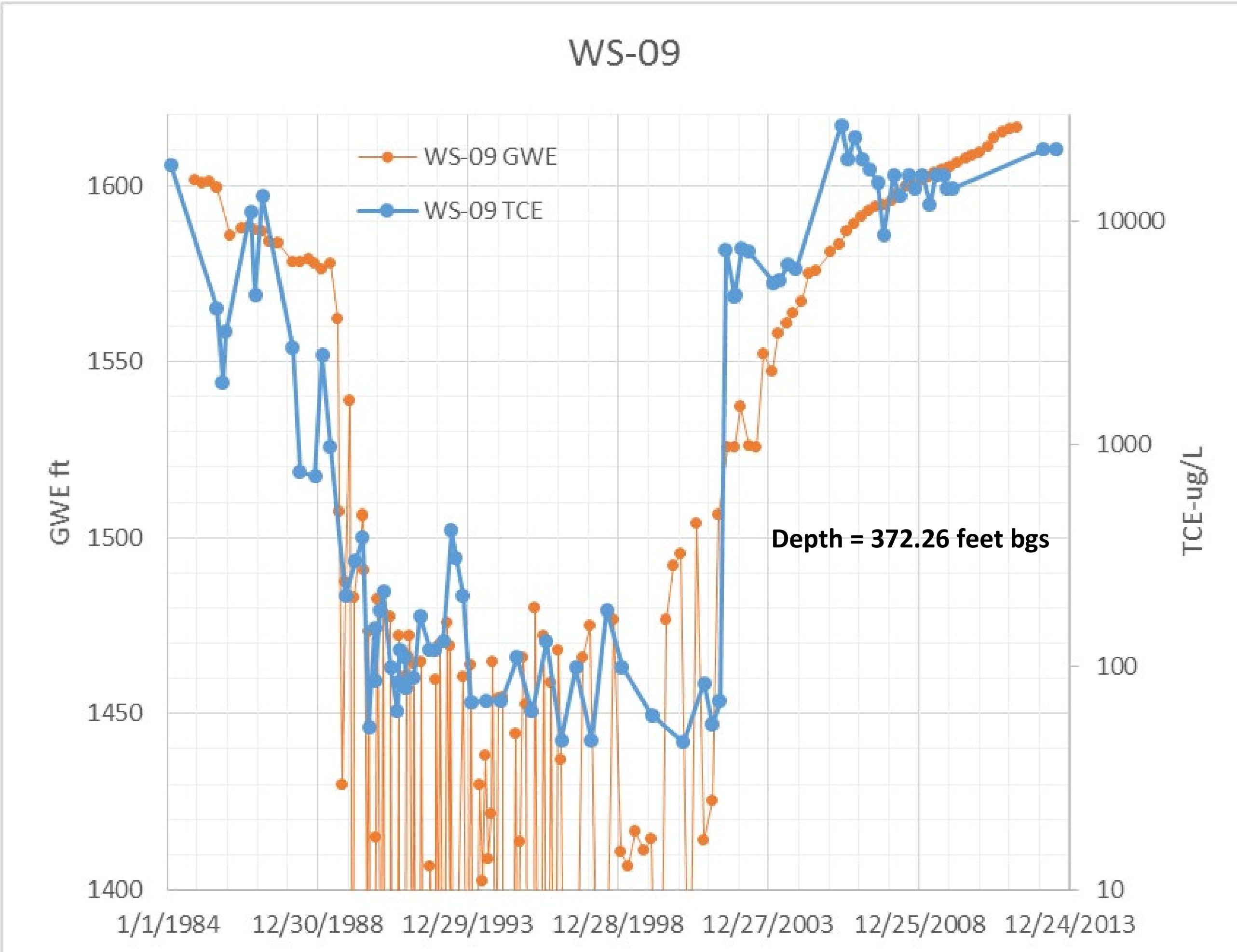
AST - Above-ground storage tank
J - Concentration is estimated
NGVD29 - National Geodetic Vertical Datum of 1929
S - Data is appropriate for screening purposes only
TCE - Trichloroethene
U - Concentration is below detection limit
µg/L - micrograms per liter
µg/m3 - micrograms per cubic meter

0 75 150
(IN FEET)
Horizontal Scale 1 inch = 150 feet
Vertical Exaggeration: 1.35x

Screen Interval
Packer Interval
Bedrock Vapor Sample Interval
Location of Source Area or Potential Source Area
Approximate Weathered/Competent Bedrock Interface
Groundwater Elevation (and FLUTe port number, where applicable) and approximate water table, Winter 2016
Approximate Extent of TCE in Chatsworth Formation Groundwater (dashed where inferred)
Inferred Extent of TCE in Vadose Zone (see note 2)
Siltstone with Minor Shale and Fine Sandstone Interbeds

TCE Concentrations
2.5 - Traditional Groundwater Sample (µg/L)
2.5 - Packer Groundwater Sample (µg/L)
2.5 - Bedrock Vapor Sample (µg/m3)

Figure D-5
Alfa/Bravo AIG Hydrogeologic Cross Section B-B'
NASA Phase 1 Groundwater CMS
NASA SSFL, Ventura County, California



Notes:
The TCE concentrations are the blue-toned line, and the water level is the orange line.
Ground surface elevation is 1,882.26 feet above mean sea level.

FIGURE D-6
Bravo WS-09 TTA TCE Concentration and Groundwater Elevation Correlation
NASA Phase 1 Groundwater CMS, SSFL, Ventura County, California

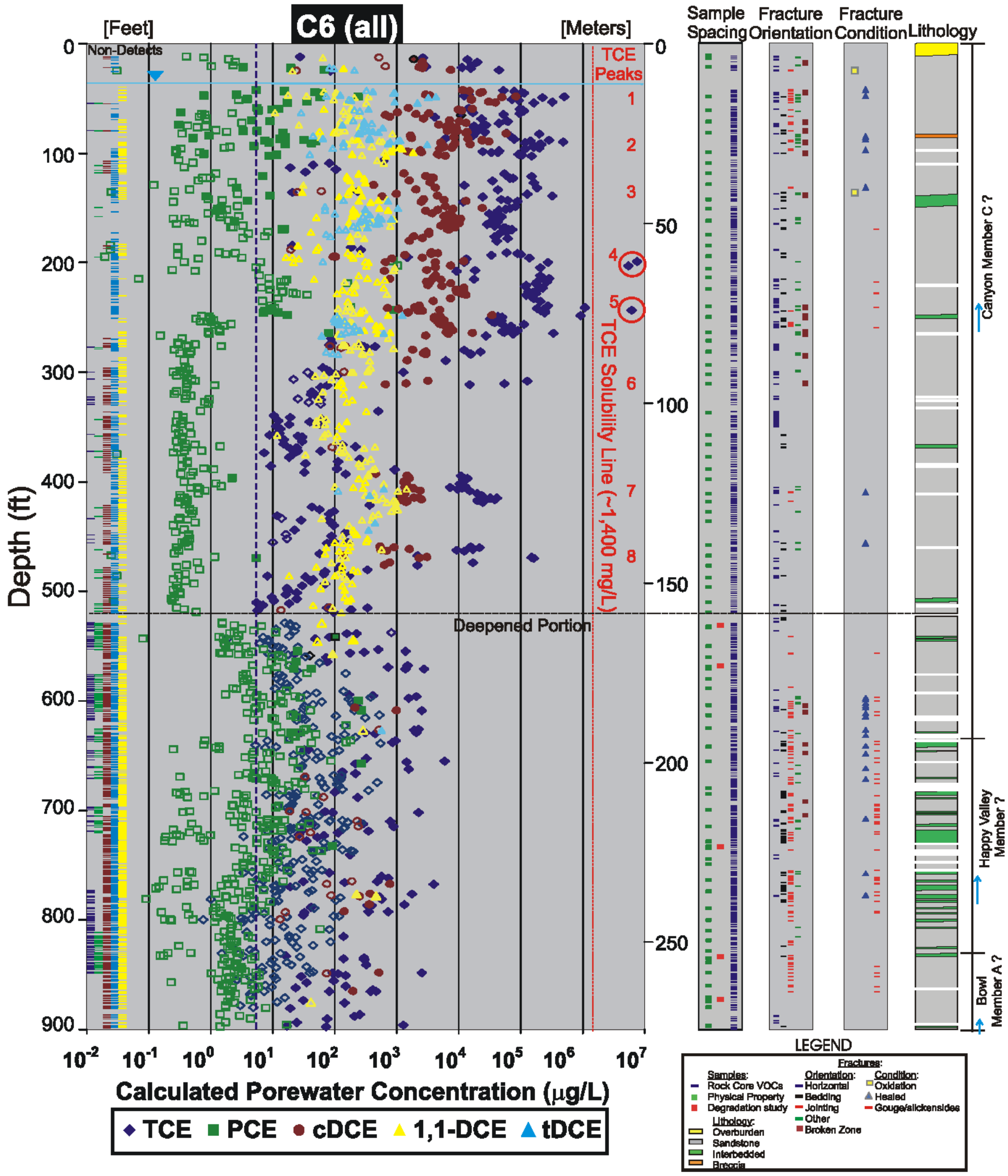
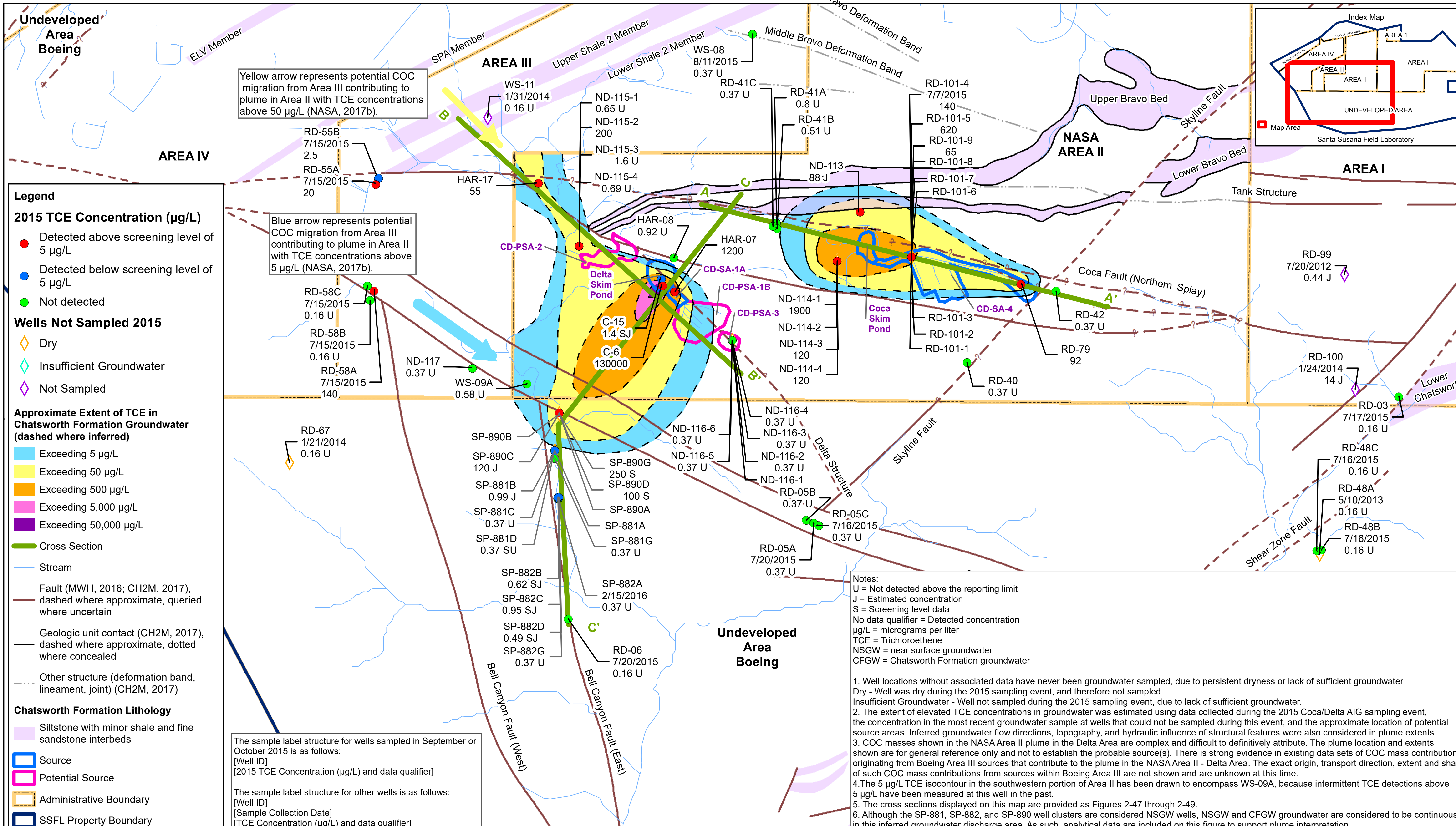


FIGURE D-7

Delta C-6 TTA Rock Core Porewater Concentration Data

NASA Phase 1 Groundwater CMS, SSFL, Ventura County, California



The sample label structure for wells sampled in September or October 2015 is as follows:
[Well ID]
[2015 TCE Concentration (µg/L) and data qualifier]

The sample label structure for other wells is as follows:
[Well ID]
[Sample Collection Date]
[TCE Concentration (µg/L) and data qualifier]

Notes:
U = Not detected above the reporting limit
J = Estimated concentration
S = Screening level data
No data qualifier = Detected concentration
µg/L = micrograms per liter
TCE = Trichloroethene
NSGW = near surface groundwater
CFGW = Chatsworth Formation groundwater

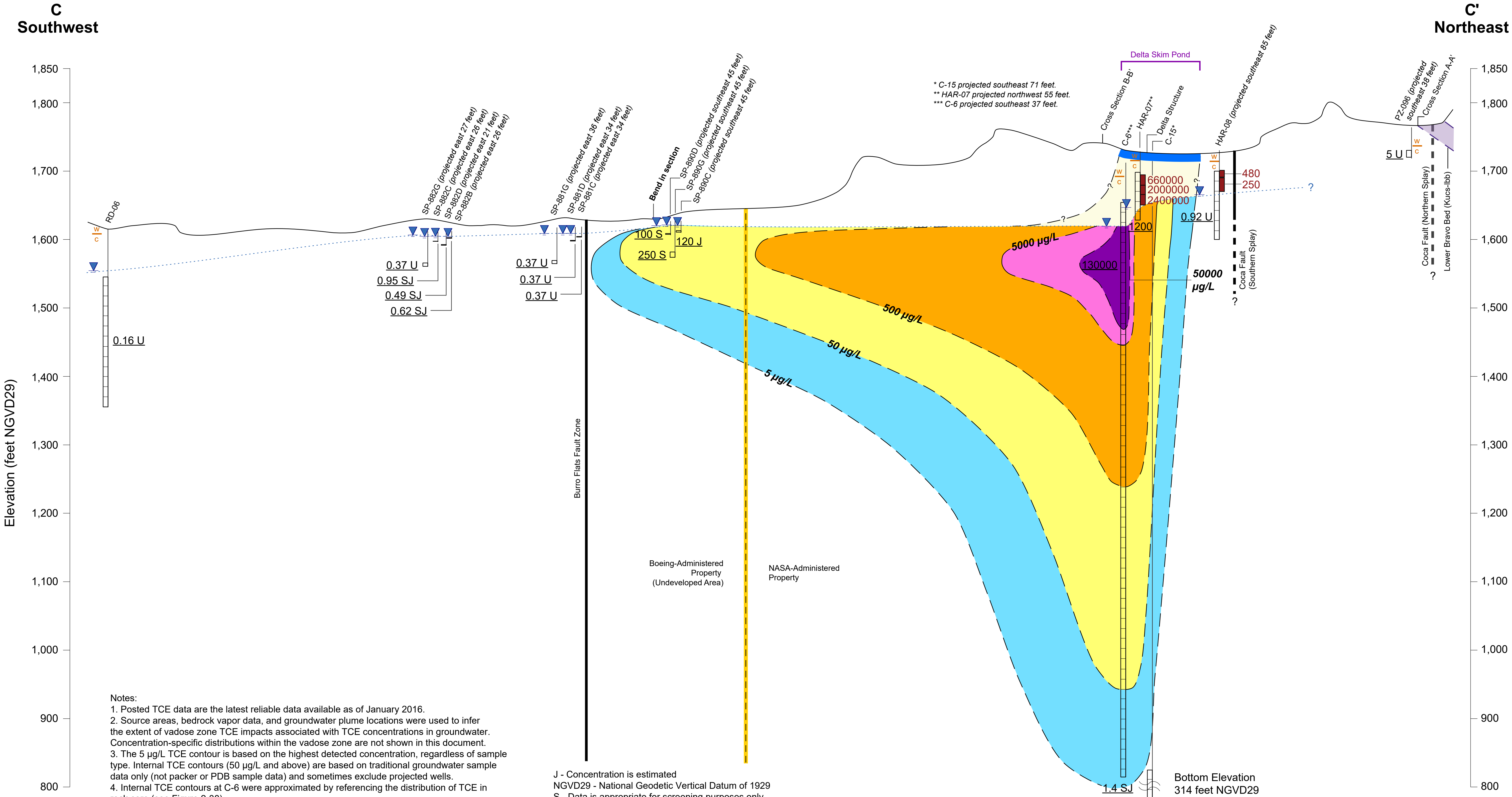
1. Well locations without associated data have never been groundwater sampled, due to persistent dryness or lack of sufficient groundwater
Dry - Well was dry during the 2015 sampling event, and therefore not sampled.
Insufficient Groundwater - Well not sampled during the 2015 sampling event, due to lack of sufficient groundwater.
2. The extent of elevated TCE concentrations in groundwater was estimated using data collected during the 2015 Coca/Delta AIG sampling event, the concentration in the most recent groundwater sample at wells that could not be sampled during this event, and the approximate location of potential source areas. Inferred groundwater flow directions, topography, and hydraulic influence of structural features were also considered in plume extents.
3. COC masses shown in the NASA Area II plume in the Delta Area are complex and difficult to definitively attribute. The plume location and extents shown are for general reference only and not to establish the plume source(s). There is strong evidence in existing data sets of COC mass contributions originating from Boeing Area III sources that contribute to the plume in the NASA Area II - Delta Area. The exact origin, transport direction, extent and shape of such COC mass contributions from sources within Boeing Area III are not shown and are unknown at this time.
4.The 5 µg/L TCE isocontour in the southwestern portion of Area II has been drawn to encompass WS-09A, because intermittent TCE detections above 5 µg/L have been measured at this well in the past.
5. The cross sections displayed on this map are provided as Figures 2-47 through 2-49.
6. Although the SP-881, SP-882, and SP-890 well clusters are considered NSGW wells, NSGW and CFGW groundwater are considered to be continuous in this inferred groundwater discharge area. As such, analytical data are included on this figure to support plume interpretation.

0 250 500 1,000 Feet
0 75 150 300 Meters

01-Oct-2020
Drawn By:
A. Cooley

Figure D-8
Extent of Trichloroethene in Chatsworth Formation Groundwater
Phase 1 Groundwater CMS
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\RFI\COCA_DELTA_AIG-TCE_CFGW.mxd



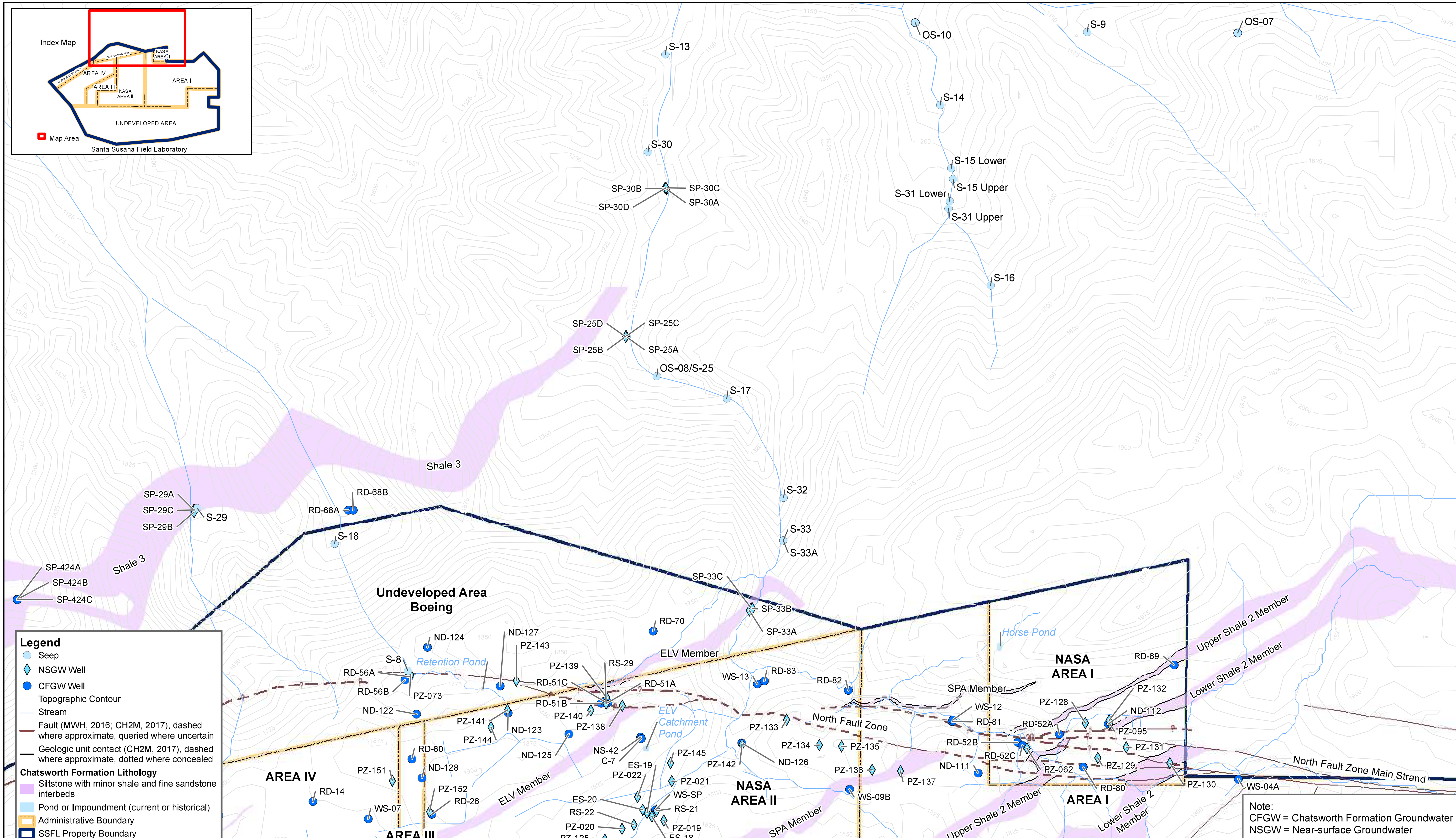
Notes:
1. Posted TCE data are the latest reliable data available as of January 2016.
2. Source areas, bedrock vapor data, and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown in this document.
3. The 5 µg/L TCE contour is based on the highest detected concentration, regardless of sample type. Internal TCE contours (50 µg/L and above) are based on traditional groundwater sample data only (not packer or PDB sample data) and sometimes exclude projected wells.
4. Internal TCE contours at C-6 were approximated by referencing the distribution of TCE in rock core (see Figure 2-38).
5. HAR-07, C-6, SP-890D, SP-890G, SP-881D, SP-882C, SP-882D, and SP-882G are offset for clarity.
6. The location and orientation of this cross section can be viewed on Figure 2-41.
7. Depicted bedding inclinations represent apparent dips.

J - Concentration is estimated
NGVD29 - National Geodetic Vertical Datum of 1929
S - Data is appropriate for screening purposes only
TCE - Trichloroethene
U - Concentration is below detection limit
µg/L - micrograms per liter
µg/m3 - micrograms per cubic meter

TCE Concentrations
2.5 - Traditional Groundwater Sample (µg/L)
2.5 - Bedrock Vapor Sample (µg/m3)

Screen or Open Interval
Bedrock Vapor Sample Interval
Location of Source Area
Approximate Weathered/Competent Bedrock Interface
Groundwater Elevation (and FLUTe port number, where applicable) and approximate water table, Winter 2016
Approximate Extent of TCE in Chatsworth Formation Groundwater (dashed where inferred)
Inferred Extent of TCE in Vadose Zone (see note 2)
Siltstone with Minor Shale and Fine Sandstone Interbeds
Fault
Administrative Boundary

Figure D-9
Coca/Delta AIG Hydrogeologic Cross Section C-C'
Phase 1 Groundwater CMS
NASA SSFL, Ventura County, California



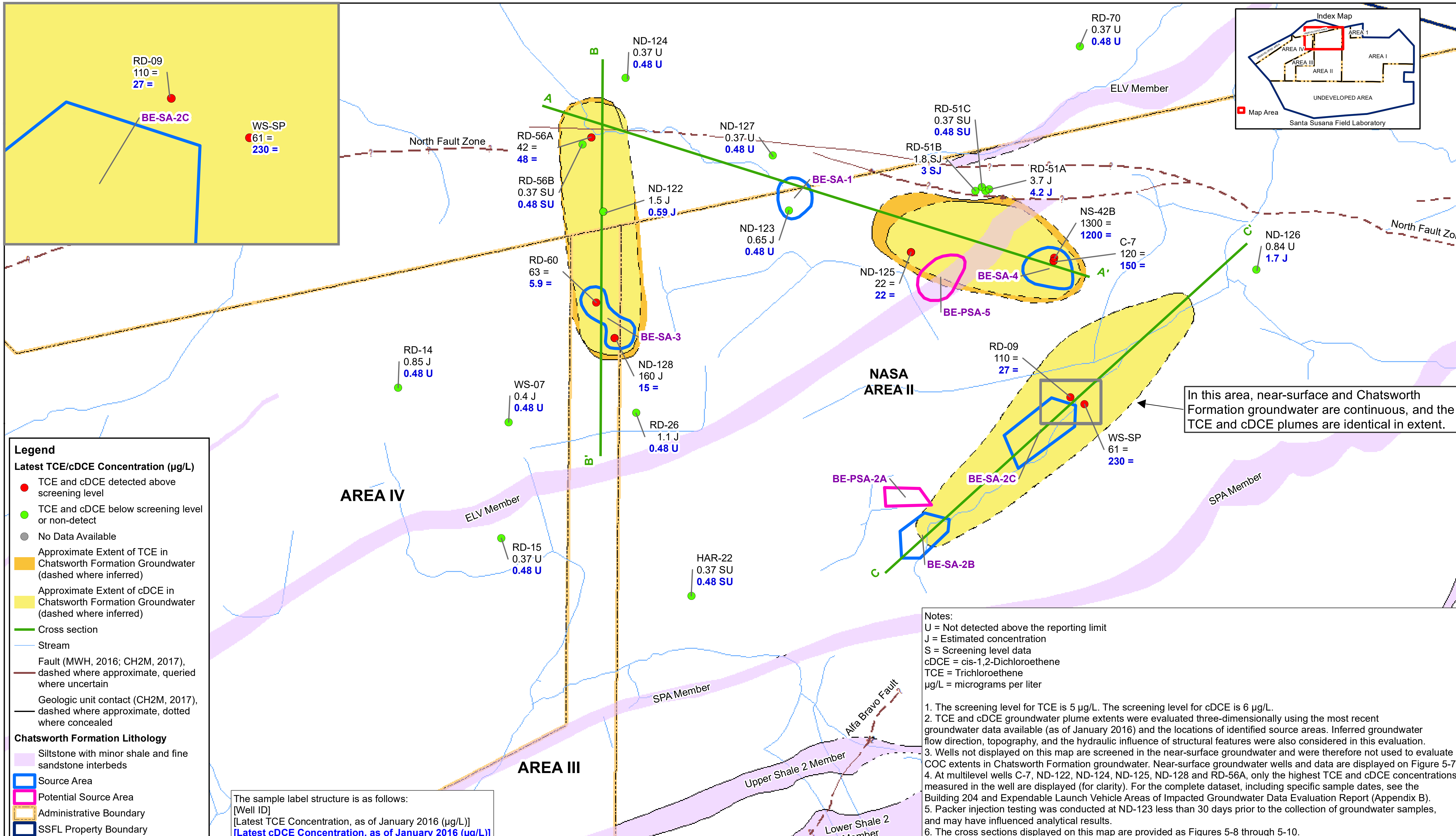
0 300 600 1,200 Feet

0 87.5 175 350 Meters

27-Mar-2020
Drawn By:
A. Cooley

Figure D-10
B204/ELV AIG Plan View Showing Seep Sample Locations
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\NASA_RFI\BE_LOX_SeepLocs.mxd



Notes:
U = Not detected above the reporting limit
J = Estimated concentration
S = Screening level data
cDCE = cis-1,2-Dichloroethene
TCE = Trichloroethene
µg/L = micrograms per liter

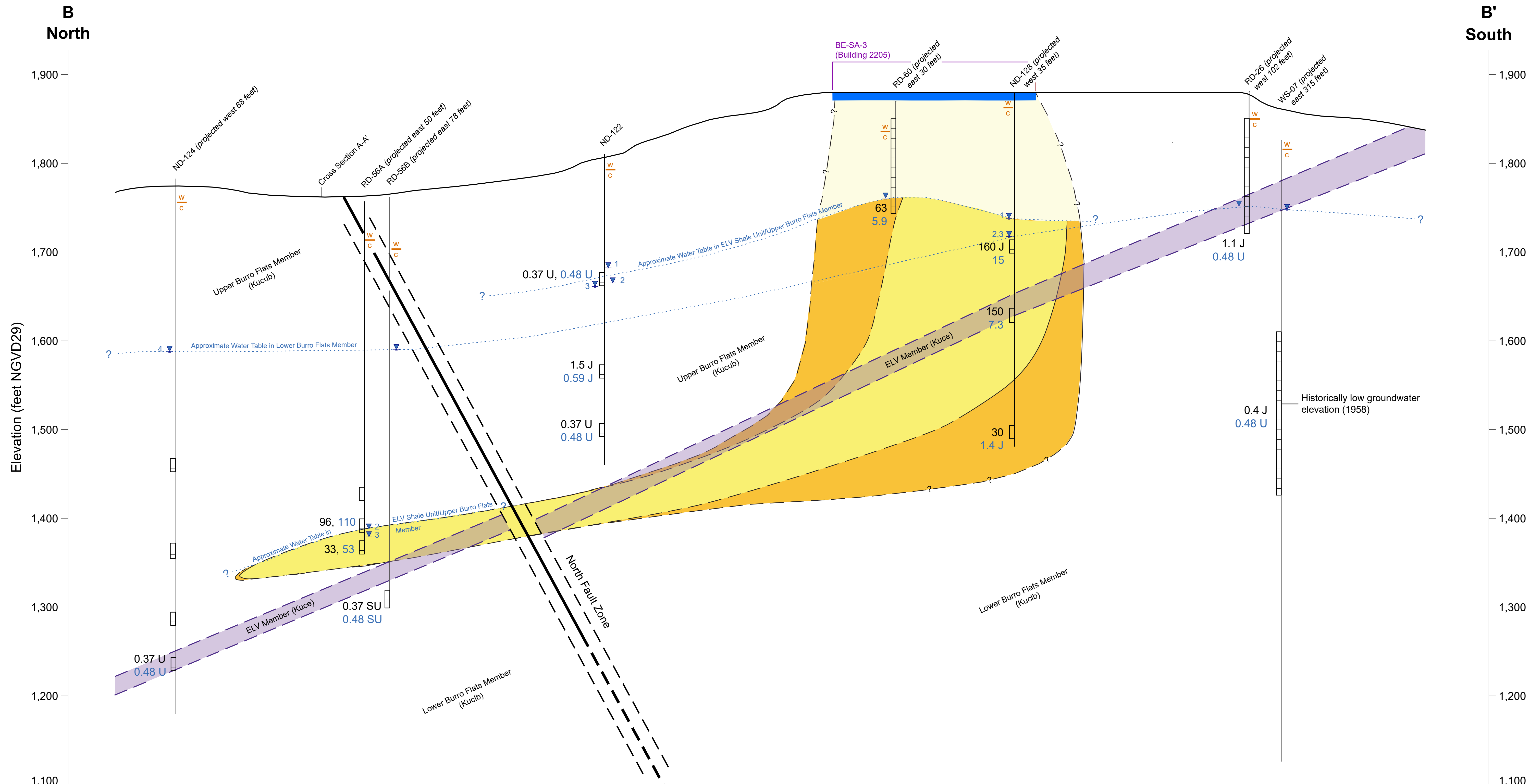
1. The screening level for TCE is 5 µg/L. The screening level for cDCE is 6 µg/L.
2. TCE and cDCE groundwater plume extents were evaluated three-dimensionally using the most recent groundwater data available (as of January 2016) and the locations of identified source areas. Inferred groundwater flow direction, topography, and the hydraulic influence of structural features were also considered in this evaluation.
3. Wells not displayed on this map are screened in the near-surface groundwater and were therefore not used to evaluate COC extents in Chatsworth Formation groundwater. Near-surface groundwater wells and data are displayed on Figure 5-7a.
4. At multilevel wells C-7, ND-122, ND-124, ND-125, ND-128 and RD-56A, only the highest TCE and cDCE concentrations measured in the well are displayed (for clarity). For the complete dataset, including specific sample dates, see the Building 204 and Expendable Launch Vehicle Areas of Impacted Groundwater Data Evaluation Report (Appendix B).
5. Packer injection testing was conducted at ND-123 less than 30 days prior to the collection of groundwater samples, and may have influenced analytical results.
6. The cross sections displayed on this map are provided as Figures 5-8 through 5-10.

0 250 500 1,000 Feet
0 75 150 300 Meters

03-Jan-2020
Drawn By:
A. Cooley

Figure D-11
Plan View Showing B204/ELV AIG Cross-section Alignment
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\NASA_RFI\BE_RFI_CFGW_TCE_cDCE.mxd



Notes:
1. Posted data are the latest reliable data available as of January 2016.
2. Source areas, bedrock vapor data, and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown in this document.
3. The location and orientation of this cross section can be viewed on Figure 5-7b.
4. Depicted bedding inclinations represent apparent dips.

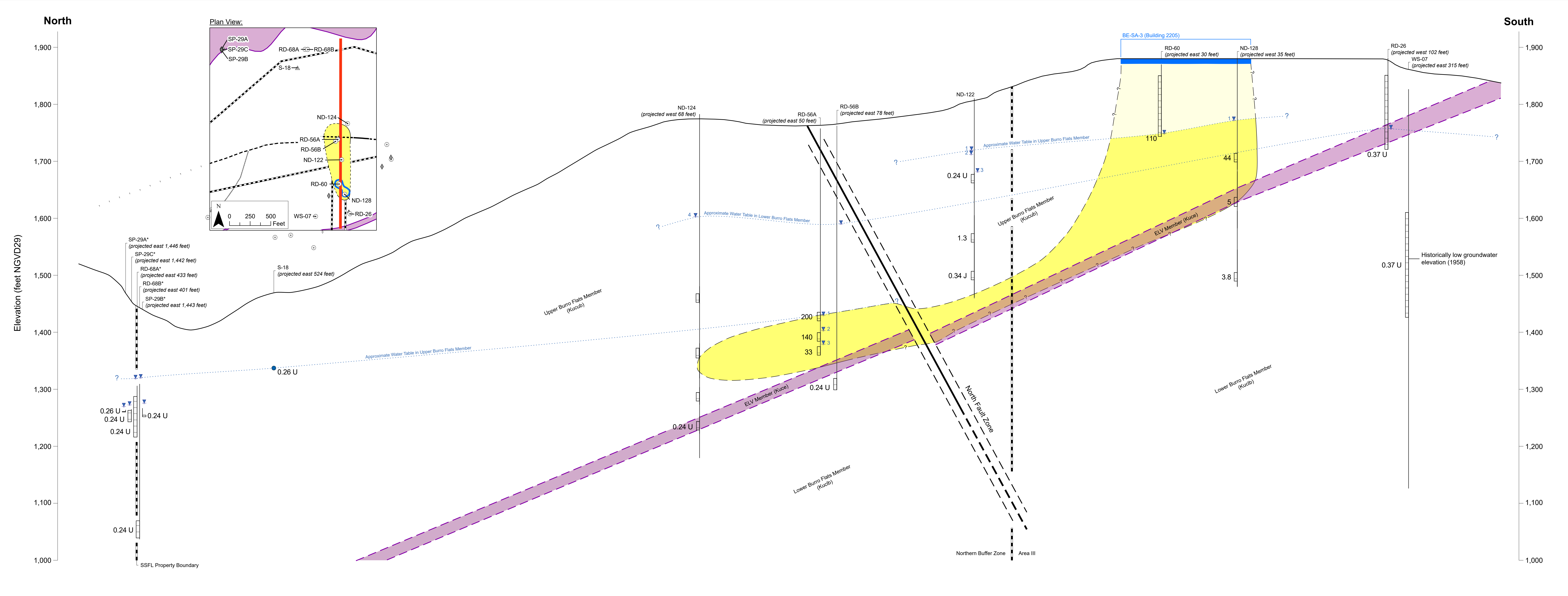
cDCE - cis-1,2-Dichloroethene
J - Concentration is estimated
NGVD29 - National Geodetic Vertical Datum of 1929
S - Data is appropriate for screening purposes only

TCE - Trichloroethene
U - Concentration is below detection limit
µg/L - micrograms per liter

0 50 100
(IN FEET)
Horizontal Scale 1 inch = 100 feet
Vertical Exaggeration: 0.9x

Screen Interval
Location of Source Area
Inferred Extent of TCE in Vadose Zone (see note 2)
Approximate Extent of TCE in Chatsworth Formation Groundwater ≥ 5 µg/L (dashed where inferred)
Approximate Extent of cDCE in Chatsworth Formation Groundwater ≥ 6 µg/L (dashed where inferred)
Siltstone with Minor Shale and Fine Sandstone Interbeds
Approximate Weathered/Competent Bedrock Interface
Groundwater Elevation (and FLUTe port number, where applicable) and approximate water table, Fall 2015
Fault Zone
Groundwater Concentrations (µg/L)
2.5 - Trichloroethene
2.5 - cis-1,2-Dichloroethene

Figure D-12
Building 204 Area Cross-section Showing Geologic Features and Interpreted Plume Extent
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California



23 Screen Interval and TCE Concentration (where available, in µg/L)

Extent of TCE above 5 µg/L in Chatsworth Formation Groundwater (dashed where inferred)

Inferred Extent of TCE in Vadose Zone (see note 2)

Location of Source Area

Groundwater Elevation (and port number, where applicable) and approximate water table, July 2020

Surface Seep

Siltstone with Minor Shale and Fine Sandstone Interbeds

Fault Zone

Administrative Boundary

Cross Section Location (plan view)

Notes:
1. Posted TCE data are the latest reliable data available as of December 2020.
2. Bedrock vapor data and source area and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown.
3. Depicted bedding inclinations represent apparent dips.

* Location is laterally offset for clarity.

Data Qualifiers:
J - Concentration is estimated
U - Concentration is below detection limit

Other Acronyms:
NGVD29 - National Geodetic Vertical Datum of 1929
TCE - Trichloroethene
µg/L - micrograms per liter

0 50 100
(IN FEET)
Horizontal Scale 1 inch = 100 feet
Vertical Exaggeration: 0.9x

Figure D-13
Building 204 Extended Cross-section
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California

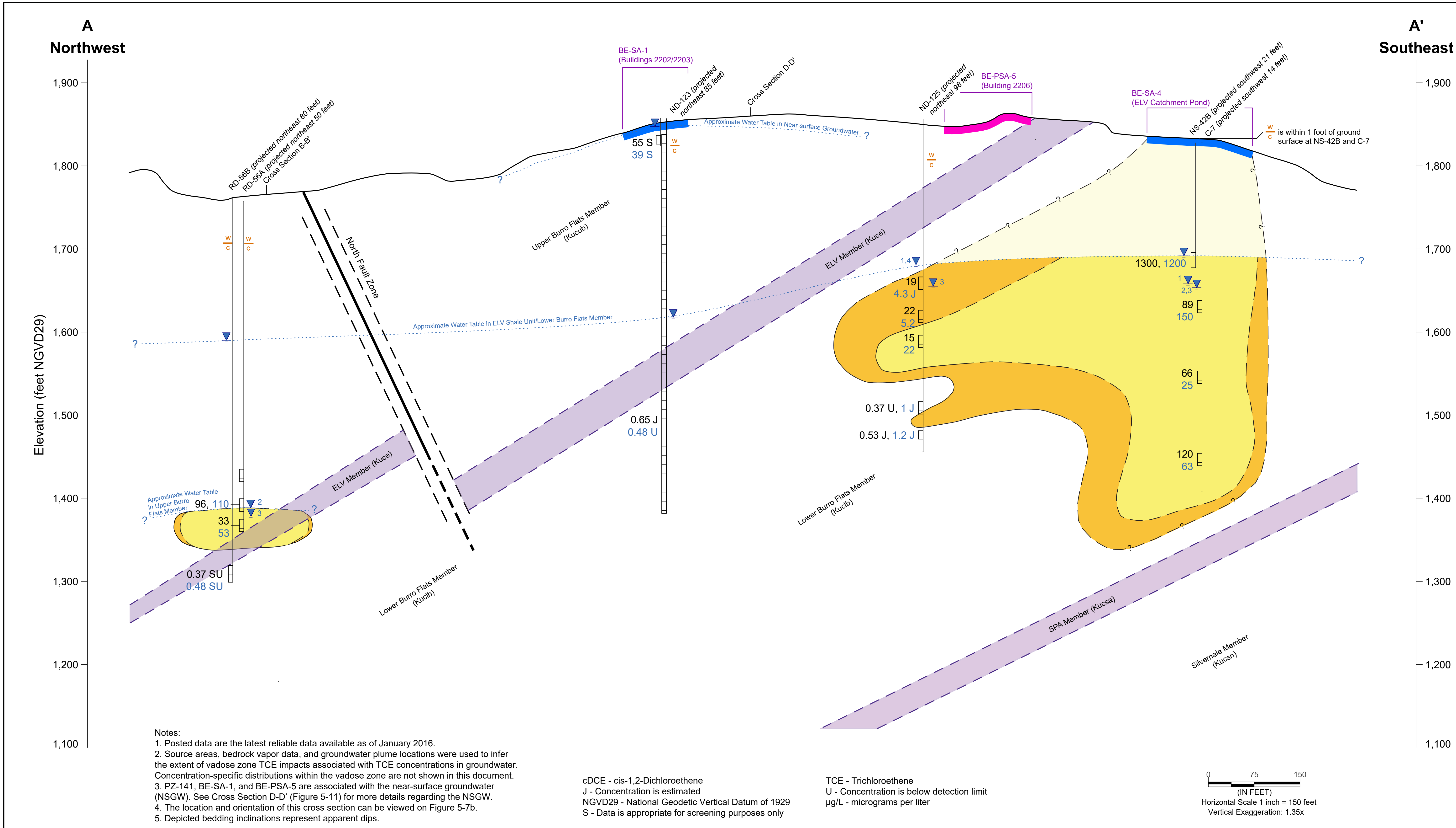
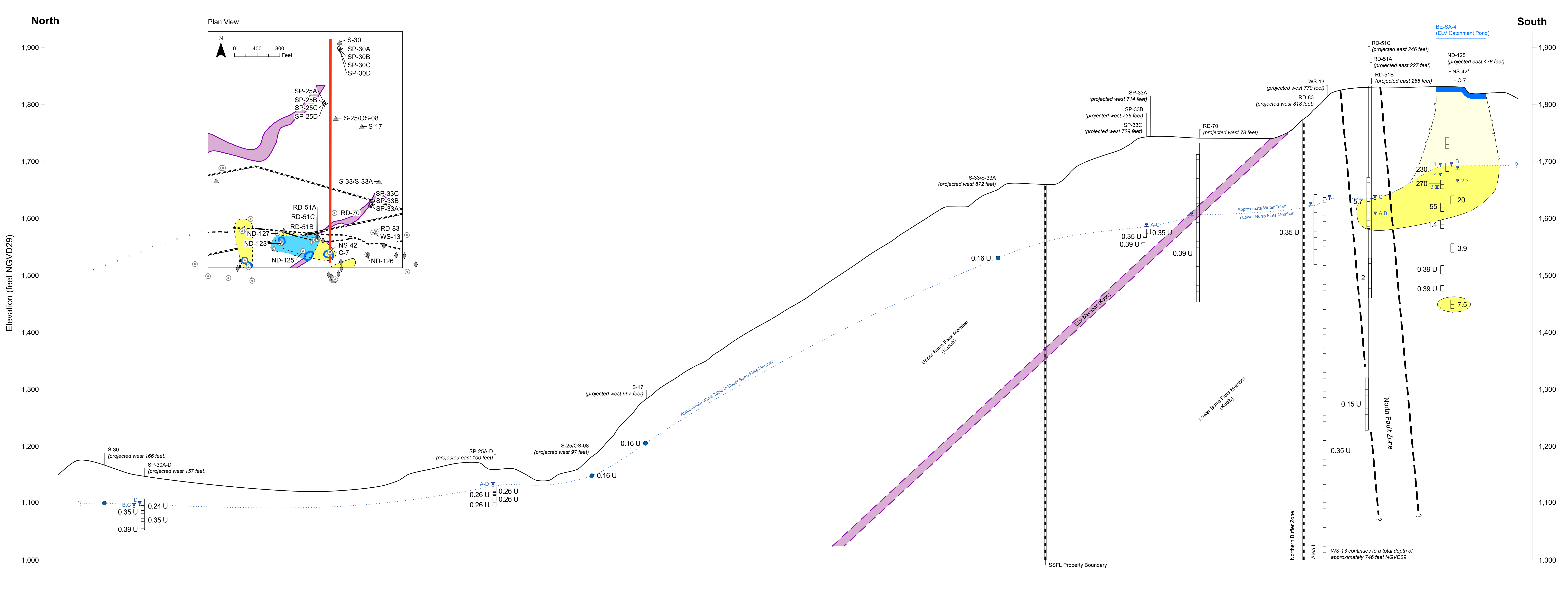


Figure D-14

ELV Cross-section Showing Geologic Features and Interpreted Plume Extent

NASA Phase 1 Groundwater CMS

SSFL, Ventura County, California



23 Screen Interval and TCE Concentration (where available, in µg/L)

Extent of TCE above 5 µg/L in Chatsworth Formation Groundwater (dashed where inferred)

Inferred Extent of TCE in Vadose Zone (see note 2)

Location of Source Area

Groundwater Elevation (and port number, where applicable) and approximate water table, October 2022

Surface Seep

Siltstone with Minor Shale and Fine Sandstone Interbeds

Fault Zone

Administrative Boundary

Cross Section Location (plan view)

Notes:
1. Posted TCE data are the latest reliable data available as of December 2022.
2. Bedrock vapor data and source area and groundwater plume locations were used to infer the extent of vadose zone TCE impacts associated with TCE concentrations in groundwater. Concentration-specific distributions within the vadose zone are not shown.
3. Depicted bedding inclinations represent apparent dips.

* Location is laterally offset for clarity.

Data Qualifiers:
J - Concentration is estimated
U - Concentration is below detection limit

Other Acronyms:
NGVD29 - National Geodetic Vertical Datum of 1929
TCE - Trichloroethene
µg/L - micrograms per liter

0 87.5 175
(IN FEET)
Horizontal Scale 1 inch = 175 feet
Vertical Exaggeration: 1.59x

Figure D-15
ELV Extended Cross-section
NASA Phase 1 Groundwater CMS
SSFL, Ventura County, California

Note: The SP-890 seep well cluster is located on NASA Area II property. The NASA property line in the SSFL Geographic Information System (GIS) Gold-copy geodatabase is shifted north of the actual property line.

FIGURE D-16
Southern Seep Area
NASA Phase 1 Groundwater CMS, SSFL, Ventura County, California

Appendix E
Green Remediation Evaluation Matrix (GREM) for Source Area Groundwater and Seep Alternatives

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Green Remediation Evaluation Matrix (GREM) for Source Area Groundwater Alternatives

NASA Phase 1 Groundwater CMS, Santa Susana Field Laboratory, Ventura County, California

Stressors	Affected Media	Mechanism/ Effect	Alternative 1 - MNA & LUCs Narrative	Alternative 1 Score	Alternative 2a - EISB, BVE, MNA, & LUCs Narrative	Alternative 2a Score	Alternative 2b - T-EISB, BVE, MNA, & LUCs Narrative	Alternative 2b Score	Alternative 3 - Pump and Treat, BVE, MNA, & LUCs Narrative	Alternative 3 Score	Alternative 4 - ISCO, BVE, MNA, & LUCs Narrative	Alternative 4 Score
Substance Release/Production												
Airborne NOx & SOx	Air	Acid rain & photochemical smog	Small amounts related to combustion by-products from transportation of personnel for sampling and drilling of new monitor wells, administering LUCs, energy used for chemical analysis	1	Same as Alt. 1 plus: transportation of treatment reagents, energy used to produce treatment reagents, energy used for reactivation of carbon from BVE, drilling injection and extraction wells, electricity used to operate recirculation system	2	Same as Alt. 2a with additional energy use from electrical powered heater to heat water prior to injection	2.1	Same as Alt. 1 plus: transportation of treatment reagents, energy used to produce treatment reagents, treatment equipment, and transmission conveyance piping; energy used for reactivation of carbon from BVE, drilling injection and extraction wells	5	Same as Alt. 1 plus: transportation of treatment reagents, energy used to produce treatment reagents, energy used for reactivation of carbon from BVE, drilling injection and extraction wells, electricity used to operate recirculation system	2
Chloro-fluorocarbon vapors	Air	Ozone depletion	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA
Greenhouse gas emissions	Air	Atmospheric warming	Same as NOx & SOx	1	Same as NOx & SOx	2	Same as Alt. 2a	2.1	Same as NOx and SOx	5	Same as NOx & SOx	2
Airborne particulates/toxic vapors/gases/water vapor	Air	General air pollution/toxic air/humidity increase	Only particulate matter related to the same emissions described for NOx and SOx	1	Only particulate matter related to the same emissions described for NOx and SOx; vapor from BVE system will be treated with carbon before being discharged to air	2	Same as Alt. 2a with additional energy use from electrical powered heater to heat water prior to injection	2.1	Only particulate matter related to the same emissions described for NOx and SOx; vapor from BVE system will be treated with carbon before being discharged to air	5	Only particulate matter related to the same emissions described for NOx and SOx; vapor from BVE system will be treated with carbon before being discharged to air	2
Liquid waste production	Water	Water toxicity/sediment toxicity/sediment	Small amounts of IDW from groundwater sampling and new monitor well development	1	Same as Alt. 1 plus: IDW from installation of injection and extractions	2	Same as Alt. 2a	2	Same as Alt. 1 plus: IDW from installation of extraction wells. NASA is expected to generate approximately 50 gpm of treatment effluent, which will be reinjected into the aquifer WS-05	5	Same as Alt. 1 plus: IDW from installation of injection and extractions	2
Solid waste production	Land	Land use/toxicity	Small amounts of IDW related to PPE from groundwater sampling and IDW from new well installation	1	Same as Alt. 1 plus: IDW from installation of injection and extraction wells and spent carbon from BVE operations	2	Same as Alt. 2a	2	Same as Alt. 1 plus: IDW from installation of injection and extraction wells and spent carbon from BVE operations; waste from GETS treatment plant operations including spent bag filters, backwash tank settled solids, spent carbon, spent ion-exchange resin, PPE associated with GETS operations	5	Same as Alt. 1 plus: IDW from installation of injection and extraction wells and spent carbon from BVE operations	2
Thermal Releases												
Warm water	Water	Habitat warming	No warm water releases to habitat	NA	No warm water releases to habitat	NA	No warm water releases to habitat	NA	No warm water releases to habitat	NA	No warm water releases to habitat	NA
Warm vapor	Air	Atmospheric humidity	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA
Physical Disturbances/Disruptions												
Soil structure disruption	Land	Habitat destruction/ soil Infertility	Scale alternative too small to impact soil fertility or habitat	NA	Scale alternative too small to impact soil fertility or habitat	NA	Scale alternative too small to impact soil fertility or habitat	NA	Construction of the GETS (which has already been completed)	NA	Scale alternative too small to impact soil fertility or habitat	NA
Noise/odor/vibration/aesthetics	General environment	Nuisance & safety	Minor noise associated with monitoring and well installation	1	Minor noise associated with treatment operations, monitoring, and well installation	1	Minor noise associated with treatment operations, monitoring, and well installation	1	Minor noise from GETS operations; unlikely to be detected by community.	1	Minor noise associated with treatment operations, monitoring, and well installation	1
Traffic	Land; general environment	Nuisance & safety	Light additional traffic related staff transportation to site and occasional drilling equipment	1	Light additional traffic related staff transportation to site and occasional drilling equipment	5	Same as Alt. 2a	5	Personnel operating GETS and occasional shipment of supplies and equipment.	5	Light additional traffic related staff transportation to site and occasional drilling equipment	5
Land stagnation	Land; general environment	Remediation time; cleanup efficiency; redevelopment	Alternative will not prevent future planned use of site	1	Alternative will not prevent future planned use of site	1	Alternative will not prevent future planned use of site	1	Footprint of GETS system can not be repurposed until treatment is complete	2	Alternative will not prevent future planned use of site	1

Green Remediation Evaluation Matrix (GREM) for Source Area Groundwater Alternatives

NASA Phase 1 Groundwater CMS, Santa Susana Field Laboratory, Ventura County, California

Stressors	Affected Media	Mechanism/ Effect	Alternative 1 - MNA & LUCs Narrative	Score	Alternative 2a - EISB, BVE, MNA, & LUCs Narrative	Score	Alternative 2b - T-EISB, BVE, MNA, & LUCs Narrative	Score	Alternative 3 - Pump and Treat, BVE, MNA, & LUCs Narrative	Score	Alternative 4 - ISCO, BVE, MNA, & LUCs Narrative	Score
Resource Depletion/Gain (Recycling)												
Petroleum (energy)	Subsurface	Consumption	Fuel related to transportation for sampling and energy used for chemical analysis; fuel related to installation of new monitoring wells	1	Same as Alt. 1 plus: installation of new injection and extraction wells and energy for recirculation system and BVE operations	2	Same as Alt. 2a	2	Same as Alt. 1 plus: Energy for GETS operations and BVE operations	5	Same as Alt. 1 plus: installation of new injection and extraction wells, and energy for recirculation system and BVE operations	2
Mineral	Subsurface	Consumption	Not applicable, no mineral use with alternative	NA	Not applicable, no mineral use with alternative	NA	Not applicable, no mineral use with alternative	NA	Not applicable, no mineral use with alternative	NA	Permanganate requires mined resources	1
Construction materials (soil/concrete/plastic)	Land	Consumption/reuse	Minor amounts that may be associated with installing new monitor wells.	1	Same as Alt. 1 plus: materials for injection and extraction wells. Treatment reagents for EISB and vapor phase carbon.	2	Same as Alt. 2a	2.1	Same as Alt. 1 plus: conveyance piping from extraction wells to GETS location, treatment plant structures, equipment, and facilities	5	Same as Alt. 1 plus: materials for injection and extraction wells. Treatment reagents for EISB and vapor phase carbon.	2
Land & space	Land	Impoundment/reuse	Installation of monitor wells	1	Not applicable	2	Not applicable	2	GETS location and conveyance piping from extraction wells to GETS location	5	Not applicable	2
Surface water & groundwater	Water, land (subsidence)	Impoundment/ sequester/reuse	Surface water and wetlands not impacted by alternative	NA	Surface water and wetlands not impacted by alternative	NA	Surface water and wetlands not impacted by alternative	NA	Treated effluent is returned to the aquifer via reinjection at WS-05	NA	Surface water and wetlands not impacted by alternative	NA
Biology resources (plants/trees/animals/microorganisms)	Air, water, land/forest, subsurface	Species disappearance/ diversity reduction regenerative ability reduction	Biological resources not impacted by alternative	NA	Biological resources not impacted by alternative	NA	Biological resources not impacted by alternative	NA	Biological resources not impacted by alternative	NA	Biological resources not impacted by alternative	NA
				11		23		23.4		48		24

* Use for evaluating one technology or remedial alternative as a checklist.
** State whether the impact applies or does not apply to the alternative and continue the evaluation.
DTSC Matrix (12/09)

BVE = bedrock vapor extraction
DTSC = California Department of Toxic Substances Control
EISB = enhanced in situ bioremediation
GETS = groundwater extraction and treatment system
gpm = gallon(s) per minute
IDW = investigation-derived waste
ISCO = in situ chemical oxidation
LUC = land use control
MNA = monitored natural attenuation
NA = not applicable
NASA = National Aeronautics and Space Administration
NOx = nitrogen oxides
PPE = personal protective equipment
SOx = sulfur oxides

APPENDIX E-2
Green Remediation Evaluation Matrix (GREM) for Seep Alternatives
NASA Phase 1 Groundwater CMS, Santa Susana Field Laboratory, Ventura County, California

Stressors	Affected Media	Mechanism/ Effect	Alternative S1 - MNA & LUCs		Alternative S2- Pump and Treat, BVE, MNA, & LUCs		Alternative S3 - EISB	
			Narrative	Score	Narrative	Score	Narrative	Score
Substance Release/Production								
Airborne NOx & SOx	Air	Acid rain & photochemical smog	Small amounts related to combustion by-products from transportation of personnel for sampling and drilling of new monitor wells, administering LUCs, energy used for chemical analysis.	1	Same as Alt. 1 plus: transportation of treatment reagents, energy used to produce treatment reagents, treatment equipment, and transmission conveyance piping; energy used for reactivation of carbon from BVE, drilling injection and extraction wells	5	Transportation of treatment reagents, energy used to produce treatment reagents, energy used for reactivation of carbon from BVE, drilling injection and extraction wells, electricity used to operate recirculation system	2
Chloro-fluorocarbon vapors	Air	Ozone depletion	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA	Not applicable, no chloro-fluorocarbon vapors are anticipated	NA
Greenhouse gas emissions	Air	Atmospheric warming	Same as NOx & SOx	1	Same as NOx and SOx	5	Same as NOx & SOx	2
Airborne particulates/toxic vapors/gases/water vapor	Air	General air pollution/toxic air/humidity increase	Only particulate matter related to the same emissions described for NOx and SOx	1	Only particulate matter related to the same emissions described for NOx and SOx; vapor from BVE system will be treated with carbon before being discharged to air	5	Only particulate matter related to the same emissions described for NOx and SOx; vapor from BVE system will be treated with carbon before being discharged to air	2
Liquid waste production	Water	Water toxicity/sediment toxicity/sediment	Small amounts of IDW from groundwater sampling and new monitor well development	1	Same as Alt. 1 plus: IDW from installation of extraction wells. NASA is expected to generate approximately 50 gpm of total treatment effluent, which will be reinjected into the aquifer WS-05	3	Same as Alt. 1 plus: IDW from installation of injection and extractions	2
Solid waste production	Land	Land use/toxicity	Small amounts of IDW related to PPE from groundwater sampling and IDW from new well installation	1	Same as Alt. 1 plus: IDW from installation of injection and extraction wells and spent carbon from BVE operations; waste from GETS treatment plant operations including spent bag filters, backwash tank settled solids, spent carbon, spent ion-exchange resin, PPE associated with GETS operations	3	Same as Alt. 1 plus: IDW from installation of injection and extraction wells and spent carbon from BVE operations	2
Thermal Releases								
Warm water	Water	Habitat warming	No warm water releases to habitat	NA	No warm water releases to habitat	NA	No warm water releases to habitat	NA
Warm vapor	Air	Atmospheric humidity	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA	No warm vapor releases that could increase humidity	NA

Green Remediation Evaluation Matrix (GREM) for Seep Alternatives

NASA Phase 1 Groundwater CMS, Santa Susana Field Laboratory, Ventura County, California

Stressors	Affected Media	Mechanism/ Effect	Alternative S1 - MNA & LUCs Narrative	Alternative S1 Score	Alternative S2- Pump and Treat, BVE, MNA, & LUCs Narrative	Alternative S2 Score	Alternative S3 - EISB Narrative	Alternative S3 Score
Physical Disturbances/Disruptions								
Soil structure disruption	Land	Habitat destruction/ soil Infertility	Scale alternative too small to impact soil fertility or habitat	NA	Construction of the GETS (which has already been completed)	NA	Scale alternative too small to impact soil fertility or habitat	NA
Noise/odor/vibration/aesthetics	General environment	Nuisance & safety	Minor noise associated with monitoring and well installation	1	Minor noise from GETS operations; unlikely to be detected by community.	1	Minor noise from EISB operations; unlikely to be detected by community.	1
Traffic	Land; general environment	Nuisance & safety	Light additional traffic related staff transportation to site and occasional drilling equipment	1	Personnel operating GETS and occasional shipment of supplies and equipment	2	Light additional traffic related staff transportation to site and occasional drilling equipment	2
Land stagnation	Land; general environment	Remediation time; cleanup efficiency; redevelopment	Alternative will not prevent future planned use of site	NA	Footprint of GETS system can not be repurposed until treatment is complete	1	Alternative will not prevent future planned use of site	NA
Resource Depletion/Gain (Recycling)								
Petroleum (energy)	Subsurface	Consumption	Fuel related to transportation for sampling and energy used for chemical analysis; fuel related to installation of new monitoring wells	1	Same as Alt. 1 plus: Energy for GETS operations and BVE operations	5	Same as Alt. 1 plus: installation of new injection and extraction wells and energy for recirculation system and BVE operations	2
Mineral	Subsurface	Consumption	Not applicable, no mineral use with alternative	NA	Not applicable, no mineral use with alternative	NA	Not applicable, no mineral use with alternative	NA
Construction materials (soil/concrete/plastic)	Land	Consumption/reuse	Minor amounts that may be associated with installing new monitor wells.	1	Same as Alt. 1 plus: conveyance piping from extraction wells to GETS location, treatment plant structures, equipment, and facilities	5	Same as Alt. 1 plus: materials for injection and extraction wells. Treatment reagents for EISB and vapor phase carbon	2
Land & space	Land	Impoundment/reuse	Installation of monitor wells	1	GETS location and conveyance piping from extraction wells to GETS location	5	Not applicable	2
Surface water & groundwater	Water, land (subsidence)	Impoundment/ sequester/reuse	Not applicable, no water management of alternative	NA	Treated effluent is returned to the aquifer via reinjection at WS-05	1	Aside from injection of treatment reagents, no impacts to subsidence	1
Biology resources (plants/trees/animals/microorganisms)	Air, water, land/forest, subsurface	Species disappearance/ diversity reduction regenerative ability reduction	Not applicable	1	Potential to remove water to degree that could negatively impacts flora and fauna	3	Potential to mobilize redox sensitive metals and impact ecosystem receptors	5
TOTAL QUALITATIVE SCORE				**11**		**44**		**25**

* Use for evaluating one technology or remedial alternative as a checklist.

** State whether the impact applies or does not apply to the alternative and continue the evaluation.

DTSC Matrix (12/09)

BVE = bedrock vapor extraction
DTSC = California Department of Toxic Substances Control
EISB = enhanced in situ bioremediation
GETS = groundwater extraction and treatment system
gpm = gallon(s) per minute
IDW = investigation-derived waste
LUC = land use control
MNA = monitored natural attenuation
NA = not applicable
NASA = National Aeronautics and Space Administration
NOx = nitrogen oxides
PPE = personal protective equipment
SOx = sulfur oxides

Appendix F
Bravo Bedrock Vapor Extraction Treatability Study Summary

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Bravo Bedrock Vapor Extraction Treatability Study Summary

Revised Final

October 2023

Prepared for

National Aeronautics and Space Administration
Santa Susana Field Laboratory, Ventura County, California

Contents

Appendixes

Tables

Figures

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Acronyms and Abbreviations

µg/L	microgram(s) per liter
$\mu g/m^3$	microgram(s) per cubic meter
°F	degree(s) Fahrenheit
ABFF	Alfa Bravo Fuel Farm
AIG Characterization Plan	*Draft Characterization Plan – Alfa/Bravo Areas of Impacted Groundwater at the Santa Susana Field Laboratory, Ventura County, California*
AST	aboveground storage tank
bgs	below ground surface
btoc	below top of casing
BVE	bedrock vapor extraction
BVE IP	*Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan*
BVE TM	*Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Technical Memorandum*
CFC-113	1,1,2-trichloro-1,2,2-trifluoroethane
CMS	Corrective Measure Study
COC	constituent of concern
CUA	chemical use area
DCE	dichloroethene
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EST	Environmental Support Technologies
eV	electron-volt
GAC	granular activated carbon
GC	gas chromatograph
GWTU	Groundwater Treatment Unit
HAR	Hydrogeologic Assessment Report
HWSA	Hazardous Waste Storage Area
IDW	investigation-derived waste
in. H_2O	inch(es) water
in. Hg	inch(es) mercury
LOX	liquid oxygen
LPG	liquid propane gas

mg/kg	milligrams per kilogram
msl	mean sea level
N/A	not applicable
NAD	North American Datum
NAPL	nonaqueous-phase liquid
NASA	National Aeronautics and Space Administration
Northstar	Northstar Environmental Remediation
NSGW	Near-surface groundwater
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PID	photoionization detector
ppm	part(s) per million
ppmv	part(s) per million by volume
Praxis	Praxis Environmental Technologies
psi	pound(s) per square inch
PZ	piezometer
R-12	dichlorodifluoromethane
RCRA	Resource Conservation and Recovery Act
RD	Rocketdyne Deep
RFI	RCRA Facility Investigation
SCFM	standard cubic feet per minute
SOP	standard operating procedure
SPA	Storable Propellant Area
SSFL	Santa Susana Field Laboratory
TCE	trichloroethene
TM	technical memorandum
TPH	total petroleum hydrocarbons
TS	treatability study
VC	vinyl chloride
VCAPCD	Ventura County Air Pollution Control District
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
WCT	waste coolant tank
WH	wellhead

1. Introduction

1.1 Background

In 2009, a bedrock vapor extraction (BVE) treatability study (TS) work plan (MWH, 2009a) was prepared for the Bowl Test Area at the Santa Susana Field Laboratory (SSFL), Ventura County, California, to evaluate the feasibility of vapor extraction of the Chatsworth Formation Operable Unit. An addendum (MWH, 2012) was prepared in 2012 that included modifications to the plan based on comments from the California Department of Toxic Substances Control (DTSC). The 2012 addendum to the original BVE TS work plan was subsequently approved by DTSC. In 2013, the National Aeronautics and Space Administration (NASA) proposed implementation of the approved BVE TS to be conducted at the Bravo Area (Figure 1-1) (NASA, 2013). NASA prepared and submitted a technical memorandum (TM) consistent with the objectives and applicable scope of the original approved BVE TS and addendum. Following the submittal of a revised TM (based on comments from DTSC) in 2014, two sets of responses to comments in 2014, and discussions/meetings with DTSC, the *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Technical Memorandum* (BVE TM) (NASA, 2014a) was approved by the DTSC on May 22, 2014.

The BVE TS field work was conducted in August through October of 2014 and summarized in an executive-summary-level TM submitted to DTSC in November 2015 (*Results from Bravo Bedrock Vapor Extraction Treatability Study* [NASA, 2015]). DTSC provided comments on the Results from the Bravo BVE TS TM (NASA, 2015) in a letter dated October 14, 2016, and NASA agreed to include a full BVE TS report in its groundwater Corrective Measure Study (CMS). Therefore, this BVE TS report is included as an appendix to the groundwater CMS. NASA's response to comments on the Bravo BVE TS TM, and how those comments are inherently addressed in this full BVE TS report, are included in Appendix O of this report.

1.2 Results from Bravo Bedrock Vapor Extraction Treatability Study

The Bravo Area was selected for the BVE TS based on the presence of elevated concentrations of volatile organic compounds (VOCs), an inferred deep vadose zone with adequate separation from the ground surface located within an unlined bedrock corehole (HAR-19), proximity to source areas (such as the Bravo Skim Pond), logistical accessibility, decreased chance of short-circuiting (created by a shallow near surface groundwater table), and documented indication of faulting likely having extensive fracture flow paths. Existing wells and piezometers within 400 feet of HAR-19 were identified to potentially support the evaluation of vacuum response in fractures and matrix blocks, and to evaluate the effects of lithology changes and/or structural features along the formation. As discussed further in Section 2, four additional nested vapor piezometers and one groundwater piezometer were installed to better support the goals of the TS.

1.3 Project Goals and Objectives

As presented in the approved BVE TM (NASA, 2014a), NASA's objectives for the BVE TS are as follows:

1) Quantify bedrock air removal using standard vapor extraction methods.
2) Quantify the volatile organic mass flow rate over time in the BVE well.

3) Quantify the vacuum response in fractures and in matrix blocks.
4) Improve understanding of lithologic and/or structural variations and their impacts on formation advective flow paths under a BVE system.
5) Improve understanding of the diffusive response of VOCs from the rock matrix post-treatment.

This technical summary report documents the implementation of activities at the Bravo Area outlined in the BVE TM and presents an interpretation of results from the BVE TS.

1.4 Site Use History

1.4.1 Bravo Area Summary

The Bravo Area covers approximately 8.9 acres in the central portion of Area II. It is bordered to the west by the Hazardous Waste Storage Area (HWSA) and Waste Coolant Tank (WCT), to the east by the Alfa Area, to the north by the Alfa Bravo Fuel Farm (ABFF), and to the immediate south by undeveloped land (Figure 1-1).

Three engine test stands were operated in the Bravo Area between 1956 and 2005. Buildings and structures were also maintained in the Bravo Area to support the test stand activities. A Groundwater Treatment Unit (GWTU) operated onsite from the late 1980s until 2000. Figure 1-1 illustrates the general current and historical layout of the site. Detailed discussions of the Bravo Area site features and chemical use areas (CUAs) can be found in the *Draft Characterization Plan – Alfa/Bravo Areas of Impacted Groundwater at the Santa Susana Field Laboratory, Ventura County, California* (AIG Characterization Plan) (NASA, 2014b). As shown on Figure 1-1, the buildings, structures, and features of the Bravo Area consist of the following:

- Bravo Test Area and associated buildings
- Bravo Area drainage and ponds, including the Bravo Skim Pond and Alfa/Bravo Skim Pond
- Two leach fields
- Fuel pipelines from ABFF and water conveyance pipelines
- Bravo Area GWTU

Approximately 47 former and existing aboveground storage tanks (ASTs) contained hydraulic oil, rocket propellant-1, liquid oxygen, kerosene, lube oil, gaseous nitrogen, deionized water, or unknown contents. Records do not exist for many of the removed ASTs; however, at least one trichloroethene (TCE) AST (Unknown-AT-BV-31) may have been located within an awning-covered solvent storage area approximately 75 feet southwest of Test Stand 3, based on historical plan drawings of the site (Rocketdyne, 1959). Historical chemical usage in the Bravo Area included fuels, solvents, polyaromatic hydrocarbons (PAHs), propellants, oil-related material and debris, dioxins, pesticides, and polychlorinated biphenyls (PCBs) (NASA, 2014b).

1.4.2 VOC Constituents of Concern and Historical Uses

The groundwater VOC constituents of concern (COCs) at the Bravo Area identified in the AIG Characterization Plan (NASA, 2014b) consist of TCE, the degradation products of TCE (cis-1,2-dichloroethene [DCE], trans-1,2-DCE, and vinyl chloride [VC]), 1,1-DCE, and carbon tetrachloride. TCE was used to flush system piping before and after tests, to clean engines and engine components, and as a utility solvent for washing down test areas and cleaning tools and parts. Before beginning TCE recovery efforts in 1961, the TCE from engine flushing operations was discharged from the test stands into concrete spillways, which drained to unlined channels. The channels fed to the Bravo Skim Pond (an unlined surface impoundment with a 150,000-gallon capacity) and eventually to the Alfa/Bravo Skim Pond (an unlined surface impoundment with an estimated 200,000-gallon capacity). Beginning in 1961, TCE was captured in a catch pan, contained in a storage tank after being flushed through the engines, and reused for the next engine tests. Using TCE for this purpose in the Bravo Test Area was discontinued in approximately 1965, when the transition was completed from tests that needed TCE flushing, to testing that did not require TCE flushing. Trichloroethane continued to be used for parts cleaning through 1994. Information on the uses of carbon tetrachloride at the Bravo Area were not found in previous technical NASA documents.

1.5 Site Conceptual Model

As described in the Site Conceptual Model for the Migration and Fate of Contaminants in Groundwater at the Santa Susana Field Laboratory prepared by the SSFL Groundwater Advisory Panel (2009) and the NASA Groundwater Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report (NASA, 2017), the primary lithology at the SSFL site is fractured and faulted sandstone and siltstone. The groundwater system is replenished through a relatively small amount of rainfall infiltrating through the vadose zone and migrating slowly through a network of ubiquitous but small, interconnected fractures that cause groundwater to mound beneath the site and generate static groundwater levels hundreds of feet above the surrounding valleys. This mounded groundwater condition results in a complex flowfield characterized by numerous potential pathways between the source areas and downgradient receptors. Most of these pathways have some combination of downward and outward oriented flow. Outward flow, could exit the site through convergence at seeps, springs, and phreatophytes. Contamination has not been detected at the majority of seeps and springs surrounding the site. Site groundwater will also migrate downward toward the base of SSFL and subsequently outward toward the valleys within the regional groundwater system. This generalized flow system is illustrated in Figure 1-2.

With respect to contaminant transport in the fractured rock environments at SSFL, Site Conceptual Model Element 17 of the Draft Site-wide Groundwater Remedial Investigation Report (MWH, 2009b) indicates that, in the vadose zone, TCE nonaqueous-phase liquid (NAPL) will imbibe into the rock matrix as a wetting fluid. This implies that NAPL released to the vadose zone could migrate along fractures and into the rock matrix. Therefore, the vadose zone could potentially store a significant amount of COC mass in both the rock fractures and in the rock matrix.

With respect to the presence of VOCs above the water table, prior to the BVE TS, there was little specific published information for the Bravo Area. From the pattern of groundwater data, the area was observed to have elevated concentrations of TCE and other VOCs in the vicinity of the Bravo Test Stands, as documented at wells RD-04 and WS-09. Though these data represent groundwater at significant depth below the vadose zone, the original migration path through the vadose zone to the groundwater would likely have been in the same areas. Similarly, some historical migration could be expected in rock fractures beneath the Alfa, Bravo, and Alfa-Bravo Skim Ponds. Additional field investigations to support the NASA Groundwater RFI (NASA, 2017), performed subsequent to the BVE TS, identified vapor TCE concentrations greater than 50,000 micrograms per cubic meter (μg/m^3) in three primary areas in the Alfa/Bravo AIG. The highest TCE concentrations (as high as 36,000,000 μg/m^3) were detected by Alfa Test Stand 1 (an area identified in the groundwater CMS as a target treatment area). Orders of magnitude lower vapor TCE concentrations were also detected in the Bravo Test Stand area (up to 260,000 μg/m^3) and the Bravo Skim Pond areas (up to 370,000 μg/m^3) (NASA, 2017). The Bravo Skim Pond is a source area extending slightly beyond the formal physical boundaries of the Bravo Skim Pond to the northwest to incorporate well HAR-19, the location of the BVE TS.

1.6 Physical Setting

1.6.1 Climate and Precipitation

The monthly mean temperature at SSFL ranges from 50 degrees Fahrenheit (°F) during winter months to 70°F during summer months. Between April and October, a landward wind pattern occurs due to the site's proximity to the Pacific Ocean; during the winter months, this is interrupted by weather fronts (MWH, 2009b). Precipitation has been measured daily at SSFL at two onsite stations since 1960. Precipitation at SSFL is normally in the form of rain, although snow has occasionally fallen during winter months. Precipitation at the site averaged approximately 18.2 inches per year between 1960 and 2013. The annual precipitation ranged from a low of 5.7 inches in 2002 to a maximum of 41.24 inches in 1998 (MWH, 2014). The majority of annual precipitation at SSFL and surrounding area occurs between the months of November and March, consistent with the regional precipitation pattern of southern California (MWH, 2009b).

1.6.2 Topography and Drainage Patterns

The Bravo Test Area was located in the southern portion of the Bravo Area. As is typical of SSFL, the Bravo Area is characterized by variable topographic relief. Ground surface elevation ranges from a high of over 1,900 feet mean sea level (msl) in the north/central portion of the Bravo Area (near a rock outcrop) to approximately 1,825 feet msl near the Alfa/Bravo Skim Pond. Testing operations discharged to the Bravo Skim Pond in the northeast corner of the site, then to the Alfa/Bravo Skim Pond to the north along the Southwest Drainage channel (Figure 1-1). Additional drainage flowed north from the Bravo GWTU along the western boundary of the Bravo Area.

1.6.3 Geology

As described in the *Geologic Characterization of the Central Santa Susana Field Laboratory* (MWH, 2007) and the NASA Groundwater RFI (NASA, 2017), the primary geologic units present at the SSFL are Quaternary alluvium/colluvium and the underlying Cretaceous Chatsworth Formation. Near the Alfa/Bravo AIG, the Chatsworth Formation consists of, from oldest to youngest, Sandstone 1, Shale 2 (Lower and Upper Members), and Sandstone 2. Sandstone 1 is subdivided into members, the uppermost (youngest) of which is the Sage Member, which includes the Upper and Lower Bravo Beds. Sandstone 2 is also subdivided into members, the lowest (oldest) three of which are the Silvernale, Storable Propellant Area (SPA), and Lower Burro Flat Members. The Silvernale and Lower Burro Flat Members are primarily sandstone, whereas the Shale 2 (Upper and Lower Members) and the SPA Member are interbedded fine-grained sandstone, siltstone, and shale. It is noted that the Lower and Upper Bravo Beds, Shale 2 (Upper and Lower Members), and SPA Member consist of siltstone based on detailed field mapping, but they recessively weather similar to shale. For consistency, this report will continue to refer to these units by their established names with the understanding that they are siltstone units. As shown on Figure 1-3, the Shale 2 crosses the northern portion of the Alfa/Bravo AIG from southwest to northeast, whereas the Upper Bravo Bed crosses the southern portion of the Alfa/Bravo AIG. The Upper Bravo Bed is located within the larger Sage Member, whereas the Silvernale Member sandstone overlies Shale 2 to the northwest. Figure 1-4 presents a north/south-oriented cross section through the Bravo BVE Area that illustrates the stratigraphic relationships with the information available at the time of the BVE TS.

The thickness of alluvium/overburden in the Bravo Area ranges from approximately 1 to 15 feet. The thickest intervals of alluvium/overburden were logged at piezometers near the skim ponds (PZ-061 and PZ-070). There is uncertainty with respect to the thickness of the weathered Chatsworth Formation. The weathered/competent bedrock interface was noted at 14 feet below ground surface (bgs) at well RD-104, while varying degrees of weathering were noted to the total depth of many piezometers in the area (25 to 60 feet bgs). The inferred thickness of the weathered bedrock in the southwest drainage is approximately 25 to 75 feet (NASA, 2009). The top of the competent Chatsworth Formation was not intersected during the drilling of location PZ-156, located along the road leading to the Bravo Test Area. Therefore, the total thickness of alluvium/overburden and weathered bedrock near the Bravo Test Area is inferred to be in excess of 140 feet (NASA, 2009, NASA, 2014b).

Bedding orientations in the Alfa/Bravo AIG are locally variable, but typically strike approximately N65°E and dip approximately 25° to the northwest (NASA, 2017). The Chatsworth Formation has undergone a complex history of regional tectonic stresses, exposing it to multiple orientations of compressional, extensional, and shear forces. Additionally, SSFL has been subjected to local stresses, including faulting and erosional unloading. As a result, complex structural patterns (including sets of faults, fractures, and joints) are present within the Chatsworth Formation. The primary geologic features in the vicinity of the Alfa/Bravo AIG are the northwest-dipping beds of the Chatsworth Formation. There are also structural joints that are sharp, linear breaks in the bedrock that result in steep cliffs and other linear features such as lineaments. Based on the geologic mapping completed in the Alfa/Bravo AIG by NASA for the NASA Groundwater RFI (NASA, 2017), a minor fault extending to the northeast away from the Bravo Area was noted northwest of the Bravo Test Stand (Figure 1-3) that has an offset of a few feet. Historically, an Alfa Deformation Band was mapped in the Alfa Area as a fault (MWH, 2015). However, the Alfa Deformation Band was examined during NASA RFI field mapping (NASA, 2017) and identified as an east/west trending linear feature cutting through a massive sandstone bed. The feature appears to be a large fracture noted between massive sandstone beds with a separation of approximately 15 feet that extends approximately 450 feet through a prominent rock outcrop. The area between the sandstone beds is filled with sand-sized sediment and large rocks. No evidence of displacement (lateral or vertical) was noted on the exposed rock and no evidence of deformation was noted; therefore, this feature appears to be a large joint that can be observed in the eastern portion of the Alfa/Bravo AIG but does not extend westward to the Bravo Test Stands, and does not cut across the ridge near the Bravo Skim Pond. The feature was removed from the geologic map.

The contact between the Sandstone 1 Sage member and the Shale 2 is noted in both logs at wells HAR-19 to HAR-20 of cross section A-A′ (Figure 1-4). However, the mapped contact locations do not correlate with the depths observed on the logs. It is possible that the mapped contact locations indicate strata displacement caused by unidentified faulting in the area.

1.6.4 Groundwater Occurrence

Groundwater at the Bravo Area occurs in the alluvium/overburden and Chatsworth Formation. Near-surface groundwater (NSGW) at the Bravo Area occurs within the alluvium/overburden and weathered bedrock of both Sandstone 1 and the Shale 2. NSGW at the Bravo Area occurs within the alluvium/overburden and weathered bedrock of both Sandstone 1 and the Shale 2. Wells PZ-059, PZ-070, and PZ-156 are completed within the weathered Sandstone 1 and are generally dry or contain residual groundwater in the well. Location PZ-155 is a relatively deeper NSGW piezometer completed within the weathered Sandstone 1 near the Bravo Skim Pond. Depth to groundwater at PZ-155, which has a relatively short period of record, ranges from approximately 53 to 61.5 feet below top of casing (btoc). Groundwater elevation data for this location confirm that NSGW is temporally persistent at this depth zone over this short period of record. Wells RS-08 and HAR-09, located in the north/northwest portion of the Bravo Area, are completed within the weathered Shale 2. Depth to groundwater in these wells ranges from 1.5 to 18 feet btoc (NASA, 2014b).

Chatsworth formation groundwater (CFGW) wells WS-09, RD-04, HAR-20, and HAR-19 within the Bravo Area are screened within the Sandstone 1. CFGW elevations within the Sandstone 1 are significantly lower than the overlying NSGW (when present). Recent depth to groundwater at wells HAR-19 and HAR-20 has ranged from 174 to 177 feet btoc. Wells HAR-21 and RD-104 are screened within the finer-grained Shale 2 and/or Sandstone 2 units. CFGW wells in this area exhibit groundwater elevations that are vertically continuous with NSGW, meaning there is little vertical head difference between the two groundwater systems.

2. Field Investigation

The field investigation for the BVE TS was conducted between July 16 and October 23, 2014. This section describes the field activities that were performed, in accordance with the *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan* (BVE IP) (NASA, 2014c) and the BVE TM (NASA, 2014a).

2.1 Rock Coring and Installation of Vapor Probes and Groundwater Piezometer

Five boreholes were drilled in the BVE study area in order to accommodate the installation of four new multilevel vapor probe clusters (referred to as piezometers in this summary) and one groundwater piezometer (completed in association with one vapor probe). The completed piezometers have been assigned well IDs PZ-201, PZ-202, PZ-203, PZ-203A, and PZ-204. As will be discussed in Section 2.1.3, each piezometer houses a cluster of vapor ports to facilitate evaluation of pressure responses at specific depths within the formation. The final piezometer locations are shown in Figure 2-1. As requested by the DTSC, PZ-203A (a companion borehole to PZ-203) was drilled 10 feet below the water table (to 188 feet bgs) to accommodate installation of both a soil vapor probe screened in competent rock matrix and a groundwater piezometer. The remaining boreholes were drilled and completed within the unsaturated zone, just above the water table (approximately 165 to 172 feet bgs). Each piezometer was constructed as a cluster of four vapor probes screened at distinct intervals. Details of the drilling operations and piezometer installations performed during the BVE TS are described in the subsections that follow.

2.1.1 Pre-Drilling Activities

Following the initial planning phase for the new piezometers, which occurred during the development of the BVE TM (NASA, 2014a) and subsequent discussions with DTSC, activities conducted in preparation for borehole drilling included the procurement of necessary well permits and a subsurface utility clearance. A well permit was obtained from the Ventura County Watershed Protection District on June 20, 2014 (Appendix A), in compliance with Ventura County Well Ordinance No. 4184, and is applicable for four of the piezometers installed during the BVE TS. An amended permit was obtained on August 26, 2014 to allow drilling of a fifth borehole, where the rock-matrix vapor probe (requested by DTSC) and the groundwater piezometer were installed; the amended permit also included destruction of a soil boring that required abandonment after a core barrel broke off of the drill string and could not be retrieved. Subsurface utility clearance survey of the BVE study area was performed by Spectrum Geophysics on June 24, 2014, using an electromagnetic locator. Detected utilities were marked with spray paint and whisker flags and were not found to be in conflict with planned piezometer locations.

2.1.2 Borehole Drilling

Drilling operations for the BVE TS occurred over four weeks between July 16 and August 14, 2014 and incorporated both HQ rock coring and air rotary methods. Drilling activities were conducted by Gregg Drilling & Testing, Inc., under the supervision of a California Registered Professional Geologist. Activities during this phase of work included lithologic logging of rock core and the collection of core samples for laboratory analysis of VOCs. The BVE IP for borehole drilling specified HQ rock coring and sampling at new boreholes, with air rotary drilling to ream boreholes to an appropriate diameter for nested piezometer construction

(NASA, 2014c). Because of complications encountered during the coring of the first two boreholes (PZ-203 and PZ-202/202a), a decision was made to switch the drilling method from HQ rock coring to air rotary drilling for the remaining three boreholes (PZ-201, PZ-203A, and PZ-204). This decision was made in collaboration with DTSC during a BVE TS update teleconference held on August 5, 2014. Boreholes drilled using air rotary methods were subsequently video logged. The specific details of the drilling and logging program are described in Appendix B, rock core logs are presented in Appendix C, and the video log summary is included in Appendix D. Table 2-1 provides a summary of BVE TS drilling operations.

Prior to advancing boreholes by drill rig at each new piezometer location, three clearance holes were hand-augered to a depth of at least 5 feet bgs or to a depth at which refusal was encountered. The clearance holes were drilled for additional verification that no subsurface utilities were present or would be encountered by the rig, per the standard operating procedure (SOP) for well drilling and installation (refer to Appendix A of the BVE IP [NASA, 2014c]). Additionally, a Native American monitor from R. Indigenous Consultants Tribal Monitoring, LLC, was present at all times when drilling through unconsolidated material, to verify that no artifacts or remains of potential archaeological significance were encountered or disturbed during drilling activities.

2.1.3 Piezometer Construction

After drilling each borehole, the rock core and/or video logs were reviewed to select the number and depth intervals for the vapor probes in each cluster. The BVE TM (NASA, 2014a) and BVE IP (NASA, 2014c) specified that up to five 1-inch-diameter probes were to be installed per borehole, and that one 2-inch-diameter groundwater piezometer would be installed at PZ-203. The screen interval-selection process was designed to accomplish the following:

- Target zones with photoionization detector (PID) readings greater than 0 parts per million (ppm)
- Target zones with multiple fractures, focusing on steeply dipping (greater than 45 degrees from horizontal) or open fractures
- Include a range of depths, from approximately 50 feet bgs to just above the static water level
- Provide sufficient space between screened intervals (approximately 10 feet or greater), to allow for construction of an effective seal between zones

Preliminary piezometer construction details were presented to DTSC in teleconferences held on August 12 (to discuss PZ-202 and PZ-203) and August 19 (to discuss PZ-201 and PZ-204), 2014. DTSC concurred with the number and depths of vapor probes proposed and requested one additional vapor probe screened across competent rock matrix at borehole PZ-203. The goal of this additional vapor probe was to assess the potential effect of matrix permeability on vapor transport in the BVE TS area. This additional rock-matrix probe and the groundwater piezometer were installed in an additional soil boring (PZ-203A) to avoid installing more than four casing strings in a single boring. The rock-matrix vapor probe and the groundwater piezometer were installed in a separate borehole to significantly improve the likelihood of installing a leak-free seal between land surface and the screened interval of the rock-matrix vapor probe.

Piezometer construction was performed by Gregg Drilling & Testing, Inc. between August 15 and 21, 2014. In order to create effective seals between vapor probes, the following general construction steps were used during multi-level vapor probe construction:

1) The borehole was filled with bentonite chips to approximately 1 foot beneath the lowest planned screen interval. The bentonite intervals were hydrated as they were installed.

2) A 1-inch diameter Schedule 80 polyvinyl chloride (PVC) (or 2-inch diameter in the case of the groundwater piezometer) casing, with the appropriate length of 0.020-inch slotted screen, was lowered to the deepest planned probe depth.
3) A lift of #3 sand was placed on top of the bentonite chips, adjacent to the probe screen, and to approximately 1 foot above the top of the screen.
4) Approximately 0.25 to 1 foot of #8 bentonite was placed above the filter pack sand, followed by the installation of bentonite chips to 1 foot beneath the next planned screen interval.
5) Steps 2 through 4 were repeated for the remaining probes. For the shallowest probe, the bentonite chip interval extended to approximately 15 feet bgs, followed by the installation of a Portland cement/bentonite grout mixture to ground surface.

During installation, individual probes within each piezometer were assigned a letter designation of "a" through "d," depending on depth (with "a" representing the shallowest probe in a cluster and "d" representing the deepest). The matrix probe and groundwater piezometer, which were installed in PZ-203A, received separate designations of "v" and "gw," respectively. Piezometers were surveyed for horizontal and vertical control by CalVada Surveying, Inc. on September 25, 2014. Final construction details for the new BVE piezometers, as well as the six previously existing wells used as part of the BVE network, are provided in Table 2-2. Detailed construction diagrams of the new piezometers are provided in Appendix E, and their locations are presented on Figure 2-1. A graphical profile of the BVE monitoring wells (screened intervals) is shown on Figure 2-2.

2.1.4 Well Development

Groundwater piezometer PZ-203Agw was developed on October 24, 2014, using a 10-foot-long, 1.5-inch-diameter steel bailer. The clarity/color, temperature, pH, and specific conductance of the purge water were measured approximately every 5 to 10 minutes throughout development. Turbidity was also measured, but readings were only obtained during the first hour of bailing because of the sudden failure of the turbidity meter. Parameter stabilization in the remaining parameters (defined as three consecutive measurements within 10 percent of their previous values) was achieved after 2.5 hours, at which point the water level in the well also became too low to sustain further bailing and development ceased.

2.1.5 Investigation-derived Waste Management

Investigation-derived waste (IDW) generated from coring and drilling activities included Chatsworth Formation drill cuttings, plastic debris and PPE, recirculated coring water, decontamination water, and spent vapor-phase granular activated carbon (GAC). Because of historical site activities (specifically the use and discharge of spent TCE during engine testing), environmental media from the boreholes, when removed, are considered listed hazardous waste.

Chatsworth Formation drill cuttings were containerized in three 20-cubic-yard (cy) sludge boxes. Liquids (waste waters) were containerized in seven portable totes and one 3,000-gallon polyethylene tank. All containers were labeled in accordance with requirements provided in Title 22, California Code of Regulations, Division 4.5, Section 66262.34. Containers were inspected weekly prior to offsite shipment and disposal. Sludge boxes and portable totes were temporarily staged at the BVE study area during drilling activities, then transferred to the 90-day waste-accumulation area (located at the Storage Propellant Area) when filled.

Chatsworth Formation drill-cutting samples IDWSO1002S001, IDWSO1003S001, and IDWSO1004S001 were collected and analyzed for volatile constituents, Title 22 metals, and total petroleum hydrocarbons (TPH).

Samples for volatile constituent analysis were collected as discrete grab samples. Nonvolatile constituent samples were collected as composite samples. Liquid waste sample IDWLI1006S001 was collected and analyzed for pH, VOCs, semivolatile organic compounds, TPH, and Title 22 metals. GAC sample IDWS01006S001 was collected and analyzed for VOCs. All samples were shipped to EMAX laboratories in Torrance, California for analysis.

Media in two sludge boxes did not contain detectable concentrations of TCE (less than the method detection limit of 0.001 milligrams per kilogram [mg/kg]) or daughter products. The two sludge boxes were transported for disposal at Chiquita Canyon Landfill, located in Santa Clarita, California, on October 27, 2014. Media in one sludge box contained TCE at a concentration of 0.0016 mg/kg. NASA requested a contained-in determination for this media in a letter to DTSC dated September 22, 2014. Because of the time constraints (90-day accumulation time limit) NASA provided disposal of this waste as listed hazardous waste (F002). The sludge box was transported for disposal to the US Ecology Beatty Landfill located in Beatty, Nevada, on November 19, 2014.

Wastewater generated during well installation, development, and decontamination was containerized in eight 275-gallon poly totes, one 55-gallon drum, and one 3,000-gallon poly tank. Liquid wastes were characterized as hazardous (F002) and transported for treatment to the RCRA-permitted Evoquoa Water Technologies facility located in Vernon, California, on November 7, 2014. Vapor extracted from the vapor probes during the treatability study required carbon treatment per the VCAPCD permit. Following completion of the study, used GAC was extracted from the canisters and containerized in eleven 55-gallon drums. The 55-gallon drums were stored at the 90-day waste-accumulation area and sampled for VOCs. Analytical results of waste characterization sample IDWS01006S001 indicated carbon is a state of California and federal characteristic hazardous waste (751, D040 [TCE] and D043 [vinyl chloride]). GAC waste has been profiled for treatment and will be disposed at US Ecology Beatty landfill in Beatty, Nevada, following transport within the 90-day waste accumulation period.

2.2 Bedrock Core Sampling and Analysis

Rock core samples were collected from borings PZ-202, PZ-202a, and PZ-203, and were submitted for laboratory analysis of VOC concentrations in the rock matrix. Each rock core generated during drilling was approximately 5 feet in length. Portions of the core submitted for analysis generally met the following criteria:

- Sample length between 3 and 5 inches
- Sample depth greater than 40 to 50 feet bgs
- Centered on significant fractures or fracture zones (for example, those with prominent weathering and signs of hydroalteration), and/or zones with elevated PID readings

Sampling was performed in accordance with the Deep Borehole Rock Core Sampling SOP (refer to Appendix A of the BVE IP [NASA, 2014c]). Thirty-two core samples, including field duplicates, were shipped to EMAX Laboratories, Inc. in Torrance, California, for VOC analysis by U.S. Environmental Protection Agency (EPA) Methods 8260B and 8260B-SIM. A summary of the collected core samples is provided in Table 2-3. Rock core analytical data are provided in Appendix F.

2.3 BVE Network Setup and Preparation

To facilitate the collection of bedrock vapor samples and installation of pressure transducers, wellhead modifications were made to wells included in the BVE TS monitoring network. As shown on Figure 2-2, this included the extraction well (HAR-19), and five existing wells, and the newly installed vapor probes. Wellhead modifications and transducer deployment were performed concurrently with installation of the BVE system on August 25 and 26, 2014.

2.3.1 Wellhead Modifications

As shown on Figure 2-1, the following wells underwent wellhead modification as part of the BVE TS:

- The BVE extraction well – existing groundwater monitoring well HAR-19 (after removal of its dedicated bladder pump)
- Seventeen new vapor probes – PZ-201 (a through d), PZ-202 (a through d), PZ-203 (a through d and v), and PZ-204 (a through d)
- Five existing groundwater monitoring wells – RD-104, HAR-20, PZ-156, PZ-070, and PZ-061

Existing groundwater monitoring wells used as vapor-monitoring locations were retrofitted with temporary 2-inch-diameter PVC tees and sampling ports. These included a ball valve and hose barb fittings for connection to tubing during purging and bedrock vapor sample collection. Tees were secured to existing wellheads with flexible PVC couplings, and capped with J-plugs. Modifications to the new vapor probes were similar, except PVC tees were 1 inch in diameter and were secured to wellheads with low-VOC PVC cement. Additionally, joints between the PVC components were caulked with silicone to prevent vapor leakage.

Modification of the HAR-19 wellhead was customized to facilitate connection of the vapor extraction equipment, as well as the operation of the Pneulog system (Pneulog system details are provided in Section 2.4.2). HAR-19 was configured at the surface as an 8-inch-diameter PVC riser, with an 8-inch-diameter tee to provide for lateral connection to a vacuum blower and top access for downhole flow and VOC measurement. The modification of the existing 10.125-inch steel casing is shown in progress in the following image:

A sealed top cap assembly for the 8-inch tee was installed by Praxis Environmental Technologies (Praxis). Northstar Environmental Remediation (Northstar) performed the remainder of the modifications to HAR-19, as well as the five existing wells. CH2M HILL performed the wellhead modifications to the new vapor probes. Wellheads were checked to verify that modifications were properly completed and installed in accordance with the BVE System Protocol (refer to Appendix B of the BVE IP [NASA, 2014c]).

2.3.2 Transducer Deployment

In Situ Level TROLL 500 pressure transducers, rated to 30 pounds per square inch (psi), were installed in the 22 BVE monitoring wells on August 26, 2014, and in HAR-19 on August 29, 2014. These instruments were installed to record downhole pressure variations throughout the duration of the BVE TS. Transducer cables were secured to plastic loops in wellhead J-plugs by either fishing line or zip-ties, with each transducer hanging up to approximately 5 feet below top of casing. An In Situ BaroTROLL data logger was employed to monitor ambient barometric and temperature changes throughout the study. The BaroTROLL was placed at ground surface at PZ-204 on August 29, 2014. Transducers were set to record pressure and temperature measurements every 10 minutes, leading to a total of over 3,000 individual measurements per well at the time of retrieval (September 15, 2014). Transducer data are presented and discussed in Section 3.

2.3.3 BVE System Installation

Northstar installed the BVE system at HAR-19. The system includes the following primary components:

- 50-horsepower blower with a variable powertrain drive
- Liquid separator vessel with 88-gallon capacity, and associated liquid transfer pump and water-holding tank
- Two 1,000-pound vapor-phase granular activated carbon (VGAC) adsorbent vessels

- 5.5-kilowatt generator, fueled by liquid propane gas (LPG)
- Three 50-gallon LPG tanks
- Various gas regulators and discharge/measurement valves

The BVE system is mobile and self-contained on a 20-foot trailer. Therefore, installation tasks were focused on properly securing the system inlet to the HAR-19 wellhead and verifying that connections were absent of leaks.

2.4 Bedrock Vapor Extraction

BVE operations occurred for one 5-day (100-hour) and two 4-day (73- to 75-hour) periods over 3 weeks, between August 26 and September 12, 2014. On the first and last day of each operating period, the first 3 to 4 hours of the first day, and the same period for the final hours of the last day, were used to gather soil vapor data from the 22 piezometers, either just before or just after the extraction cycle. This activity was necessary to track the performance of the system and to address the BVE TS objectives. The BVE system did not operate on weekends during this period. After nearly 6 weeks of inactivity, the system was restarted for a 24-hour rebound test on October 22 and 23, 2014. Northstar performed BVE operations, daily system checks, and maintenance. Table 2-4 provides a summary of the full BVE operational schedule.

A permit was obtained from the Ventura County Air Pollution Control District (VCAPCD) on January 6, 2014, authorizing the installation and operation of the BVE system through August 31, 2014. The principal conditions of the permit mandated that: all emissions would be captured by a carbon adsorption system, reactive organic compound and total non-methane organic compound emissions at the outlet of the carbon adsorption system would not exceed 100 ppm as methane (tested once daily), and that the maximum exhaust flow rate would not exceed 669 standard cubic feet per minute (SCFM). An extension of the air permit to operate the BVE system through October 31, 2014 was requested on June 19, 2014 and was granted by VCAPCD on June 26, 2014. A copy of the original VCAPCD permit as well as the email granting the extension are provided in Appendix A.

2.4.1 BVE System Startup and Operation

The initial startup of the BVE system occurred on Tuesday, August 26, 2014, at 12:48 pm. Upon startup, Northstar adjusted the system settings until a maximum stable flow rate was achieved from HAR-19; this flow rate was found to be between 65 and 66 SCFM, with an associated wellhead vacuum of approximately 6 inches mercury (in. Hg) (68 inches of water [in. H_2O]). The system continued extraction at this approximate rate throughout the 3 weeks of operation. Exceptions included adjustments during weekly startups and during Pneulog survey interruptions. Northstar monitored vacuum and flow on a daily basis, adjusting the system as necessary. Northstar also obtained daily PID measurements of effluent from both VGAC vessels to confirm compliance with the VCAPCD permit. PID monitoring employed the use of a 10.6-electron-volt (eV) PID calibrated to hexane, and converting to equivalent ppm as methane, as required under the VCAPCD permit. VGAC vessel effluent remained at 0.0 ppm throughout the duration of the BVE TS. Appendix G provides a record of monitoring data collected during BVE system operations.

A summary of BVE system flow rate and wellhead vacuum measurements taken during weekly system startups and shutdowns are provided in Table 2-4.

2.4.2 Pneulog Evaluations at HAR-19

Praxis performed five Pneulog surveys of HAR-19 throughout the BVE TS, in order to locate the depths of major fractures intersecting the HAR-19 corehole above the water table, and to quantify the vapor flow and VOC concentrations associated with those fractures at different stages of the BVE system operation. Pneulog profiling was generally timed to occur either immediately after system startup and flow stabilization, or immediately prior to system shutdown. The specific dates and times of each Pneulog survey are provided in Table 2-4.

The general procedure for Pneulog profiling work was as follows:

- Installation of Pneulog equipment at the HAR-19 wellhead
  - For the profiles that occurred after system startup (beginning of the week), equipment was installed prior to the beginning of extraction
  - For the profiles that occurred prior to system shutdown (end of the week), a brief interruption to extraction (of 10 minutes or less) was incurred in order to install equipment
- Initiation of Pneulog testing, which included:
  - Lowering of the Pneulog equipment at a rate of approximately 8 feet per minute, from 30 feet bgs (top of the open borehole interval in HAR-19) to near the water table at approximately 172 feet bgs, followed by raising of the equipment back to 30 feet bgs at the same rate
  - Continuous logging of flow and vacuum
  - Collection of approximately 25 vapor samples in Tedlar bags, at varying depths throughout the logging interval
  - Continuous monitoring of vapor concentrations by PID (calibrated to isobutylene)
- Termination of Pneulog testing and removal of Pneulog equipment from HAR-19
- Laboratory analysis of Tedlar bag vapor samples for VOCs within 24 hours of collection, by a calibrated gas chromatograph (GC) using a modified EPA Method 18

Appendix H provides a preliminary summary report for the five Pneulog survey events. Additional discussion of the Pneulog surveys and interpretation with respect to the BVE TS objectives is provided in Section 3.

2.4.3 Soil Vapor Sampling and Pressure Measurements

To evaluate how the vapor monitoring well field responded to the BVE system operation, wellhead pressures and VOC concentrations in soil vapor were monitored throughout the BVE TS. The collection of soil vapor samples and wellhead pressure readings at the BVE well, HAR-19, occurred twice weekly during the primary 3-week operation period: once immediately before system startup on the first day of each operational week, and again prior to system shutdown on the last day of each operational week. It should be noted that soil vapor samples were not collected on the last day of the first week because the mobile laboratory was unavailable; however, the mobile laboratory was used during rebound testing. Manual wellhead pressure readings and soil vapor samples were obtained at vapor monitoring points during the study. A final round of soil vapor sampling and wellhead pressure measurements occurred during rebound testing on October 22 and 23, 2014.

2.4.3.1 Soil Vapor Sampling

Soil vapor sampling during the BVE TS was performed in general accordance with the Collection of Vapor Samples from Existing Piezometers and Wells SOP, and from an Operating Vapor Extraction Well SOP (refer to Appendix A of the BVE IP [NASA, 2014c]), and involved the collection of approximately ten 0.5-liter glass bulb samples and up to two 1-liter summa canisters per sampling event. Glass bulb samples were analyzed via EPA Method 8260B on the same day of collection at an onsite mobile laboratory operated by Environmental Support Technologies (EST). Summa canisters were shipped to ALS Environmental (under subcontract to EMAX Laboratories, Inc.) for analysis via EPA Methods TO-15 and 3C at the fixed laboratory in Simi Valley, California.

Ten glass bulb samples were collected during each sampling event. Four of the samples were collected from the vapor-monitoring probe at each newly installed piezometer (PZ-201 through PZ-204) with the highest PID reading at the end of purging. The remaining six glass bulb samples were reserved for HAR-19 and discretionary sampling (which was generally focused on the vapor probes with the second highest PID readings, or modified wells with elevated PID or pressure readings). Summa canister samples were collected at HAR-19 during each sampling event. The vapor samples collected during the BVE TS are summarized in Table 2-5, and the associated laboratory results are provided in Appendix I. Appendix J presents a discussion of the sample collection methodology and Appendix K presents sample purge logs and PID readings.

2.4.3.2 Wellhead Pressure Measurements

In addition to the pressure data recorded by in-well transducers (Section 2.3.2), manual wellhead pressure measurements were recorded at the BVE TS piezometers on the first and last day of each operational week and during the rebound test. These manual readings were intended to provide immediate information regarding wellhead pressure responses to the airflow generated by the BVE system. Northstar provided an electronic handheld pressure sensor for this collection of these data. The electronic sensor was sensitive to tenths of an inch of water. Manual wellhead pressure measurements are presented in Appendix K.

2.5 Groundwater Sampling and Analysis

Groundwater sampling for the BVE TS was conducted at the extraction well, HAR-19. An initial, pre-study sample was collected on July 14, 2014 as part of routine site-wide groundwater monitoring activities. A second sample was collected immediately following completion of BVE system rebound testing activities on October 23, 2014; this sample was compared to the initial sample and used to evaluate any potential effect of the BVE system operation on VOC concentrations in groundwater. Both samples were analyzed for VOCs by EPA Method 8260B. The *Draft SSFL NASA Area 1 LOX and Area II Groundwater Monitoring Report Third Quarter 2014* (NASA, 2014d) provides details regarding collection and analysis of the initial sample. All sampling was performed using low-flow well-purging techniques, as described in the Low-Flow Purge and Groundwater Sampling SOP provided in Appendix A of the BVE IP (NASA, 2014c). The results of these groundwater-sampling events are presented in Section 3.6.

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3. Data Analysis

This section presents an analysis of the data collected during the BVE TS, organized in the structure of the five TS objectives outlined in Section 1.

3.1 Quantify Bedrock Air Removal Using Standard SVE Methods

The first objective of the BVE TS was to assess the effectiveness of standard soil vapor-extraction methodologies to remove air from the vadose zone in the fractured bedrock system, which is characteristic of VOC-contaminated sites at SSFL. Both wellhead and downhole airflow measuring devices were used to refine the understanding of the potential for bedrock vapor removal.

3.1.1 Airflow Response to Various Wellhead Vacuum Levels

Standard vapor extraction methodologies were used during the BVE TS to remove air from the vadose zone. The first step was to assess the airflow under varying wellhead vacuum pressures. As described in Section 2.4, a Sutorbilt Model 6M positive displacement blower was used to apply vacuum to the wellhead of HAR-19. The vacuum applied by the blower induces airflow out of the borehole. Increases in vacuum generally result in increases in the extraction rate from the borehole; reductions in airflow increase with increased vacuum tend to occur in boreholes that are in hydraulic connection to the water table. Under these circumstances, the vacuum in the borehole draws up the standing water column in the borehole, or in fractures connected to the borehole, such that some of the airflow pathways are cut off by the rising water. Given this potential behavior at HAR-19, several wellhead vacuum and extraction rates were tested during system start-up on August 26, 2014, by systematically increasing the vacuum and monitoring the airflow rates. The results are provided in Table 3-1.

Figure 3-1 presents the wellhead vacuum and airflow data in graphical form. Both Table 3-1 and Figure 3-1 indicate that there is nonlinear airflow to a given vacuum, and that the airflow at 6 in. Hg (81.57 in. H_2O) varied from 76.8 to 65.0 SCFM depending on the stage of the extraction. It is considered likely that this behavior is caused by vacuum-induced submergence of air-supplying fractures. The time variability of airflow under a constant vacuum is examined in Section 3.1.2.

3.1.2 BVE System Startup and On-off Cycles

The second performance evaluation of the BVE well, HAR-19, was to assess the change in flow rate over time during system startup as the BVE system equilibrated with subsurface airflow movement. As discussed in the preceding section, the BVE system was started with a wellhead vacuum pressure of approximately 6 in. Hg (81.57 in. H_2O). During system startup, the airflow rate was monitored while keeping the vacuum pressure as constant as possible.

Wellhead vacuum and airflow were monitored throughout the extraction phases of the 9-week TS. Figure 3-2 presents the applied wellhead vacuum and corresponding airflow rate at HAR-19. These data suggest that airflow can vary widely, while vacuum remains relatively stable.

Figure 3-3 presents a plot of wellhead vacuum and airflow at the BVE well during the first several hours of operation following system restart at the beginning of week 3 of the BVE TS. The initial flow rate of approximately 110 SCFM drops rapidly and stabilizes to a rate of approximately 65 SCFM. These data suggest that the water table upwelling is likely to have completely relaxed over the previous shut down, and that the progressive decline of flow after system startup is due to renewed upwelling and submergence of airflow-generating fractures upon the re-establishment of a relatively constant wellhead vacuum.

3.1.3 Pneulog Downhole Airflow Surveys

Pneulog downhole vapor flow profiling was performed in HAR-19 on four occasions over the 3-week operational period of the BVE TS and once during the rebound test. The extraction vacuum and airflow over the duration of the BVE TS were initially stable at 6 in. Hg (81.57 in. H_2O) and 65 SCFM, respectively. Two of the Pneulog profiles were conducted after a period of weekend shutdown of the BVE system (August 26 and September 2, 2014) and the remaining two surveys were conducted at the end of a BVE extraction period (August 29, 2014 and September 12, 2014). The various Pneulog profiles tested intervals at differing depths using both top-down and bottom-up surveys. The top-down airflow survey results are shown on Figure 3-4. A complete top-down survey was not performed during the profiling effort on August 29, 2014 due to significant scraping of the Pneulog device along the borehole wall, which yielded unrealistic flow measurements in a large portion of the profile. Therefore, the August 29, 2014 survey is not shown on Figure 3-4. Cumulative airflow presented on Figure 3-4 refers to the total accumulated flow along the corehole profile with depth. Pneulog flow is computed based on airflow velocity, which is monitored nearly continuously along its depth. Under ideal conditions, the cumulative airflow curve shown on Figure 3-4 would only increase; however, it is apparent that cumulative airflow both increases and decreases. Decreases in cumulative flow result from increases in the cross-sectional area of the corehole with depth that are not accounted for when computing airflow from velocity (that is, the airflow is computed from the measured velocity assuming a constant borehole diameter). The Pneulog report is provided in Appendix H.

The general result of the Pneulog airflow profiling at HAR-19 suggests that approximately 80% of the airflow originates in the deeper portion of the borehole, below approximately 158 feet bgs. Appendix H contains the details of the Pneulog fieldwork and results. The analysis conducted by Praxis (2014) concludes that there is no significant change in downhole airflow patterns within the corehole over the entire test period, despite the differences in accumulated flow with depth shown in Figure 3-4. The precision in airflow measurement (affected primarily by the irregular cross-sectional area of the corehole) is likely the source of the differences in accumulated flow between the curves presented in Figure 3-4.

Pneulog surveys were conducted at vacuum levels of approximately 6 in. Hg (81.57 in. H_2O) with a resultant airflow of 50 SCFM and at 4 in. Hg (54.38 in. H_2O) with an airflow rate of approximately 20 SCFM. These data suggest that an increased vacuum would result in an increase in the extraction rate. As previously discussed, vacuum levels higher than approximately 6 in. Hg (81.57 in. H_2O) could result in a noticeable change in flow, likely because of a rise the water table in the borehole and blockage of the interval of highest airflow production.

3.2 Quantify VOC Removal in BVE Well

The vapor extracted from well HAR-19 carries the VOCs of concern, the removal of which is the primary driver of the BVE TS. VOCs are pulled from the surrounding vadose zone of fractured sandstone and shale. As discussed in Section 2.4.1, airflow rate and VOC concentrations were measured at the HAR-19 wellhead. As presented in the measurement logs included in Appendix G, VOC concentrations were measured using a handheld PID at several points along the BVE system, at the wellhead (pre-dilution influent), downstream from the blower (post-dilution influent), and downstream of each of the two carbon treatment vessels (lead and lag vessel effluent). Additionally, vapor samples were collected and analyzed via both fixed and mobile labs using standard analytical methods of TO-15 and SW8260. PID and vacuum measurements were collected periodically at the wellhead, whereas the vapor samples were collected for analysis once during the first week extraction, and twice per week for the following two weeks. Figure 3-5 presents the time-series data for the wellhead airflow rate and VOC data for HAR-19 over the 3-week extraction and rebound test extraction phases of the BVE TS. Total VOC concentrations measured using methods TO-15 and 8260B are lower than the PID readings. The source of this discrepancy is unclear; however, this could be caused by the presence of fuel hydrocarbons, the analysis of which was not conducted under the scope of this TS. Mass calculations presented later were conducted using total VOC concentrations rather than those from the PID. As shown in Appendix G, pre-dilution influent PID measurements were not collected during the first week of BVE system operation but were collected periodically during the subsequent 2 weeks. For these instances, pre-dilution influent PID values were estimated from the post-dilution PID measurements using the average ratio of the two values where both measurements were collected (post-dilution/pre-dilution = 0.29).

The average VOC mass removed from HAR-19 was computed for each week of the BVE TS, and the average VOC mass removal was computed for each VOC constituent detected in the soil vapor samples analyzed by either method TO-15 or 8260B. These constituents included TCE, cis-1,2-DCE, trans-1,2-DCE, VC, 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113), and dichlorodifluoromethane (R-12). Average VOC mass removal for each operational week of the BVE TS was estimated by multiplying the average measured VOC concentration for each week by the time-weighted average wellhead airflow for that week. Only one VOC sample was collected during the first week's extraction, which occurred during the beginning of the week. To compensate for this, the average VOC concentrations were adjusted based on the percent increase of the PID over that week. The adjusted average VOC concentrations were used in the VOC mass removal calculation. For the second and third weeks of BVE system operation, analytical samples were collected at the beginning and end of each week, providing data with which to estimate average VOC concentration. The estimated VOC mass removal rates for HAR-19 are presented by compound in Table 3-2. The total average VOC mass removal over the 3-week period was approximately 30 pounds, of which approximately 15 to 20 pounds was TCE.

As discussed in Section 3.1, Pneulog surveys were performed at several times during the BVE system operational period. In addition to measurements of airflow with depth, the Pneulog surveys provided measurements of PID concentration. Figure 3-6 shows the downhole PID measurements (converted to TCE equivalent concentration) from the four Pneulog profiles presented in Section 3.1.3. These results indicate that almost all of the VOCs in HAR-19 entered the corehole between 160 and 170 feet bgs, where most of the airflow entered the corehole, as well. The negative slope of the TCE Pneulog profiles above approximately 160 feet bgs suggests that dilution by lower concentration soil vapor may be occurring. The depth where most of the VOCs entered shifted over the period of the TS, possibly due to submergence of deep fractures that may have been initial VOC sources to the corehole.

3.3 Quantify Vacuum Response in Fractures and Matrix Block

This section presents an evaluation of the pressure responses to applied vacuum in monitoring wells around the BVE well HAR-19. Vacuum responses in monitoring wells are understood to be an indication of the regions of the vadose zone that are pneumatically connected to the vapor extraction well and may indicate areas of subsurface airflow. As discussed in Section 2.3.2, the wells within the vadose zone monitoring network for the BVE TS were equipped with data-logging pressure transducers. An additional pressure transducer was deployed above ground to monitor atmospheric conditions (BaroTROLL).

Four of the five new piezometers (PZ-201 through PZ-204) were instrumented with vapor probes screened at four depths. The depths naming convention for these vapor probes are presented in Table 2-2. A fifth new vapor monitoring location (PZ-203Av) was installed to monitor conditions within a matrix block, at approximately 70 feet bgs, and is within 10 feet of PZ-203. The distribution of the vapor-monitoring network included in the BVE TS is presented on Figure 2-1.

Vacuum response at each monitoring well was calculated as the difference between the measured vacuum during and immediately prior to HAR-19 extraction for the each of the first 3 weeks' extraction cycles. Barometric (atmospheric) pressure variations were observed in all of the measured vacuum signals. The barometric variations were removed from the vacuum signals using the publicly available signal-processing software SeriesSee, published by the United States Geological Survey (USGS, 2012). The signal processing is described fully in Appendix L.

The vacuum response time series data for the new piezometers are presented on Figures 3-7 through 3-10. These plots show responses to HAR-19 vapor extraction at piezometers PZ-201, PZ-202, PZ-203, PZ-204, respectively. Figure 3-11 presents the responses of the existing piezometer and observation wells HAR-20, PZ-156, RD-104, PZ-061, and PZ-070. The applied wellhead vacuum maintained over the duration of the BVE TS was approximately 6 in. Hg (81.572 in. H_2O). The applied vacuum applied at the end of the rebound period was approximately 4 in. Hg (54.38 in. H_2O).

As discussed in Section 2.4.3, periodic vapor sampling, which included purging each well, took place in the vapor monitoring wells during the BVE TS. Vapor sampling protocols are detailed in Appendix J and vapor sampling logs are presented in Appendix K. The well purging increases the vacuum in each well, which periodically resulted in a "spike" in the vacuum signals that were two to three times greater than the non-purging data. These signals were removed from the time series in Figures 3-7 through 3-11. One notable observation regarding the seemingly spurious behavior of well PZ-202c (Figure 3-8) is that vacuum responses in this well appear to behave in a highly time-delayed manner. The vacuum response variations appear to correspond to well purging during sampling; however, this behavior appears to diminish over time. Field personnel noted that large quantities of water were used during drilling of this well to overcome drilling difficulties, as noted in Section 2.1.2. The delayed drainage of this water from the interval screened by PZ-202c likely caused pneumatic disconnection (or reduced connection) with the area surrounding the port from the surrounding vadose zone until this water drained away from this port. This is supported by the consistent vacuum response in PZ-202c during the rebound phase of the TS.

The vacuum responses are best summarized by computing a plateau vacuum response for each signal for each week. This was accomplished by averaging the vacuum data between 4:00 AM of the day following the startup of that week's extraction test until 4:00 AM of the day prior to the end of the test.

Table 3-3 provides the tabulated plateau responses for each week in percent of applied wellhead vacuum pressure. Inspection of the time-series vacuum responses shown in Figures 3-7 through 3-11 indicates variability in the time required for each well to reach the plateau vacuum. The time-series data were processed to identify the time at which the plateau vacuum reached 50 and 90 percent of their plateau values. These metrics are inferred to quantify the delay in response to applied vacuum and indicate how responsive a given vapor monitoring well is to changes in applied vacuum at HAR-19. The transducers were removed after the third week; therefore, the plateau vacuum response was not computed for the rebound phase of the TS.

The plan view distribution of vacuum responses is shown on Figures 3-12 through 3-14. These maps present the 3-week average vacuum response (depicted as a 1 percent vacuum response contour) through the subsurface at depth intervals of 0 to 100 feet bgs, 100 to 140 feet bgs, and 140 to 165 feet bgs, respectively.

The most notable vacuum response is the propagation of greater than 3 percent of wellhead vacuum to PZ-156, at a distance of 378 feet from HAR-19, discussed below. This represents a substantial vacuum response at this distance compared to a similar wellhead vacuum and extraction rate in sedimentary vadose zones. Vacuum was not monitored at this distance from HAR-19 at all bearings; therefore, it is unclear whether this response represents a single preferential flowpath, anisotropy in the formation, or it is representative of responses in Sandstone 1 that would be observed if additional monitoring locations were available at this distance in all directions.

As shown in Table 3-3 and on Figures 3-13 and 3-14, the largest vacuum responses were observed in the “c” and “d” intervals of PZ-202 and PZ-203. These vapor probes represent the deeper intervals (120 to 160 feet bgs) at the piezometers. Of particular note is the high level of response (30 to 50 percent of wellhead vacuum) at these piezometers and at their respective depth intervals. These high vacuum responses occur at depths that correspond to the high airflow interval of HAR-19 identified during Pneulog testing. The vacuum response in the shallower “a” and “b” intervals in PZ-202 and PZ-203 as well as in PZ-070 (which is of a similar radial distance to HAR-19 and similar depth to the shallow vapor monitoring probes) were more modest, suggesting a more limited vertical connection between the shallow intervals and the BVE well and a larger lateral connection at depth between the deeper piezometer completions and HAR-19.

Figures 3-15 and 3-16 show the vacuum responses in cross sections B-B′ and C-C′, the locations of which are shown on Figure 2-1. Figures 3-15 and 3-16 indicate that the plateau vacuum increases with depth in all but one (PZ-204) of the multi-level vapor monitoring locations. This suggests that the deep fractured zone through which most of this air flows, as discussed in Sections 3.1.3 (Pneulog Surveys) and Appendix D (Video Logging), extends from HAR-19 laterally to distances of up to 90 feet and induces downward airflow toward this fractured zone, as indicated by the increasing vacuum with depth.

The exception to the trend of vacuum gradients is the PZ-204 cluster, the northern-most multi-level piezometer cluster, where the vacuum distribution with depth is reasonably uniform along its entire interval. The lack of a large vacuum response in the deep interval is uncertain, though several explanations exist. If the deep fracture identified at HAR-19 is laterally extensive, extending to PZ-204 and beyond, it is possible that the dip angle, which is approximately 30 to 35 degrees toward the northwest, places this fracture below the water table near PZ-204, which is downgradient of HAR-19. If this explanation of PZ-204’s anomalous responses holds, it suggests that airflow toward HAR-19 occurs primarily along bedding planes, or fractures parallel to the bedding planes.

The anomalous behavior at PZ-204 could also be explained by a lithologic feature that connects the four depth intervals of PZ-204. Such features could be a nearly vertical fracture or joint, or a larger-scale feature such as the interface between the Sage Member and the Shale 2.

The core logs for PZ-202 and PZ-203 do not indicate strong lithologic differences in the deeper intervals, with the material described as sandstone or conglomerate. The logs do record fracturing throughout the intervals, with fractures observed along bedding and at steep angles to bedding planes. There are no core logs for PZ-201 or PZ-204, and video and drilling logs do not provide sufficient detail to discern the extent of fracturing. However, the vacuum responses in all the piezometers indicate that the fractures are not highly connected vertically over a wide interval, resulting in pneumatic responses that preferably follow bedding planes.

Of particular note in these results is the vacuum response of PZ-156. These data represent substantial expansion of a relatively high vacuum level (up to 3.2 percent) at a distance of 378 feet from the BVE well, which is substantially greater than what was expected for this location. Additionally, this vacuum response is greater than any of the shallow (“a” or “b”) intervals of the newly installed piezometers or any of the other existing piezometers/wells PZ-061, PZ-070, RD-104, and HAR-20. PZ-156 is located roughly along strike from HAR-19 and is completed to a total depth of 114 feet bgs. With the assumed strike and dip values for this area, it appears that PZ-156 is completed in bedrock intervals that are stratigraphically higher than the zones at HAR-19 which produced most of the measured airflow. The responses observed at PZ-156 suggest that despite the observations closer to HAR-19 suggesting the fractures are not vertically extensive, there may be some cross-strata pneumatic communication further away from the BVE well, toward PZ-156.

The time-dependency values presented in Table 3-3 indicate which of the vapor monitoring wells responded fastest to BVE-applied vacuum, and which wells exhibited a delayed response; this table also shows the time to response quickens after successive restarts. In general, the fastest responses appear to occur in the deepest wells ("d" interval), and generally in wells less than 100 feet from HAR-19. Notable initially slow-responding wells include PZ-202c and PZ-156, HAR-20, and PZ-202a. The slow response in HAR-20 is likely a result of its distance from HAR-19, the large volume of air requiring evacuation to register a vacuum, and some connection to fractures beneath 30 feet (the depth of the surface casing in HAR-20). Adjacent piezometer PZ-061 (screened at 5 to 15 feet bgs) did not see a vacuum response, indicating either a stronger pneumatic connection to the ground surface and/or the absence of a significant fracture connection to HAR-19.

3.4 Quantify PID Response in the Monitoring Well Network

Changes in vapor VOC concentrations provide information about whether advective flow is affecting a given piezometer. Important to this assessment is the understanding of this piezometer's location relative to source areas of VOCs concentrations. In this way, the response data may provide information on the position of the piezometer relative to source zones beyond the immediate flow zone of the extraction well.

Vapor concentrations were sampled using a handheld PID (MiniRae). As discussed in Section 2.4.3, vapor-monitoring wells were generally sampled at the beginning and end of each week's BVE system cycle. During the vapor well purging process, PID readings from each monitoring well interval were recorded. The maximum PID readings taken at each location after two well volumes were purged are shown in Table 3-4.

The PID responses indicate subsurface airflow through the bedrock vadose zone toward HAR-19. Table 3-4 also presents the maximum PID value during the initial portion of the test (highlighted in bold font). Five of the 22 piezometers reached their maximum value in the first week, 15 reached the maximum in the second week, and 2 reached their maximum in the third week.

Figures 3-17 through 3-21 present the PID measurements from Table 3-4 for the 17 new vapor piezometers and 5 existing piezometers over the duration of the test in graphical form. The key result presented in these graphs is that the PID readings at all monitored locations, relative to their starting concentrations, either increased then decreased, or decreased; the only exception to the trend was observed at HAR-20, which remained at non-detect throughout the TS. This result is consistent with either the flushing of vapors initially present at these locations, or the arrival and pass-through of elevated VOC vapors from a remote origin.

Figures 3-19 and 3-20 show that PZ-203d and PZ-204d have the two highest maximum PID values of the newly installed piezometers and the maximum of these two probes occurred in Week 2. PZ-203d, which also showed one of the two highest vacuum responses, showed an extended period of elevated concentrations from the end of Week 1 through the end of Week 2. This is consistent with the arrival and pass-through of elevated vapor concentrations in the zone beyond PZ-203 in the flow field, likely from the contaminated area near to PZ-155, which is positioned below a discharge of the Bravo Test Stand.

Figure 3-21 shows the PID measurements from Table 3-4 for the five existing piezometers, which stand further out or are shallower than the newly installed piezometers. These are notable in that the magnitude of the PID readings is elevated in three of these piezometers (RD-104, PZ-156, and PZ-061). Of these, PZ-061 is notable in that its maximum PID value was seen in its first reading (Week 1a). In all five existing piezometers, the values showed variations, including some increases, but overall, they declined over the course of the TS.

3.5 Rebound Evaluation

The rebound evaluation of this TS assessed the changes in vapor concentration following the extraction of VOCs from the fractures supporting airflow. This evaluation was based on PID concentrations measured in the piezometers at the beginning and end of each extraction cycle, as well as the 6-week rebound period at the end of the study (Section 2.4.3). Soil vapor samples were submitted for laboratory VOC analysis by EPA Methods 8260B and TO-15 to facilitate this evaluation (Table 2-5).

The intent of the rebound evaluation was to assess the degree to which diffusion-limited VOCs in the adjacent bedrock matrix pass back into the vapor phase in the fractures, following the removal of VOCs during BVE. In its simplest form, the model supporting rebound evaluation assumes that the lateral extent of VOC contamination within the vadose zone is entirely contained within the BVE flow field. Under these conditions, as BVE proceeds, high-concentration VOC-laden soil vapor within the flow field would be replaced with “clean” atmospheric or non-VOC-laden soil vapor. As documented in Table 3-4, this pattern appears to apply in only three piezometers (HAR-20, PZ-061, and PZ-070). Patterns of PID concentrations in other soil vapor monitoring locations are variable, where this simplified model is applicable to some phases of the TS and not during others.

The piezometers to which this simplified rebound model best applies are HAR-20, PZ-061, and PZ-070. At these locations, the highest PID concentration was detected before the first extraction cycle, the PID concentrations declined during each of the three extraction cycles, and the PID concentrations rebounded during each shutdown cycle, but to a concentration lower than the initial maximum PID. It is inferred that these three locations represent the presence of a local vadose zone VOC source area.

The PID concentrations at HAR-20 were relatively low (maximum of 0.3 ppm); therefore, while changes are noted, there is uncertainty in the magnitude given the limit of quantification of the PID instruments. As shown in Table 2-2, PZ-061 and PZ-070 are the shallowest soil vapor monitoring locations in the TS network and are likely close to surficial VOC source areas. Additionally, these locations may be surrounded by sources of non-VOC containing atmospheric recharge. As shown in Table 3-5, the first 2 weeks of extraction demonstrated PID concentration reductions, while the first two rebound cycles generally demonstrated rebound (which progressively decreased in magnitude). Over the first two extraction cycles, the PID changes indicate rapid concentration decline under extraction and a short-term (weekend) rebound. These patterns are considered favorable for the use of vapor extraction as an in situ treatment technology.

The PID concentration data at these locations follow the simplified rebound model (concentration decline during extraction, concentration rebound during shutdown) through at least the first shutdown and through the third extraction period; however, the pattern was not observed during the final rebound period. PID concentrations at these locations continued to decline between shutdown following the third extraction cycle and startup during the 6-week rebound phase of the TS.

The patterns of PID concentrations in the piezometers are shown in time-series data presented on Figures 3-17 through 3-21.

In addition to the simplified rebound model discussed above for the initial cycles of PZ-061 and PZ-070, VOC concentration rebound was assessed in a broader set of concentration trends. Figures 3-22 and 3-23 show the VOC concentrations following each extraction and rebound cycle for the 10 highest concentration (greater than 10 ppm) piezometers. The extraction and rebound periods are noted by colors in these figures, to identify whether concentrations:

- Went up during extraction (likely drawing VOCs from remote source)
- Down during extraction (likely removing VOCs from a local or limited source)
- Up during shutdown (likely representing local rebound, possibly desorption from adjacent matrix)
- Down during shutdown (likely representing sorption into adjacent matrix)

The extraction cycles represent the VOC concentrations after several days of vapor extraction for the 3 weeks of BVE operation. The rebound cycles represent the VOC concentrations after equilibrium prior to startup of extraction cycles for Week 2, Week 3, and Week-9 (approximately 4 days, 3 days, and 6 weeks of rebound equilibration, respectively). Interpretations of the patterns presented on these figures are discussed further in the following sections.

3.5.1 Extraction Phase

The intra-cycle VOC changes for the extraction cycles varied; however, the third cycle's concentrations were generally lower than the first cycle. Exceptions to this include samples with concentrations at the end of the third extraction cycle less than 5 ppm, which are only slightly greater than the first week's concentrations and could be attributed to measurement error.

The changes in VOC concentrations during the active extraction phases, shown on Figures 3-22 and 3-23, provide an indication of the relative location of the VOC source for each sampling port or piezometer screen. PZ-203b, PZ-203c, PZ-203d, PZ-201b, and RD-104 exhibit VOC concentrations that rise and then fall over the 3-week BVE, suggesting that remote VOC sources contribute mass to these locations. The PZ-203 well cluster lies to the south of HAR-19, while the PZ-201 well cluster lies to the northeast, and RD-104 lies to the northwest. PZ-203c and PZ-203d ports were among the highest vacuum responses; however, PZ-201b showed modest vacuum and RD-104 exhibited no vacuum response. Some data suggest that the amount of vacuum response may be correlated to the apparent VOC movement through the bedrock vadose zone; however, this correlation is not consistent in all soil vapor monitoring locations (the different construction and static volumes of these piezometers may correlate better to the vacuum response). Locations that exhibited a slight increasing trend throughout the 3-week BVE TS include PZ-201d and PZ-204d. This progressive increase in VOC concentration indicates the possibility that a weaker source may be slowly drawing into these ports. It should be noted that these increases are small relative to the other increases, and all VOC concentrations were below 5 ppm. The trend of PZ-201c was reasonably stable and below 5 ppm. VOC concentrations at PZ-070 steadily declined during the extraction phase, indicating resident vapors were removed from this zone during extraction. PZ-156 exhibited the second-highest concentration of VOCs during the active extraction phase. Concentrations increased during the initial extraction, during the first two weekends, but decreased sharply during the second and third extraction phases, indicating that a more remote plume had begun to arrive by the end of the first extraction cycle.

3.5.2 Rebound Phase

Figures 3-22 and 3-23 show that the VOC trends for the rebound cycles after each of the three extraction cycles generally decreases over time. The first rebound cycle concentrations were generally higher than during the extraction cycle; the second rebound cycle values were comparable to the extraction cycle concentrations;

and in the third cycle, rebound concentrations were either less than the previous extraction concentration, or nearly equal. This indicates that after the third-week extraction cycle, VOC concentrations continued to decrease through the 6 weeks of equilibration time, which is the opposite of rebound.

Figure 3-24 shows the extraction and rebound phases for the average and average of the top 10 highest concentration piezometers over the three extraction and rebound cycles shown in Figures 3-22 and 3-23. This summary graph indicates that, on average, the VOC concentrations in piezometers measured in the TS declined systematically during the extraction and rebound phases. After the first extraction cycle, there was a rebound in VOC concentrations. After the second week of extraction, the magnitude of rebound declined and, by the final cycle, the arriving soil vapor had begun to transport more VOCs to the piezometers than the rock matrix could have off-gassed. This suggests that the initial release of VOCs from the rock matrix is very rapid, whereas the 6-week rebound test tended to prove that a longer-term release mechanism is not significant, at least not from the zones represented by the sampled piezometers. This also suggests that HAR-19 and the piezometers used to monitor it are located in a source area that is weaker relative to the strength of VOC sources within the overall flow zone that this short-term extraction was able to mobilize.

3.6 Additional Data and Analyses

A groundwater sample was collected from HAR-19 during its regular semiannual event, in this case the Third Quarter sample, on July 14, 2014, prior to the start-up of the BVE TS on August 25 (NASA, 2014d). After the rebound mobilization in late October, the pump was reinstalled in HAR-19 to restore its function as part of the site-wide monitoring program, and an additional sample was collected. Analytical data associated with the groundwater sample collected in October 2014 are included in Appendix M. A summary of the comparison of the results of these two groundwater samples is shown on Table 3-6.

As seen in Table 3-6, of the seven detected compounds, five decreased in value between sampling events, and two (benzene and TCE) increased. The value for benzene was reported with a J-flag, so the significance of this increase is uncertain. The increase in TCE is well above the quantification limit; it is possible this increase was related to the drawing of TCE related vapors into the open core hole of HAR-19 during the TS. It is also possible that some of this increase could have resulted from the sustained application of a vacuum of approximately 5-foot water column (4 in. Hg). The drawup in the water column could have introduced groundwater into previously unsaturated VOC-laden fractures, to then drain back into HAR-19 for the weekend shutdown (refer to notes above as to depth of VOC source in vapor, Section 3.2). The mechanisms responsible for the observed decrease in groundwater concentrations of the other compounds are uncertain but may include mass removal from the more mobile portion of the vadose zone. Additional soil vapor samples were collected from HAR-19 during the 6-week rebound phase of the TS and were analyzed for atmospheric gases. Analytical data for these samples are included in Appendix I. Of note in these results are the higher-than-expected concentration of carbon dioxide and the lower-than-atmospheric concentration of oxygen. This is consistent with the presence of an area with aerobically degrading attenuation underway within the flow field of HAR-19, such as the documented hydrocarbons in the area of Bravo Skim Pond south of PZ-203, for which the air movement by HAR-19 may have accelerated the resupply of atmospheric oxygen, the consumption of some of that oxygen, and the production of carbon dioxide.

3.7 Data Usability Assessment

A Data Usability Assessment Report for the BVE TS laboratory data is provided in Appendix N. The data quality evaluation assessed whether the laboratory data associated with the BVE TS vapor, water, and rock samples met the data quality objectives. The goal of the assessment was to demonstrate that a sufficient number of representative samples were collected, and the resulting analytical data can be used to support the decision-making process. Evaluation of 100 percent of the laboratory chemical data was performed by using the *Quality Assurance Project Plan, SSFL RFI Surficial Media Operable Unit, Revision 5, March 2013* (MEC^X, 2013). Overall, the quality of the analytical program and laboratory are sufficient to meet the project data quality objectives.

4. Results Interpretation and Synthesis

The discussions included in this section relate the information presented in Section 3 to the BVE TS objectives outlined in Section 1.

4.1 Patterns of Extracted Flow in HAR-19

As discussed in Section 3.1.1, data collected during BVE system startup indicated that increasing imposed vacuum in HAR-19 increased airflow at various vacuum levels only to a certain point, beyond which airflow is reduced. As previously discussed, this could be the result of a rise in the water column within the well, and the submerging of the deeper fracture system that was responsible for much of the airflow. This phenomenon was observed at wellhead vacuums at and above 6 in. Hg, which equates to approximately 82 in. H_2O, or almost 7 feet. This is the upper limit that water could rise within the extraction well at this vacuum pressure. Another possibility is that water could have been induced to rise in response to the vacuum within a high-flow fracture connected to HAR-19 in the surrounding formation; such a fracture might itself be connected to the water table at some distance. In such an instance, if the vacuum were transmitted through that fracture to the water table, the water would be expected to respond by filling some of the fracture, thereby cutting off airflow into it. Upon system shutoff, it would be inferred that the water would subside, both within the well and in any surrounding fractures.

As discussed in Section 3.1.2, data collected during restart of the BVE system in the third week of operation showed a reduction in airflow from approximately 110 to 65 SCFM. This reduction indicated that the system undergoes a period of equilibration between the applied vacuum and the steady-state extraction rate. The overall pattern is similar to that experienced by conventional vapor extraction wells screened into the water table, with reduced airflow after initial exposure to vacuum and higher, restored airflow after a shutdown period. These observations highlight the need to consider variable vacuum and flow and possibly limiting the vacuum in coreholes considered for future extraction, if the corehole extends below the water table, and particularly if deep fracture systems are connected to the corehole.

The Pneulog tool demonstrated usefulness by identifying a deep, limited zone of specific fractures accounting for most of the airflow (estimated at 80 percent), as well as a non-negligible portion of airflow from the matrix formation over most of the corehole depth (estimated at 20 percent). Pneulog measurements over time indicated no significant changes in these overall flow patterns within the corehole over the 3-week period. The rebound phase Pneulog results show a lower flow, but proportional to the lower vacuum applied during the rebound phase extraction. The same downhole flow patterns were present in the rebound phase as in the earlier extraction phases.

4.2 VOC Mass Removal at HAR-19

As discussed in Section 3.2, approximately 30 pounds of VOCs were removed from the vadose zone throughout the duration of the BVE TS. The primary VOC compounds extracted were TCE (58 percent), CFC-113 (25 percent), cis-1,2-DCE (6 percent), and R-12 (7 percent). Data suggest that the VOC mass removal rate remained reasonably stable over the duration of the BVE TS, with estimates between 1.6 and 3.6 pounds per day and an average of approximately 2.7 pounds per day. Rates during the second and third weeks are slightly higher than those of the first week and the rebound phase; however, these are not considered meaningful trends given the variability in the mass removal estimates. The computed mass removal rates are based on average airflow rates and VOC concentrations for each week. Data indicate that at the beginning of each week of BVE system operation, VOC concentrations start out at a minimal value and progressively increase over approximately 3 days (refer to Figure 3-5). This would suggest that the VOC extraction rates are apparently influenced by sources within the flow influence of HAR-19, but possibly at some distance away. Pneulog measurements over time indicated no significant changes in concentration, but a shift from the upper fracture to the lower fracture of the extracted VOCs over the duration of the extraction and rebound phases of this TS.

4.3 Vacuum Response in Fractures and Matrix Block

As discussed in Section 3.3, the vacuum response observed in vapor monitoring wells varied with distance from HAR-19, bearing and with depth. The distinct difference between a few very strongly responding vapor monitoring locations near HAR-19, and the large number of vapor monitoring locations showing less vacuum response supports conceptualization of the bedrock airflow system as an anisotropic, layered, dual-permeability system, consisting of the following characteristics:

- A wide network of variously-sized, interconnected fractures extending far enough into the surrounding formation to influence piezometers several hundred feet away from the BVE well (Figures 3-12 through 3-14)
- The layered nature of the sedimentary rocks create preferential flow directions along bedding planes, and is impeded in a direction normal to such bedding planes, evidenced by lower vacuum response in shallow intervals responding less than deeper intervals at PZ-202 and PZ-203
- The dipping nature of the beds, some of which are likely low permeability, create anisotropy in the vacuum response; this is inferred from the large vacuum response in PZ-156 far to the west, but little response in HAR-20, which is closer and to the north of HAR-19 and so downgradient from the extraction well. The large vacuum response at PZ-156 may be due to bedrock fractures that follow bedding planes for some distance along strike or could be due to a relatively continuous high-permeability layer within the bedrock.
- The strong vacuum response in piezometers PZ-203 and PZ-202, which are located south, and up-dip, from HAR-19, may be further evidence of fractures that follow bedding planes. These strong responses were not observed in piezometers located north (downgradient) of HAR-19, which are screened in strata that are stratigraphically above the intervals that provided the majority of airflow in HAR-19.

These results support the concept of a porous bedrock matrix comprising the majority of vadose zone volume, connected to the air-flow supporting fracture matrix; this is supported by the vacuum and PID response observed in the bedrock matrix soil vapor monitoring location, PA-203V.The dual-permeability conceptualization provides that the network of interconnected fractures is superimposed within the volume of the bedrock matrix. It is noted that if the matrix is saturated above 60 or 70 percent, it will provide little advective airflow; based on vacuum measurements at this site, at least some of the rock matrix appeared to support advective flow. As such, these two systems function dependently; they can form a continuum of available void space through which air can flow, though airflow predominantly occurs in the fractures. The relatively rapid response to applied vacuum in the vadose zone suggests that the effective flow path distance is likely more related to separation from a major fracture than lateral distance from the extraction well. This is supported by the result that the deeper intervals of PZ-202 and PZ-203 appear to be more directly connected to the airflow production zone (that is, the fractured zone) at HAR-19 than are the shallower intervals of the same piezometers. Additionally, the large vacuum response at PZ-156 (3.2 percent of wellhead vacuum), which is the most distal monitoring location from the HAR-19, and the apparent airflow patterns shown by PID concentrations (refer to Section 3.4) further supports the notion that flow path distances are related more to separation from an extensive major fracture than to the lateral distance from an extraction well.

Most piezometers responded to the BVE system operation consistently (in terms of vacuum response) over the test period, responding similarly over each extraction phase of the TS. A few piezometers showed large increase in vacuum response, and most responses occurred within hours of applied vacuum.

Large diameter wells (such as HAR-20 and RD-104) were less responsive in terms of plateau vacuum than smaller volume piezometers. This suggests that the large volumes of these wells and the low rate of air exchange at the distance of these wells might have corresponded to too small of a vacuum pressure change for the deployed transducers.

Some shallow piezometers (PZ-070 and PZ-061) showed little to no vacuum response. These probes also showed a sympathetic response to barometric fluctuation. It is surmised that the upper bedrock provides little impedance to the atmosphere, such that vacuum effects from HAR-19 might have been muted by a surface-recharged flow system.

4.4 VOC Response of Piezometers

As discussed in Section 3.4, the concentration reduction effects of the extraction from HAR-19 were very strong over just the 3 weeks of operation of the TS, and there was little to no—and even inverse—rebound after 6 weeks of equilibration. This effect is apparent in wells that had significant vacuum response and inferred flow (PZ-203c and PZ-203d), as well as some that showed no apparent vacuum, but by their PID response, appear to have had VOC removal by advective vapor flow (PZ-070, PZ-061, and RD-104).

In general, the piezometers all reached a maximum PID concentration sometime after the start of the BVE TS, as if the sample locations were initially affected by dilution from recent installation or wellhead modification work that took some period of flow to overcome; or that some piezometers observed the arrival of VOCs from a more remote source. In this last case, the maximum would correspond to the arrival time of the remote plume.

The lack of post-extraction rebound (Figure 3-24), and the time-delay (on the order of days) rise of VOC concentrations at HAR-19 during the extraction phases of the TS (Figure 3-5) suggest that the primary source of VOCs contamination is located beyond the monitoring network.

4.5 Implications for Site Characterization

The extraction-rebound cycle charts presented in Section 3.5 (Figures 3-22, 3-23, and 3-24) strongly suggest that results from this TS can be used to infer the presence of source zones of VOCs beyond the current monitoring array. In particular, the areas beyond the PZ-203 well cluster (Bravo Test Stand discharge), PZ-156 (Bravo Road), and RD-104 (west of the Alfa-Bravo Skim Pond) may have provided additional VOCs to this BVE TS. In addition, the area beyond PZ-061 and HAR-20 (Alfa Skim Pond) seem to suggest some deep vadose zone source of VOCs.

Both the strong vacuum and PID concentrations observed at PZ-156 indicate the presence of a preferential pathway connecting the high-flow zone at depth in HAR-19 and PZ-156. Figure 3-21 illustrates that PZ-156 was initially low in concentration, indicating that this well was not in a source area. The rise and fall in VOC concentrations suggest that a source of VOC vapors passed through this area, but the only known source areas east of HAR-19 lie to the southwest near the Bravo Test Stands. If the VOC vapors originating from sources near the Bravo Test Stands (for example, the WS-09 area) had moved toward HAR-19 through a flow path that passes near PZ-156, this could suggest that BVE can take advantage of extensive fracture networks, if these exist over a large radius.

Based on BVE TS results, changes and imperfections in lithology present in the formation have a dominant effect on the vadose zone airflow patterns. Strong vacuum responses were not seen in all locations and were not seen within the various depth intervals in PZ-201 and PZ-204, both of which are located north of and downgradient from HAR-19. Minimal vacuum responses were observed at HAR-20 and PZ-061, but these locations still appeared to have a flow field strong enough to transmit VOCs, as evidenced by the observed changes in PID concentrations over the duration of the BVE TS.

4.6 Remediation Insights from the Test

The 13-day (248-hour) BVE TS was successful at influencing piezometers hundreds of feet away from the extraction well, through an apparently pervasive and wide-ranging network of fractures and adjacent matrix blocks. The VOCs removed during the BVE TS are inferred to have originated from fractures and from the bedrock adjacent to these fractures. Other small-scale fracture networks may be present and have an influence on VOC migration under a BVE system; however, insufficient data are currently available to provide information regarding such micro-fracture networks.

The induced BVE TS airflow pattern resulted in the removal of approximately 30 pounds of VOCs (primarily TCE and CFC-113). As shown in Table 3-2, the average mass removal during the BVE TS was approximately 2.7 pounds per day. Based on the multiple (potential) sources of this VOC mass, it is not known how long the mass removal rate from HAR-19 would stay at the observed levels.

This TS revealed that the BVE well location was not within a strong VOC source area. For this reason, data were not collected during the TS on deep bedrock matrix desorption that could be of interest in evaluating the applicability of BVE at other locations.

In areas such as locations PZ-061 and PZ-070, the PID measurements indicates a sharp reduction from initial PID concentrations, most likely in response to airflow, and a tendency for subsequent rebound. This corresponds to a single flush of air, followed by a diffusion-controlled release from the bedrock matrix over the short term. The lack of rebound after 6 weeks could suggest that while these piezometers initially contained VOCs vapors, they are not located in deeply adsorbed VOC source zones.

Given the steady VOC concentrations in the extracted flow of HAR-19 (refer to Section 3.2), and the pattern of VOC concentrations in the piezometer array, it may be possible to continue extraction at a rate sustained by the release of VOCs from remote source areas. This suggests that while extraction close to a source is likely ideal, because of the dual-permeability, fracture-controlled flow system, remote extraction of sources may be feasible. This could lead to future tests involving existing core holes, as opposed to requiring new extraction wells to be installed. In the case of future testing, desorption of VOCs from the rock matrix of a confirmed source area would be an important component. This would likely require a longer duration TS to measure and confirm this process.

The shallow piezometers in the Alfa Skim Pond area (PZ-201 and PZ-061) as well as in Bravo (PZ-070) appear to demonstrate that substantial air movement can occur without much vacuum created in the piezometers. Based on the patterns in these piezometers, at least part of the HAR-19 airflow appears to have come from the ground surface and to have induced a rapid concentration decline in the shallow subsurface.

Overall, this test demonstrated the short-term efficiency of extracting air and some VOC mass from an existing corehole, provided the corehole is located in or near a source area and is intersected by an interconnected fracture system providing airflow and VOCs. At the original time of this BVE TS work, HAR-19 was the only well to have been tested with BVE. Since then, ND-112 in the Former Liquid Oxygen (LOX) Plant AIG has also been vapor-extracted and studied, serving as a less-fractured and more of a high-vacuum, micro-fracture or matrix-extracting well. A report summarizing the work completed at ND-112 is included as Appendix A of Appendix A of the NASA Groundwater RFI Report (NASA, 2017) and summarized in Section 4.1.1 of the Phase 1 CMS report. In addition, new rock cores and wells have been installed as part of the NASA Groundwater RFI (NASA, 2017) work, and the NASA Groundwater CMS (in which this report appears as Appendix F) captures these latest data for most productively employing BVE in Area II.

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5. Conclusions

The following subsections describe the conclusions of the BVE Pilot Test.

5.1 Objective 1: Production of Air from HAR-19

1) **Repeatable but Modest Flow**. The instantaneous startup extraction rate in HAR-19 was almost 40 percent higher (110 SCFM at 6 in. Hg [81.57 in. H_2O]; about 6 SCFM per foot) than the steady-state extraction rate. HAR-19 produced about 65 SCFM at steady state under a vacuum of about 6 in. Hg (81.57 in. H_2O). The lower steady-state flow was realized within 3 hours of startup.
2) **Fractures Dominate.** Most of this airflow came from two fracture zones between 160 and 173 feet bgs. Approximately 10 to 20 SCFM is believed to have been derived from the bedrock matrix between 30 and 160 feet bgs. This corresponds to unit flow rates of about 4 SCFM per foot in fracture zones, and 0.08 to 0.16 SCFM per foot in the bedrock matrix, under a vacuum of 6 in. Hg (81.57 in. H_2O).
3) **Little, if Any, Plasticity in Flow Parameters**. Airflow production from HAR-19 did not change after 6 weeks of re-equilibration; the flow generated from HAR-19 does seem affected by short-term water table rise or fracture submergence, as a result of applied vacuum.

5.2 Objective 2: HAR-19 Volatile Organic Compound Removal

1) **Mass Removal was Relatively Steady**. The mass extraction rate at HAR-19 was reasonably consistent during the BVE TS. The average VOC removal rate from HAR-19 was 2.7 pounds per day over the 3-week operating period. The primary VOC compounds extracted were TCE (58 percent), CFC-113 (25 percent), cis-1,2-DCE (6 percent), and R-12 (7 percent).
2) **Cycling May Not be Needed**. The mass removal rate at HAR-19 remained reasonably stable. Little or no rebound was observed in the piezometer network even though a consistent mass removal rate was measured at HAR-19 during all of the extraction phases of this short-term TS.

5.3 Objective 3: Vacuum Response in Fractures and Matrix Block

1) **Strong Vacuum Response, with Time Delay**. A measurable response was found in all piezometers (except PZ-061 and RD-104, both remote). The vacuum responses ranged from 0.1 to 50 percent of the applied wellhead vacuum, with plateau vacuum reached within 0 to 14 hours, at distances from 23 to 378 feet from HAR-19. These wells are nominally screened in a fractured bedrock setting, though some locations may be screened in relatively higher or lower permeability units. Plateau vacuum responses were comparable to those seen in fine sand to coarse gravel settings, in terms of distance and magnitude.

   For conventional SVE applications, it is not unusual to see 2 to 5 percent of the wellhead vacuum during vapor extraction in a coarse sand to gravel, up to 100 feet from the extraction well. During the BVE TS, a similar vacuum response was observed at even greater distances in the deep bedrock at the Bravo site (PZ-156), as well as in many other piezometers within about a 100-foot radius.
2) **Transducers Provide Insight**. Data from the transducers in the 22 instrumented piezometers demonstrated the vacuum from the extraction at HAR-19 could be sensed in almost all locations monitored.

The strongest response was found in three vapor monitoring probes at two piezometer locations: PZ-203c and d, and PZ-202d. At these locations, 50 percent and 37 percent of the wellhead vacuum were consistently observed, and this maximum response was achieved within 3 hours or less of BVE system startup at these locations. These locations are 30 and 84 feet away from HAR-19, respectively. There are differing amounts of spatial correlation of vacuum response to distance or lithology.

3) **Vacuum Permeates (Possibly Small Fractures) within Rock Matrix**. The vapor monitoring probe completed in a competent, low fracture zone (PZ-203Av, located within borehole PZ-203A approximately 25 feet from HAR-19, 72.5 feet bgs depth) showed a strikingly consistent vacuum response with respect to piezometers screened in shallow zones directly above (PZ-203a) and directly below (PZ-203b), which are 34 feet from HAR-19 and have screen midpoint depths of 57 and 92 feet bgs, respectively. This indicates that a bedrock zone with little to no visually discernible fractures behaves similarly to intervals above and below, which contain visible fractures. This may indicate that a fracture network may affect zones within the rock matrix as a function of time and the permeability of the rock matrix; or that the rock matrix, in this case, is made more permeable by small fractures that are too small to be visually identified. Independent of micro-fractures, this may also be related to the native porosity of the bedrock matrix and may indicate that this zone was relatively dry and therefore permissive of airflow and vacuum propagation.

4) **Flow Occurs without Measurable Vacuum**. Where comparison was possible, the shallowest vapor monitoring probes displayed lower vacuum levels than in the deeper intervals. However, PID measurements indicated flushing of more dilute air, which indicates flow in these piezometers. This could indicate ground-surface air recharge and is a possible indicator that vacuum is transmitted across a large area at depth and then propagates upward over most of the monitored area.

5.4 Objective 4: Effect of Lithology, Geology on Advective Flow Paths

1) **Dual Permeability Flow System**. The observed advective flow paths are most appropriately described as complex airflow patterns comprising rapid advection along preferential pathways of the fractures and relatively slow or no advection through less permeable matrix blocks.

2) **Flow Occurred Throughout a Wide Area**. All piezometers showed some change in the twice-weekly PID readings. In most cases, the readings showed a maximum after the first week of extraction, indicating the arrival of a more distal plume to the piezometer. Most piezometers showed some reduction in their final PID value with respect to their prior maximum. This indicates that the initial test period was sufficient to induce airflow through virtually all monitored piezometers.

3) **Limited Vertical Connectivity.** Evidence suggests that the extent to which fracture networks are vertically connected varies across the area. Data for piezometers close to the BVE well indicate that the fractures are not vertically connected across multiple bedding planes. However, the response observed at the more distal piezometer PZ-156 indicates that there may be some vertical connection further away from the BVE well.

   As such, it appears appropriate to think of major fractures that intercept an extraction well to be physical extensions of that extraction well, allowing high levels of vacuum to be expressed on the bedrock matrix at substantial lateral distances from the extraction well itself.

4) **Fracture Extent Unpredictable**. The rate of vacuum propagation in the bedrock matrix, shown by the range of response times, did not vary according to lateral separation from HAR-19. This supports the concept that the vadose zone contains substantial heterogeneity: that the fracture network, although spatially pervasive, likely does not penetrate all volumes equally.

5.5 Objective 5: Diffusive Response from Bedrock Matrix

1) **VOC Release Appears to be Rapid.** VOC response patterns showed an initial rebound in some piezometers, suggesting that a local source needed either one or two flow cycles to release its VOCs; but by the third extraction cycle, there was no piezometer displaying a strong rebound. This may be more related to the absence of a strong source, than with a general characteristic of the bedrock.

2) **Short Duration Test Drew in Remote Sources.** After the third flow cycle, during the 6-week rebound period, no piezometer increased in VOC concentration, and in almost every piezometer there was some form of decrease in vapor concentration when compared to the last measurement during extraction.

   A possible conceptual model that would explain the observed behavior is as follows:

   a) In this area peripheral to the Bravo source areas, such VOCs as were present locally transferred readily from surficial layers of the rock matrix into the vapor phase of adjacent fractures through which air flows. At this location, this process effectively occurs within the first week or two of extraction. Additional VOC mass could exist within the bedrock matrix whose flushing could be limited by the diffusion, permeability, and geometry of particular matrix blocks; this relatively short duration test (3 weeks extraction, 6 weeks rebound) may not have been long enough to investigate that aspect of bedrock matrix diffusion.

   b) Airflow through the bedrock fractures is rapid, given the extremely low fracture porosity of less than 1 percent (SSFL Groundwater Advisory Panel, 2007). This rapid airflow quickly flushes the mobile pore space. Upon flushing, newly imported VOCs then find a new equilibrium with the adjacent rock matrix and associated moisture.

   c) As new VOCs are drawn in from remote sources it is assumed that this uptake would continue, effectively storing VOCs in the adjacent rock matrix along this flow path. This interim uptake of VOCs would reverse once the zone is flushed with air containing lower VOC concentrations, low enough to reverse the concentration gradients from the adjacent rock matrix to the fracture zone being flushed.

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Tables

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Table 2-1. Drilling Summary

Bravo Bedrock Vapor Extraction Treatability Study Summary

Boring No.[a]	Final Well ID[b]	Drilling Start Date	Drilling End Date	Drilling Method[c]	Depth (ft bgs)	Reamed[d]	Comments
PZ-201	PZ-201	8/12/14	8/12/14	Air rotary	167	No	--
PZ-202	N/A	7/25/14	7/29/14	HQ rock coring	138	No	Abandoned after core barrel broke off of drill string
PZ-202a	PZ-202	7/30/14	8/1/14	HQ rock coring	158	Yes	PZ-202 replacement boring
PZ-203	PZ-203	7/16/14	7/24/14	HQ rock coring	188	Yes	Drilled 10 feet into groundwater
PZ-203A	PZ-203A	8/19/14	8/19/14	Air rotary	188	No	Borehole adjacent to PZ-203, for installation of groundwater piezometer and rock-matrix vapor probe
PZ-204	PZ-204	8/13/14	8/13/14	Air rotary	165	No	--

[a] Boring numbers were used to identify locations before final well construction and are referenced in associated field notes and lithologic logs.
[b] The final well IDs were assigned following well construction and refer to the final completed piezometer locations.
[c] "HQ" is the standard industry designation for a 2.5-inch inner-diameter drill core.
[d] Borings were reamed to a diameter of 8.5 inches, where applicable. Borings that were not reamed or abandoned were drilled at their full 8.5-inch diameter.
ft bgs = foot (feet) below ground surface
ID = identification number
N/A = not applicable
PZ = piezometer

Table 2-2. BVE Piezometer Construction Details and Survey Results

Bravo Bedrock Vapor Extraction Treatability Study Summary

Well ID	Date Constructed	Probe ID	Screened Interval (ft bgs) Upper	Screened Interval (ft bgs) Lower	Diameter (in)	Northing[a]	Easting[a]	Ground Surface Elevation (ft msl)[b]
PZ-201	8/21/14	A	55.0	65.0	1	267,249.48	1,789,431.80	1,832.36
		b	100.0	115.0	1			
		c	124.9	139.9	1			
		d	149.8	164.8	1			
PZ-202	8/15/14	A	50.9	60.9	1	267,159.17	1,789,442.10	1,829.38
		b	80.8	90.8	1			
		c	116.0	131.0	1			
		d	146.2	156.2	1			
PZ-203	8/18/14	A	52.0	62.0	1	267,166.01	1,789,387.84	1,829.80
		b	84.8	99.8	1			
		c	131.0	146.0	1			
		d	154.9	164.9	1			
PZ-203A	8/20/14	V	70.0	75.0	1	267,173.15	1,789,381.60	1,829.77
		Gw	169.8	184.8	2			
PZ-204	8/20/14	A	50.2	60.2	1	267,237.66	1,789,356.71	1,827.98
		b	75.3	90.3	1			
		c	122.4	137.4	1			
		d	149.0	164.0	1			
HAR-19	6/17/87[c]		30.0	220.0	8	267,192.17	1,789,365.12	1,833.75
HAR-20	6/16/87[c]		30.0	230.0	8	267,367.89	1,789,484.67	1,830.65
RD-104	7/26/10[c]		30.0	60.5	8	267,305.35	1,789,160.60	1,826.49
PZ-061	1/17/01[c]		5.0	15.0	2	267,329.70	1,789,461.40	1,832.05
PZ-070	12/21/00[c]		13.0	23.0	2	267,188.80	1,789,392.00	1,834.61
PZ-156	11/12/08[c]		104.0	114.0	2	267,141.05	1,788,999.05	1,849.80

[a] Location coordinates are in the NAD 1927 California State Plane coordinate system, and represent the center of each probe cluster.
[b] Ground surface elevations reference the National Geodetic Vertical Datum of 1929.
[c] These dates represent the date the well drilling was completed.
ft bgs = foot (feet) below ground surface
ft msl = foot (feet) above mean sea level
HAR = Hydrogeologic Assessment Report
ID = identification number
in = inch(es)
NAD = North American Datum
PZ = piezometer
RD = Rocketdyne Deep

Table 2-3. Summary of Collected Rock Core Samples
Bravo Bedrock Vapor Extraction Treatability Study Summary

Boring No.	Sample ID	Sample Date	Depth (ft bgs) Upper	Depth (ft bgs) Lower	PID (ppm)	Notes
PZ-202	PZ202RCS004	7/28/14	47.0	47.3	0.0	
	PZ202RCS005	7/28/14	55.1	55.3	0.0	
	PZ202RCS006	7/28/14	76.9	77.2	0.0	
	PZ202RCS007	7/28/14	82.4	82.7	0.0	
	PZ202RCS008	7/28/14	93.5	93.8	0.0	
	PZ202RCS009	7/28/14	104.9	105.2	0.0	
	PZ202RCS010	7/28/14	110.8	111.1	0.0	
	PZ202RCS011	7/28/14	118.6	118.9	0.0	
	PZ202RCS012	7/28/14	123.6	123.8	0.0	
	PZ202RCS013	7/28/14	128.1	128.4	0.0	
PZ-202a	PZ202RCS014	8/1/14	144.9	145.4	0.0	Field duplicate also collected.
	PZ202RCS015	8/1/14	156.2	156.6	0.0	
PZ-203	PZ203RCS001	7/17/14	19.6	19.85	0.0	
	PZ203RCS002	7/17/14	27.25	27.6	0.0	
	PZ203RCS003	7/17/14	34.1	34.5	0.0	
	PZ203RCS004	7/18/14	46.9	47.4	0.0	
	PZ203RCS005	7/18/14	58.0	58.4	0.0	
	PZ203RCS006	7/18/14	68.7	69.1	0.0	
	PZ203RCS007	7/21/14	79.55	79.85	0.0	
	PZ203RCS008	7/22/14	99.0	99.5	93.0	
	PZ203RCS009	7/22/14	99.5	99.7	16.8	
	PZ203RCS010	7/22/14	104.9	105.2	14.0	
	PZ203RCS011	7/22/14	115.7	116.2	0.0	
	PZ203RCS012	7/22/14	126.4	126.9	0.0	Field duplicate also collected
	PZ203RCS013	7/23/14	135.55	135.9	16.4	
	PZ203RCS014	7/23/14	139.9	140.3	71.5	
	PZ203RCS015	7/23/14	155.4	155.7	0.0	
	PZ203RCS016	7/23/14	163.0	163.4	16.8	
	PZ203RCS017	7/23/14	175.0	175.4	0.0	
	PZ203RCS018	7/24/14	186.5	186.9	0.0	

ft bgs = foot (feet) below ground surface
ID = identification number
PID = photoionization detector
ppm = part(s) per million

Table 2-4. Summary of BVE System Operations

Bravo Bedrock Vapor Extraction Treatability Study Summary

Event	Date	Time	HAR-19 WH Vacuum (in. Hg)[a]	HAR-19 WH Vacuum (in. H_2O)[a]	Flow Rate (SCFM)[a]	Pneulog Surveys and Times (as applicable)
Initial system startup	8/26/14	12:48	6.00	81.57	73	Pneulog 1 (15:00-17:30)
1st week system shutdown	8/29/14	13:48	5.93	80.62	66	Pneulog 2 (11:45-13:50)
2nd week system startup	9/2/14	11:38	6.30	85.65	72	Pneulog 3 (12:00-14:50)
2nd week system shutdown	9/5/14	14:25	5.84	79.40	65	None
3rd week system startup	9/8/14	11:48	6.05	82.25	111	None
Final system shutdown	9/12/14	15:30	6.05	82.25	66	Pneulog 4 (13:30-15:30)
Rebound test system startup	10/22/14	13:05	4.00	54.38	98	Pneulog 5 (13:00-16:15)
Rebound test system shutdown	10/23/14	10:05	4.02	54.65	53	None

[a.] Listed wellhead vacuum and flow rate measurements are those that were taken closest to the indicated event time, and therefore do not necessarily represent exact vacuums and flow rates at the specified times.
in. H_2O = inch(es) water
in. Hg = inch(es) mercury
SCFM = standard cubic feet per minute
WH = wellhead

Table 2-5. Vapor Samples Collected During the BVE TS

Bravo Bedrock Vapor Extraction Treatability Study Summary

	Sample Date						
Well or Probe ID	**8/26/14[c]**	**9/2/14**	**9/5/14**	**9/8/14**	**9/12/14**	**10/22/14**	**Total**
Fixed Laboratory (Summa Canister) Samples – Various Methods							
HAR-19 (TO-15)	1	1	1	1	1	2[a]	7
HAR-19 (3C)[b]	--	--	--	1	1	1	3
PZ-204C (TO-15)	1	--	--	--	--	--	1
Total	2	1	1	2	2	3	**11**
Mobile Laboratory (Glass Bulb) Samples – EPA Method 8260B							
HAR-19	--	1	1	1	1	2	6
PZ-201b	--	1	1	1	--	1	4
PZ-201c	--	1	--	--	--		1
PZ-201d	--	--	--	1	1	1	3
PZ-202a	--	1	1	--	1		3
PZ-202c	--	1	--	1	--		2
PZ-202d	--	--	1	1	1	1	4
PZ-203v	--	1	--	1	--		2
PZ-203c	--	1	1	--	1	1	4
PZ-203d	1	1	1	1	1	1	6
PZ-204a	--	1	--	--	--		1
PZ-204c	1	--	1	1	1	1	5
PZ-204d	--	1	1	1	1	1	5
PZ-061	--	--	1	--	1		2
PZ-156	--	1	1	--	1	1	4
RD-104	--	--	--	1	--		1
Total	2	11	10	10	10	10	**53**

[a] Samples collected at HAR-19 for TO-15 analysis on 10/22/14 included a 1-liter summa canister, as well as a 1-liter Bottle-Vac.
[b] TO-15 and 3C analyses were performed on a single SUMMA canister.
[c] On 8/29/14 the Mobile Lab was unavailable, so no samples could be analyzed on the final day of the first cycle.
3C = EPA Method 3C
EPA = U.S. Environmental Protection Agency
ID = identification number
TO-15 = EPA Method TO-15

Table 3-1. Airflow Response to Applied Wellhead Vacuum

Bravo Bedrock Vapor Extraction Treatability Study Summary

Date	Time	HAR-19 WH Vacuum (in. Hg)	HAR-19 WH Vacuum (in, H_2O)	Flow Rate (SCFM)
8/26/2014	14:00	4	54.38	69.0
8/26/2014	14:10	6	81.57	76.8
8/26/2014	14:20	8	108.76	89.0
8/26/2014	14:40	10	135.95	87.0
8/26/2014	16:50	6	81.57	65.0

in. H_2O = inch(es) water
in. Hg = inch(es) mercury
SCFM = standard cubic feet per minute
WH = wellhead

Table 3-2. Average VOC Mass Removal from BVE Well HAR-19

Bravo Bedrock Vapor Extraction Treatability Study Summary

Constituent	Week 1 Mass Removal (pounds)	Week 2 Mass Removal (pounds)		Week 3 Mass Removal (pounds)		Rebound Test Mass Removal (pounds)		Total Mass Removal (pounds)	
		Min	Max	Min	Max	Min	Max	Min	Max
Trichloroethene	*4.6*	3.0	*5.4*	6.0	*8.9*	0.8	*1.4*	14.4	20.5
cis-1,2-Dichloroethene	*0.6*	0.2	*0.6*	0.4	*0.8*	0.1	*0.2*	1.4	2.2
trans-1,2-Dichloroethene	*0.1*	0.02	*0.04*	0.03	*0.04*	0.01	*0.02*	0.2	0.2
Vinyl chloride	*0.2*	*0.1*	0.1	*0.1*	0.2	*0.02*	0.02	0.4	0.5
1,1,2-Trichloro-1,2,2-trifluoroethane	*1.2*	2.1	*2.8*	*3.4*	3.6	0.4	*0.5*	7.0	8.1
Dichlorodifluoromethane	*0.7*	*0.4*	0.7	*0.5*	1.2	*0.1*	0.2	1.8	2.8
Total	**7.5**	**5.8**	**9.7**	**10.4**	**14.8**	**1.4**	**2.4**	**25.1**	**34.3**
Weekly Run Time (minutes)	**4,380**	**4,487**		**5,982**		**1,255**		**16,104**	
Weekly extraction rate (lb/day)[a]	**2.5**	**3.1**		**3.1**		**2.2**		**2.7**	

Notes:
The mass-removed calculations are described in Section 3.2 of the document, and the operational data used in these calculations are provided in Appendix G of this report, which presents the field measurements of flow and concentration. An average weekly flow was used for the flow measurements.
[a] Weekly extraction rate are the average of the minimum and maximum estimates of weekly mass removal.
Results in italic text were analyzed using method TO-15.
Results in regular font were analyzed using method 8260B.
lb/day = pound(s) per day

Table 3-3. Plateau Vacuum Responses and Vacuum Response Time

Bravo Bedrock Vapor Extraction Treatability Study Summary

Location ID	Week 1 Plateau (in. H_2O [% wellhead])	Week 2 Plateau (in. H_2O [% wellhead])	Week 3 Plateau (in. H_2O [% wellhead])	Week 1 T_{50} (hr)	Week 2 T_{50} (hr)	Week 3 T_{50} (hr)	Week 1 T_{90} (hr)	Week 2 T_{90} (hr)	Week 3 T_{90} (hr)
HAR-20	0.1 (0.2%)	0.2 (0.2%)	0.2 (0.2%)	3	1	5	3	9	5
PZ-061	0 (0%)	0 (0%)	0 (0%)	NR	NR	NR	NR	NR	NR
PZ-070	0 (0%)	0 (0%)	0 (0%)	NR	NR	NR	NR	NR	NR
PZ-156	1.9 (2.3%)	2.4 (2.8%)	2.6 (3.2%)	NA	5	5	NA	14	13
RD-104	0 (0%)	0 (0%)	0 (0%)	NR	NR	NR	NR	NR	NR
PZ-201a	1.2 (1.5%)	1.3 (1.5%)	1.4 (1.6%)	3	3	3	10	12	12
PZ-201b	1.3 (1.6%)	1.7 (2.0%)	1.5 (1.9%)	2	2	1	5	15	7
PZ-201c	1.5 (1.8%)	1.7 (2.1%)	1.8 (2.2%)	3	1	2	9	9	9
PZ-201d	1.5 (1.8%)	4.2 (4.9%)	4.5 (5.4%)	2	NA	0	7	6	5
PZ-202a	0.7 (0.9%)	1.1 (1.3%)	1.1 (1.4%)	8	6	5	14	16	13
PZ-202b	1.8 (2.2%)	1.9 (2.3%)	2.0 (2.4%)	2	1	1	8	9	7
PZ-202c	4.4 (5.3%)	7.4 (8.8%)	4.7 (5.7%)	4	NA	NA	7	NA	NA
PZ-202d	25.5 (31.1%)	25.7 (30.2%)	26.6 (32.5%)	1	0	0	2	1	1
PZ-203a	1.8 (2.2%)	1.8 (2.1%)	1.7 (2.0%)	2	2	2	9	9	10
PZ-203b	1.5 (1.9%)	2.4 (2.9%)	2.5 (3.0%)	2	1	1	NA	11	5
PZ-203c	40.3 (49.2%)	40.5 (47.7%)	41.2 (50.3%)	2	0	0	3	3	0
PZ-203d	40.3 (49.2%)	40.6 (47.8%)	41.3 (50.4%)	2	0	0	2	4	0
PZ-203Av	1.9 (2.3%)	2 (2.3%)	1.9 (2.4%)	2	2	2	9	9	8
PZ-204a	1.5 (1.8%)	1.5 (1.8%)	1.6 (1.9%)	3	2	3	9	11	11
PZ-204b	2.3 (2.8%)	2.4 (2.8%)	2.4 (2.9%)	2	2	2	8	9	8
PZ-204c	1.9 (2.4%)	2.1 (2.5%)	2.1 (2.6%)	2	1	1	7	10	8
PZ-204d	2.0 (2.4%)	2.2 (2.5%)	2.1 (2.6%)	2	2	1	8	9	6

Notes:
Plateau response is in percent (%) of applied vacuum at HAR-19
% wellhead = percent of applied wellhead vacuum
hr = hour(s)
ID = identification number
in. H_2O = inch(es) of water
T_{50} = Time to reach 50% of plateau vacuum
T_{90} = Time to reach 90% of plateau vacuum
NA= not applicable
NR = no response

Table 3-4. PID Measurements at 22 Piezometers

Bravo Bedrock Vapor Extraction Treatability Study Summary

Location ID	PID Week 1a	PID Week 1b	PID Week 2a	PID Week 2b	PID Week 3a	PID Week 3b	PID Rebound Week 9
HAR-20	**0.3**	0.0	0.2	0.1	0.0	0.2	0.1
PZ-061	**314.0**	87.8	208.8	50.9	51.0	41.6	3.1
PZ-070	**64.6**	5.3	20.1	1.8	2.6	1.3	0.5
PZ-156	63.3	120.2	**215.9**	41.7	162.5	92.4	66.0
PZ-201a	0.0	1.5	**3.9**	0.8	1.0	0.7	1.1
PZ-201b	0.1	3.0	**12.9**	7.6	3.3	4.0	2.9
PZ-201c	0.0	3.0	**15.0**	2.6	3.0	3.7	2.9
PZ-201d	0.0	2.9	**10.6**	4.1	5.2	5.0	3.8
PZ-202a	1.1	**5.3**	3.8	3.0	2.2	1.7	0.7
PZ-202b	0.0	**4.0**	1.9	2.0	1.7	1.1	1.1
PZ-202c	1.4	3.4	**9.6**	2.9	2.9	0.7	1.5
PZ-202d	0.0	2.1	**7.3**	3.5	3.1	2.3	2.3
PZ-203a	1.4	1.3	1.9	**5.0**	1.0	0.0	1.0
PZ-203b	0.6	3.4	1.0	**10.3**	2.2	1.1	1.3
PZ-203c	5.1	5.9	8.9	**11.8**	4.6	4.9	4.3
PZ-203d	19.7	39.1	41.2	**43.0**	16.0	21.7	11.1
PZ-203Av	7.0	0.7	**13.0**	4.2	4.4	2.4	2.0
PZ-204a	0.8	2.2	**4.4**	1.2	1.5	0.7	1.1
PZ-204b	0.7	1.6	2.1	2.2	**2.5**	1.6	2.3
PZ-204c	2.8	2.2	4.2	4.0	**4.7**	3.6	4.0
PZ-204d	0.0	3.3	**31.6**	5.5	6.3	7.1	4.9
RD-104	28.2	73.2	**247.0**	114.9	76.2	13.1	10.3

Notes:
Initial measurements (Weeks 1a, 2a, 3a, and 9) were collected before the startup of extraction.
PID units are parts per million by volume (ppmv).
Values of 0 represent readings below the resolution (0.1 ppmv) of the MiniRae.
Values in **bold** represent the maximum measured PID concentration of the well or probe over the duration of the TS.
ID = identification number
PID = photoionization detector

Table 3-5. Changes in PID Concentrations During the Rebound TS Phase

Bravo Bedrock Vapor Extraction Treatability Study Summary

Piezometer	Initial PID (ppm)	Change in PID During First Extraction Cycle (percent)	Change in PID First Rebound Cycle (percent)	Change in PID During Second Extraction Cycle (percent)	Change in PID Second Rebound Cycle (percent)	Change in PID During Third Extraction Cycle (percent)	Change in PID Third Rebound Cycle (percent)
PZ-061	341.0	-72	138	-76	0	-18	-93
PZ-070	64.6	-92	279	-91	44	-50	-62

Notes:

This table compares the pattern of PZ-060 and PZ-071 as representative of the two principal characteristic behaviors during rebound discussed in Section 3.5 and presented on Figures 3-17 through 3-24. Table 3-4 presents the PID readings for all piezometers in the study.

Extraction cycle represents the active vapor extraction period between beginning of the week startup and end of the week shutdown.

Negative PID changes represent a decrease in concentration while positive PID changes represent an increase in concentration over a given cycle.

Rebound cycle represents the time between the extraction shutdown of one week and the extraction startup the following week (such as. the weekend).

The third rebound cycle represents the change in PID concentration between the end of the third extraction cycle and before startup of the 6-week rebound phase of the TS.

PID = photoionization detector

ppm = part(s) per million

Table 3-6. Comparison of HAR-19 Groundwater Samples

Bravo Bedrock Vapor Extraction Treatability Study Summary

Compound	Concentration (µg/L)				Comparison
	7/14/2014		10/23/2014		
1,1-Dichloroethene	2.5	J	1.4	=	Decrease
Benzene	0.23	J	0.32	J	Increase
cis-1,2-Dichloroethene	730	=	370	=	Decrease
trans-1,2-Dichloroethene	220	=	94	=	Decrease
Trichloroethene	480	=	1100	=	Increase
Vinyl chloride	77	=	6.9	=	Decrease

Notes:
Reporting limits are included in Appendix N.
J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (estimated).
µg/L = microgram(s) per liter

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Figures

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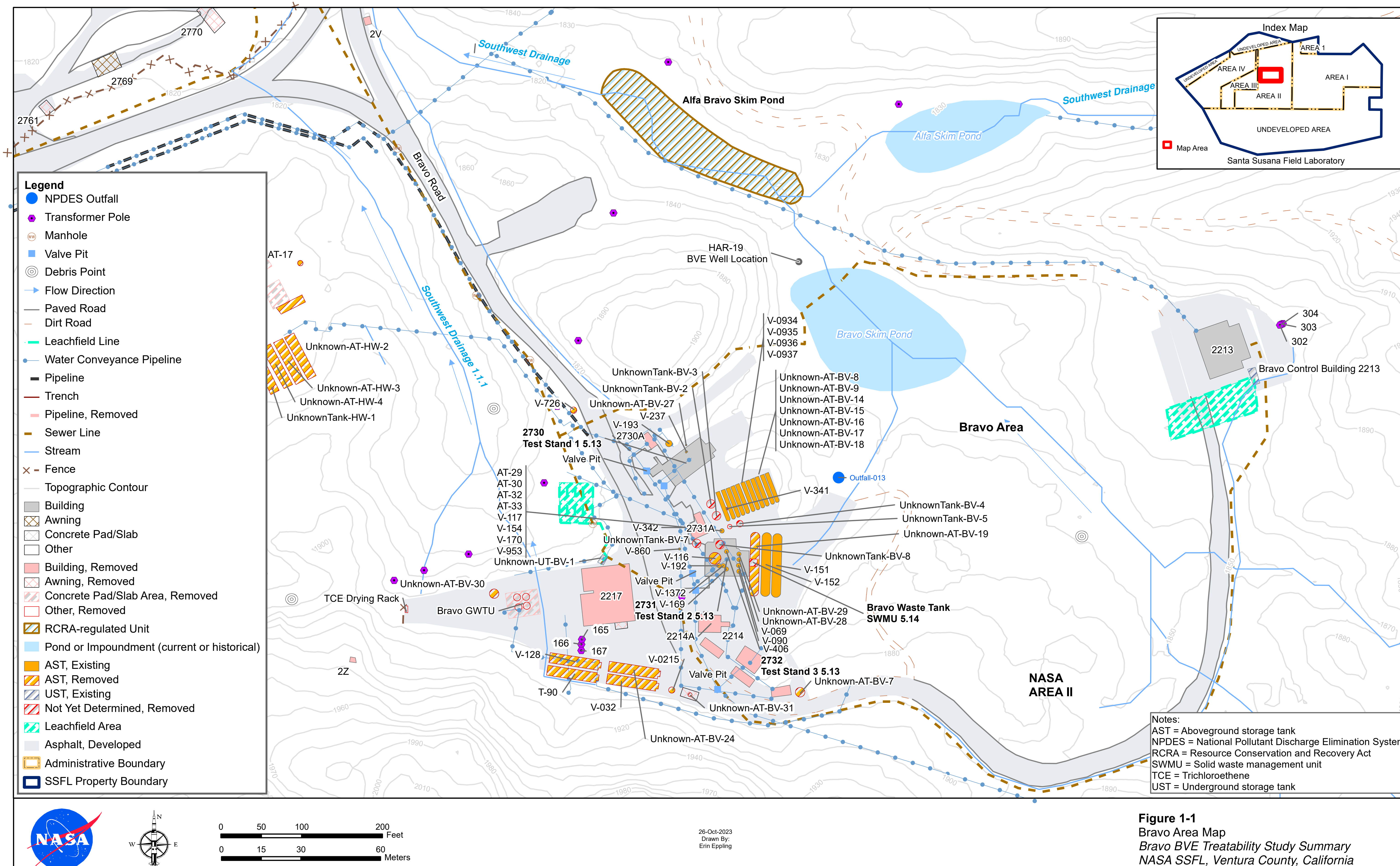

26-Oct-2023
Drawn By:
Erin Eppling

Figure 1-1
Bravo Area Map
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California

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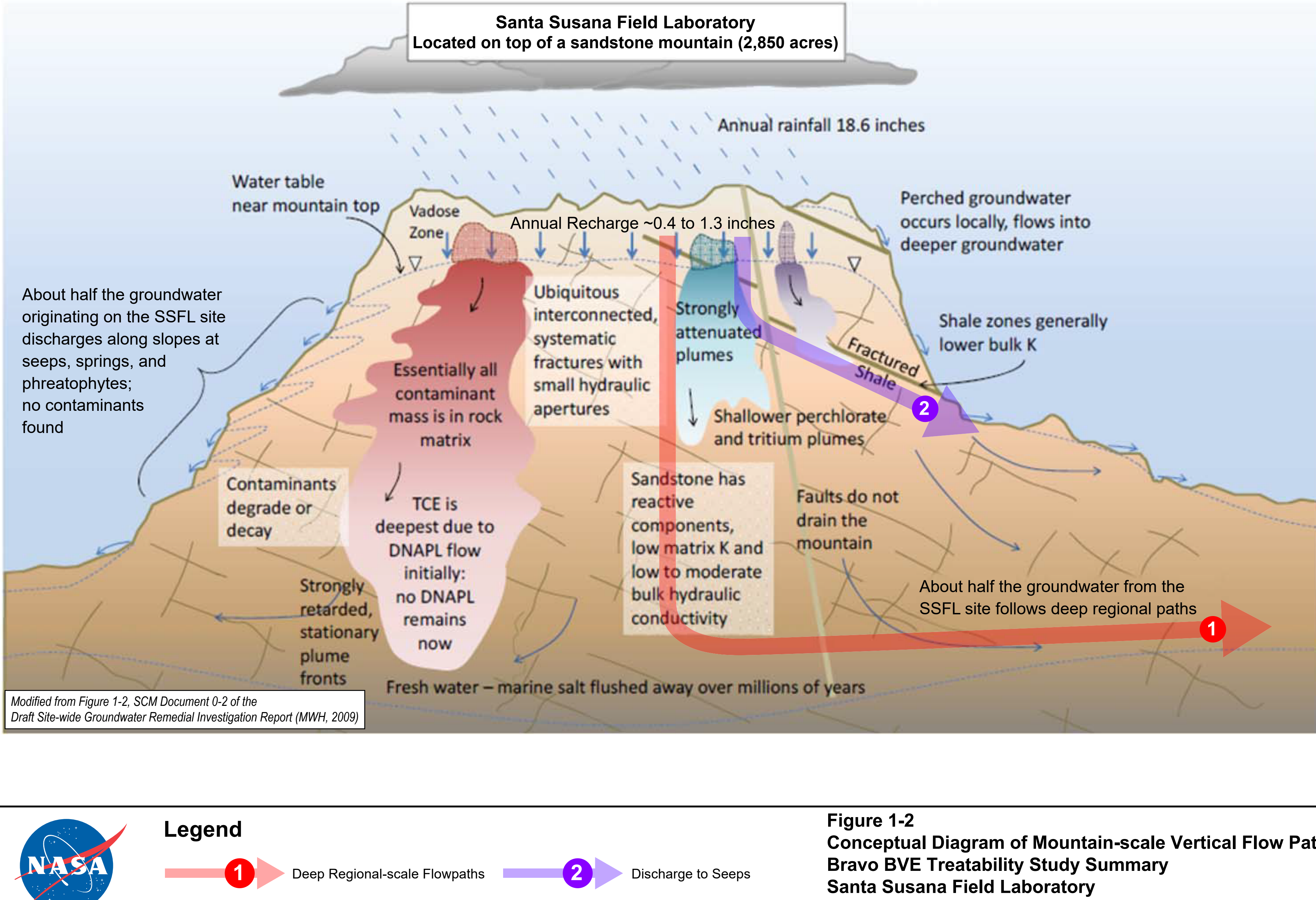

Figure 1-2
Conceptual Diagram of Mountain-scale Vertical Flow Paths
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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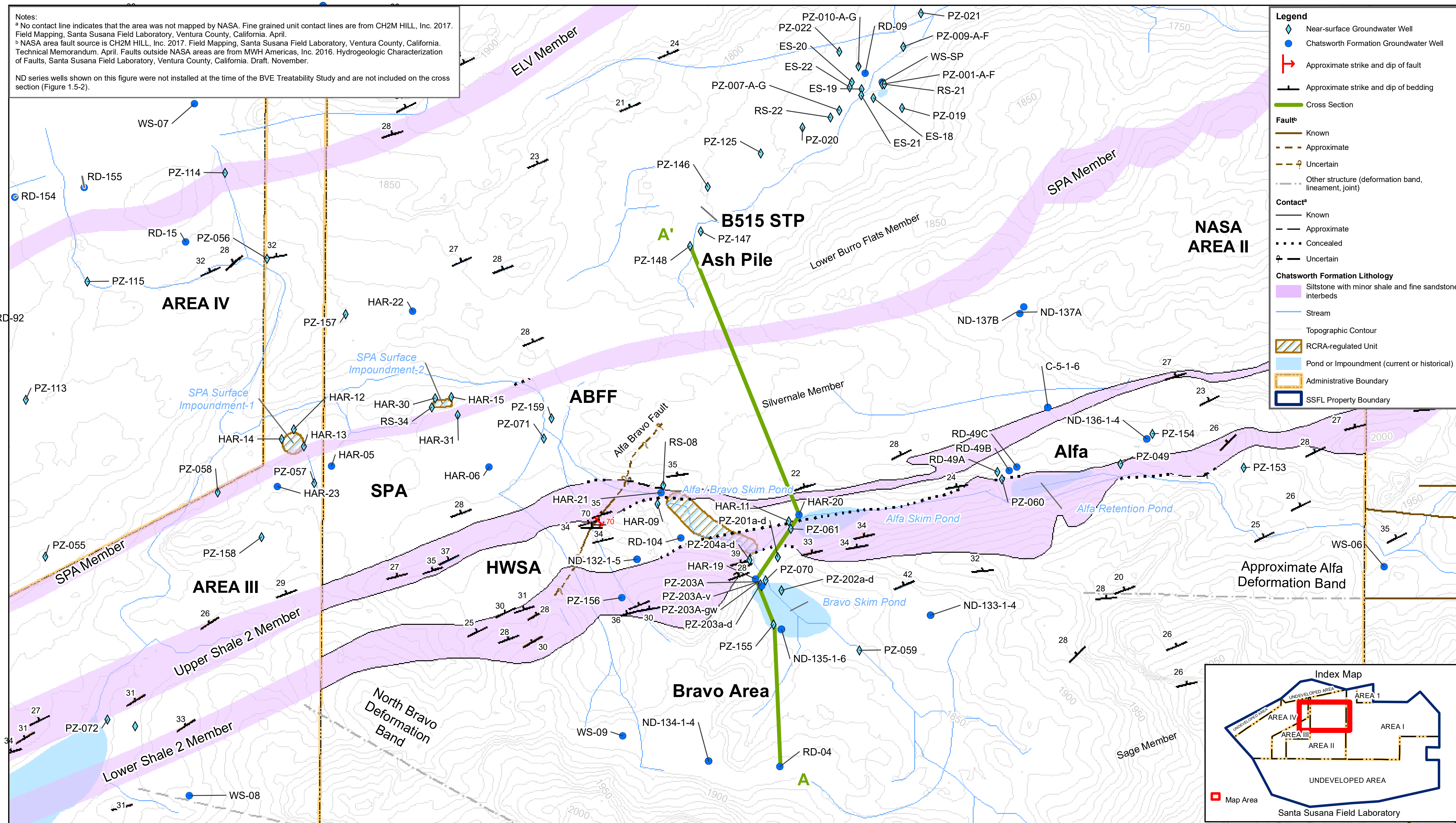

0 125 250 500 Feet
0 37.5 75 150 Meters

08-Apr-2020
Drawn By:
A. Cooley

Figure 1-3
Site Geology
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California

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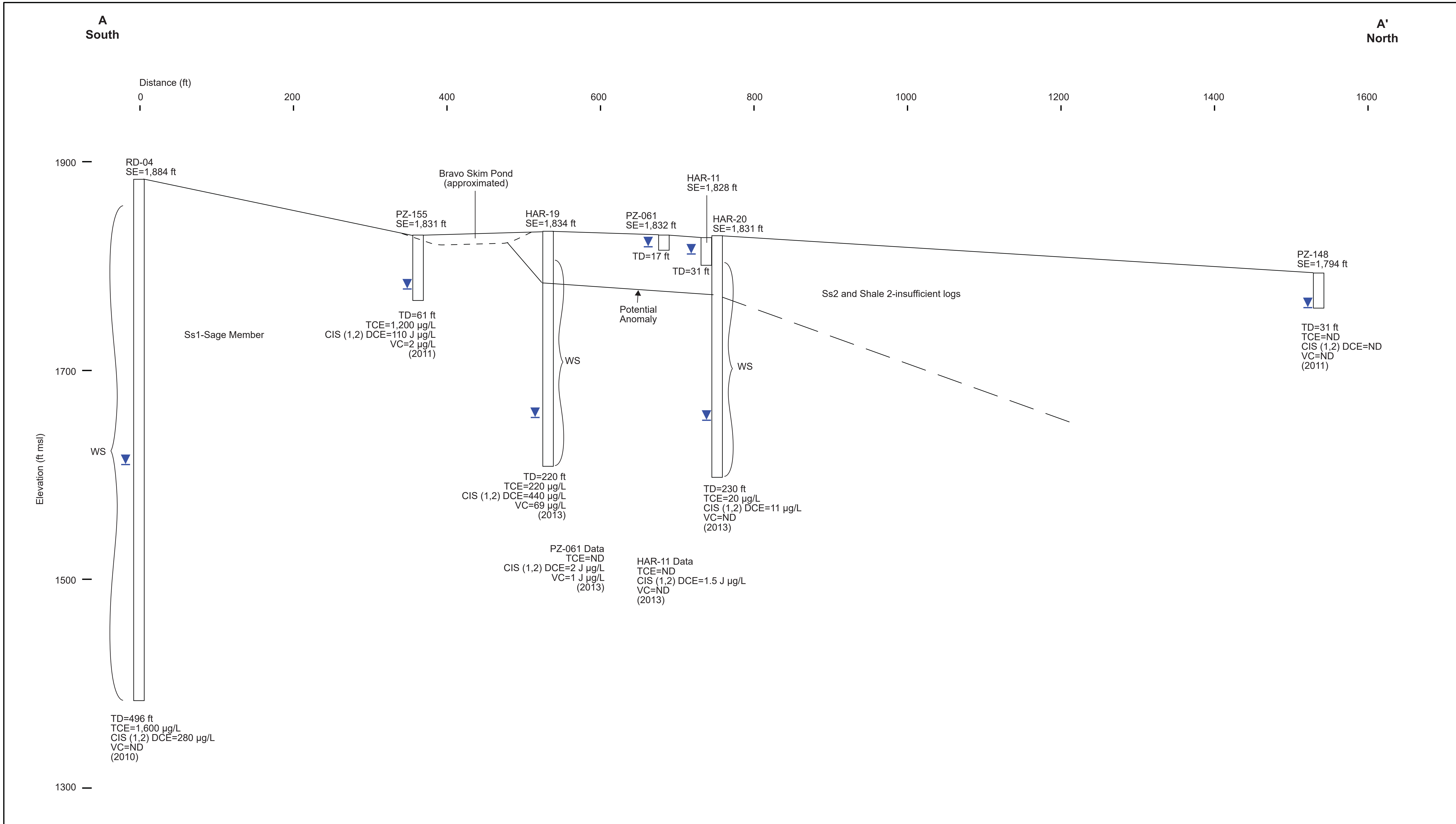

4Q11 Groundwater Elevation
CIS (1,2) DCE = cis-1,2-Dicholoroethene
ft = feet
J = estimated concentration

msl = mean sea level
ND = Nondetect
SE = Surface Elevation
Ss = Sandstone
TCE = Trichloroethene

TD = Total Depth
µg/L = micrograms per liter
VC = Vinyl Chloride
WS = Well Screen

Figure 1-4
Cross Section A-A'
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_AA_cross_section_rev1.ai 1/15

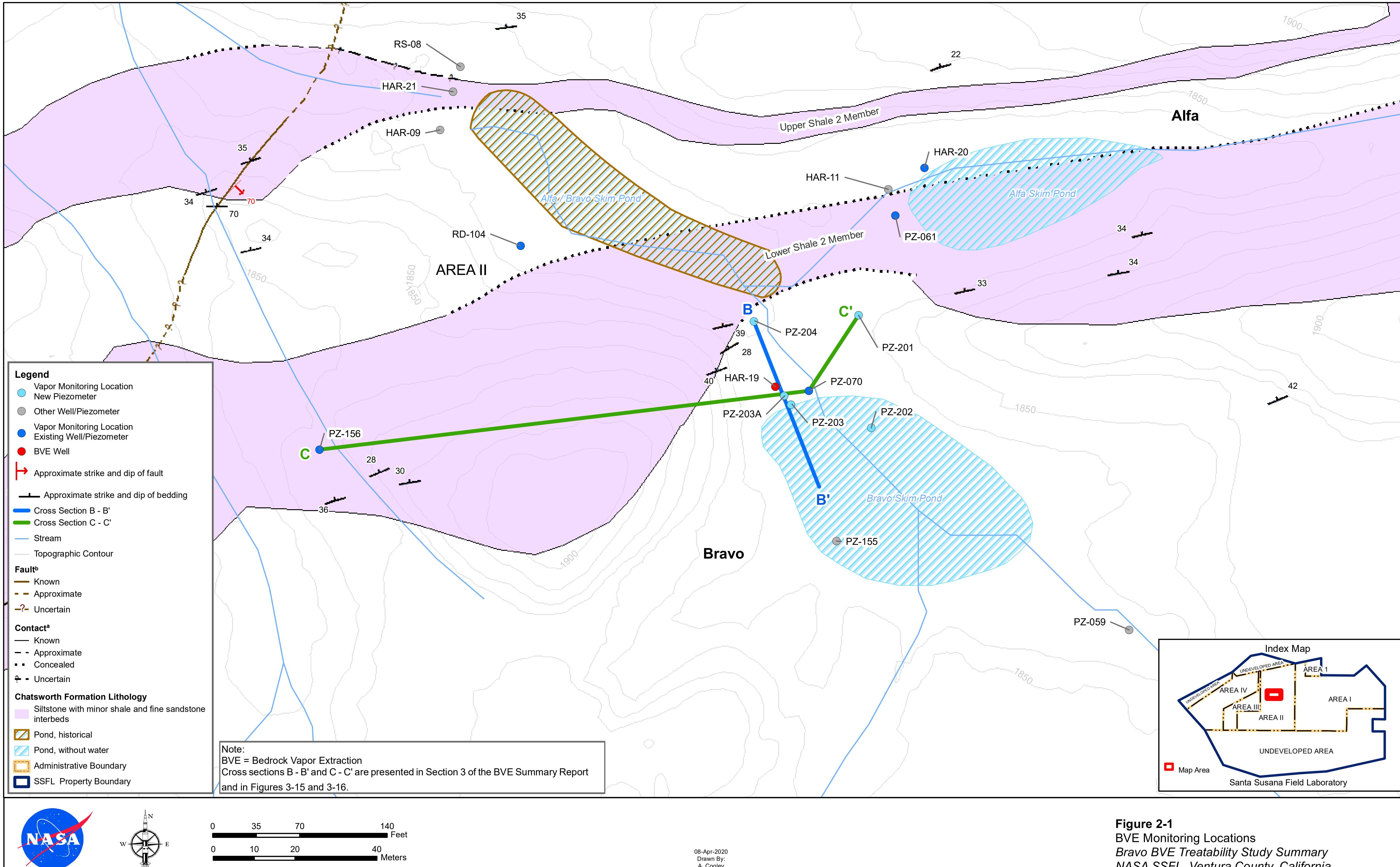

Figure 2-1
BVE Monitoring Locations
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California

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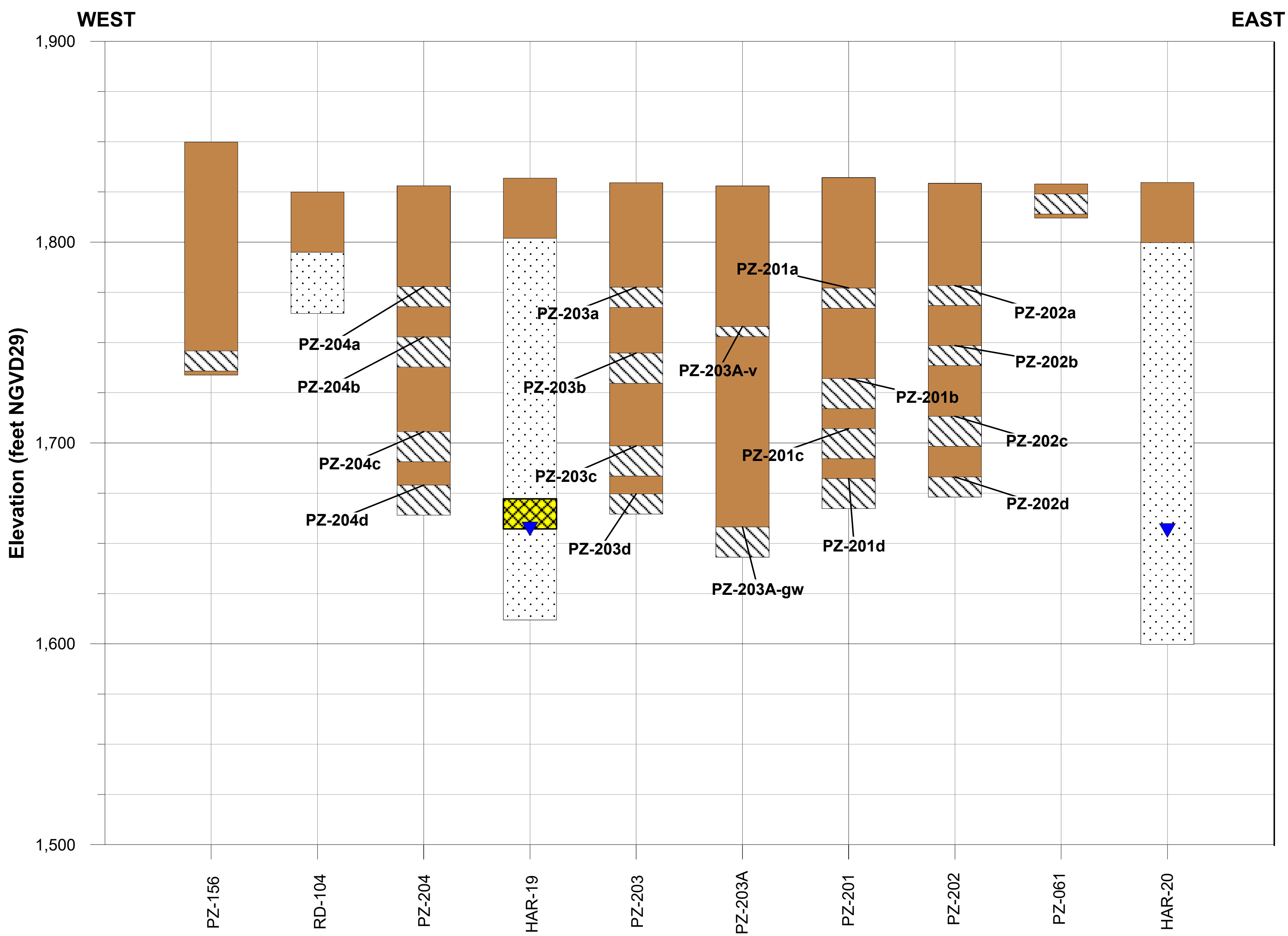
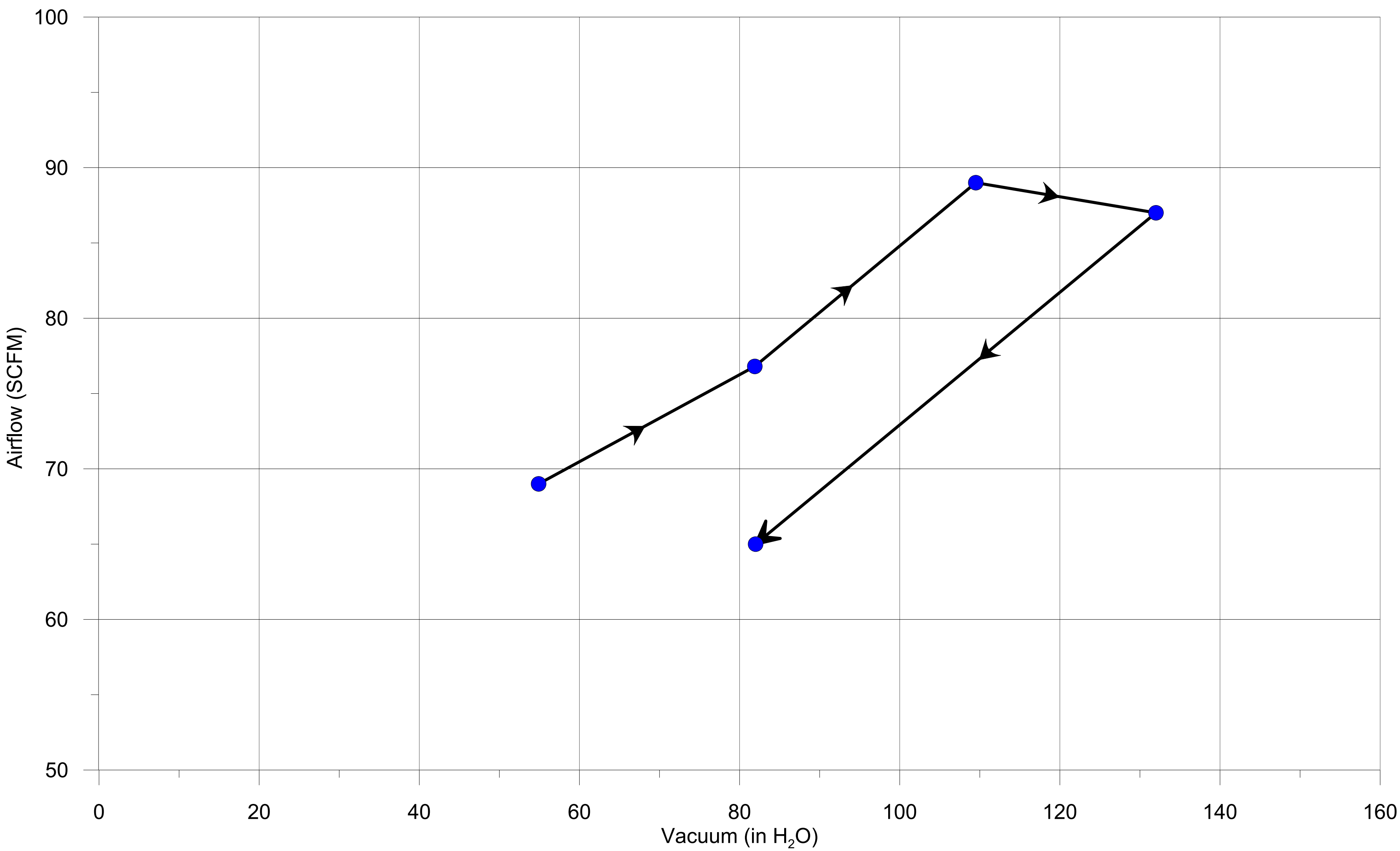


Sealed Borehole Interval
Open Borehole Interval
Screen Interval
4Q14 Groundwater Elevation
Interval Contributing to 85% of Flow in BVE Well

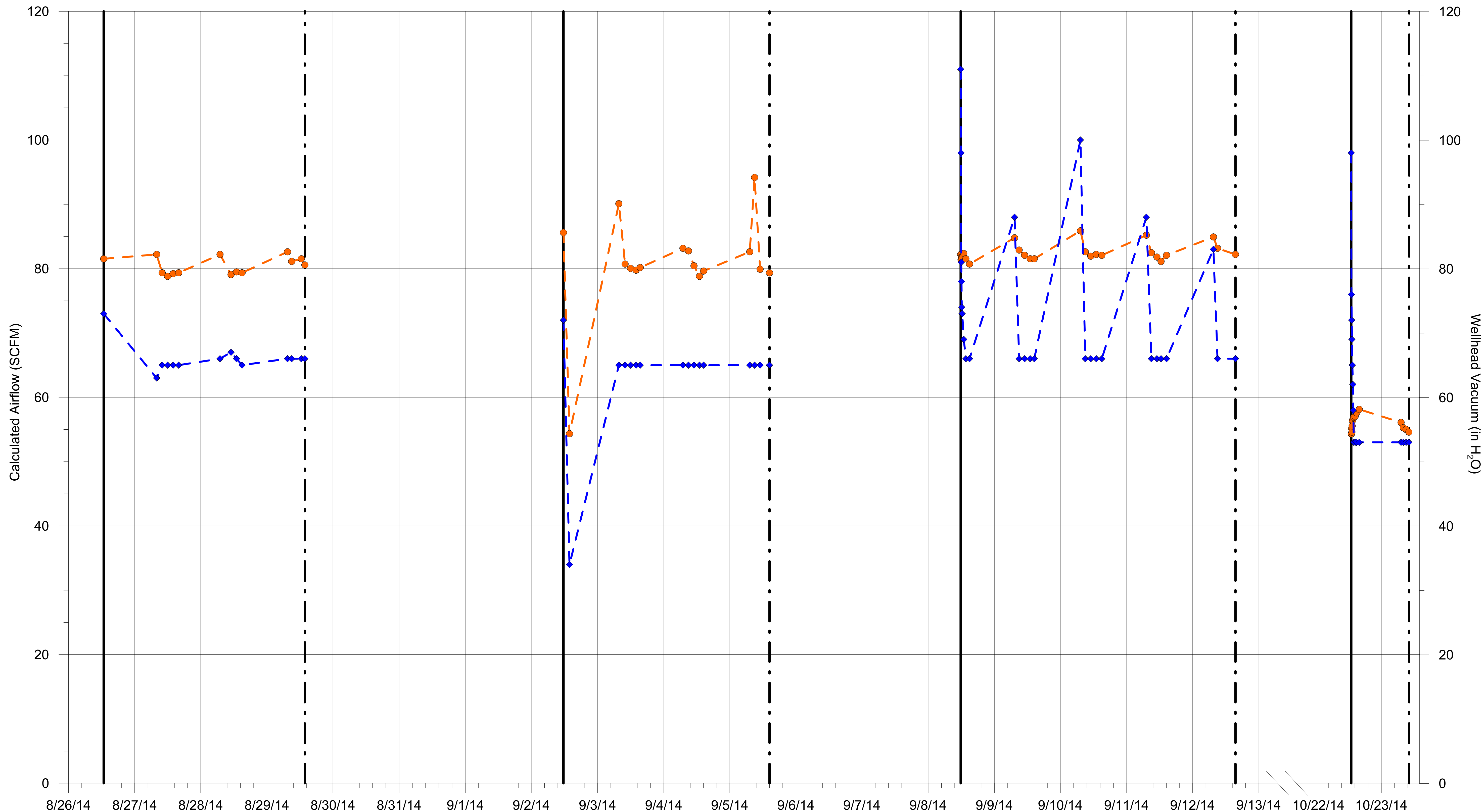
Notes:
4Q14 = Fourth Quarter 2014
BVE = bedrock vapor extraction
NGVD29 = National Geodetic Vertical Datum of 1929

Figure 2-2
Alfa/Bravo BVE Monitoring Well Profile
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California



Notes:
1. SCFM = standard cubic feet per minute.
2. in H_2O = inches of water.

Figure 3-1
Airflow as a Function of Applied Vacuum
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California



Notes:
1. SCFM = standard cubic feet per minute.
2. in H_2O = inches of water.

Figure 3-2
Wellhead Airflow and Vacuum at HAR-19
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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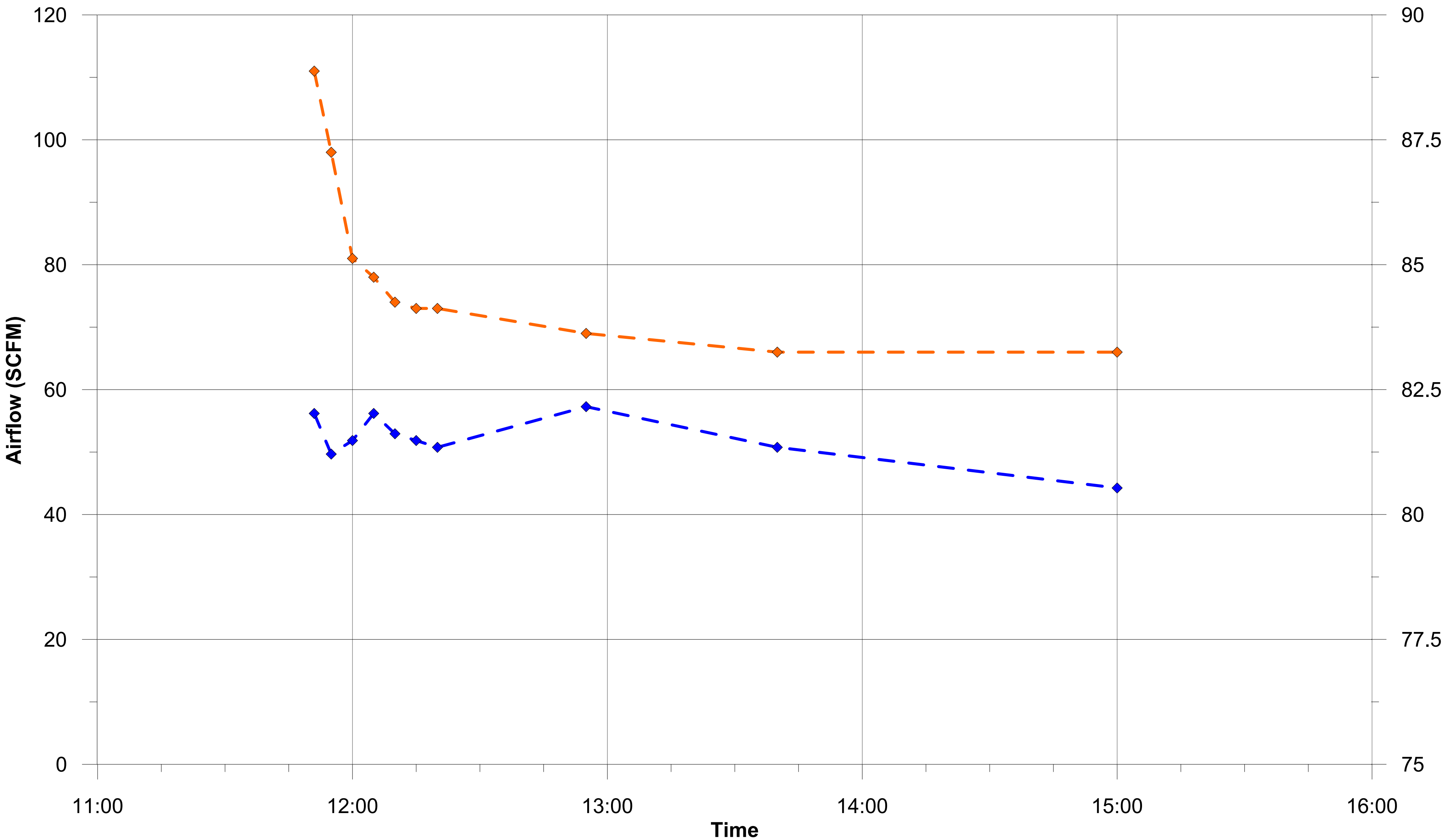

Notes:
1. SCFM = standard cubic feet per minute.
2. in H_2O = inches of water.
3. BVE = bedrock vapor extraction.
4. Measurements collected during BVE restart on 9/8/2014 at HAR-19.

Vacuum
Airflow

Figure 3-3
Airflow Response to Third Week BVE Startup
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_airflow_response_BVE.ai 10/14

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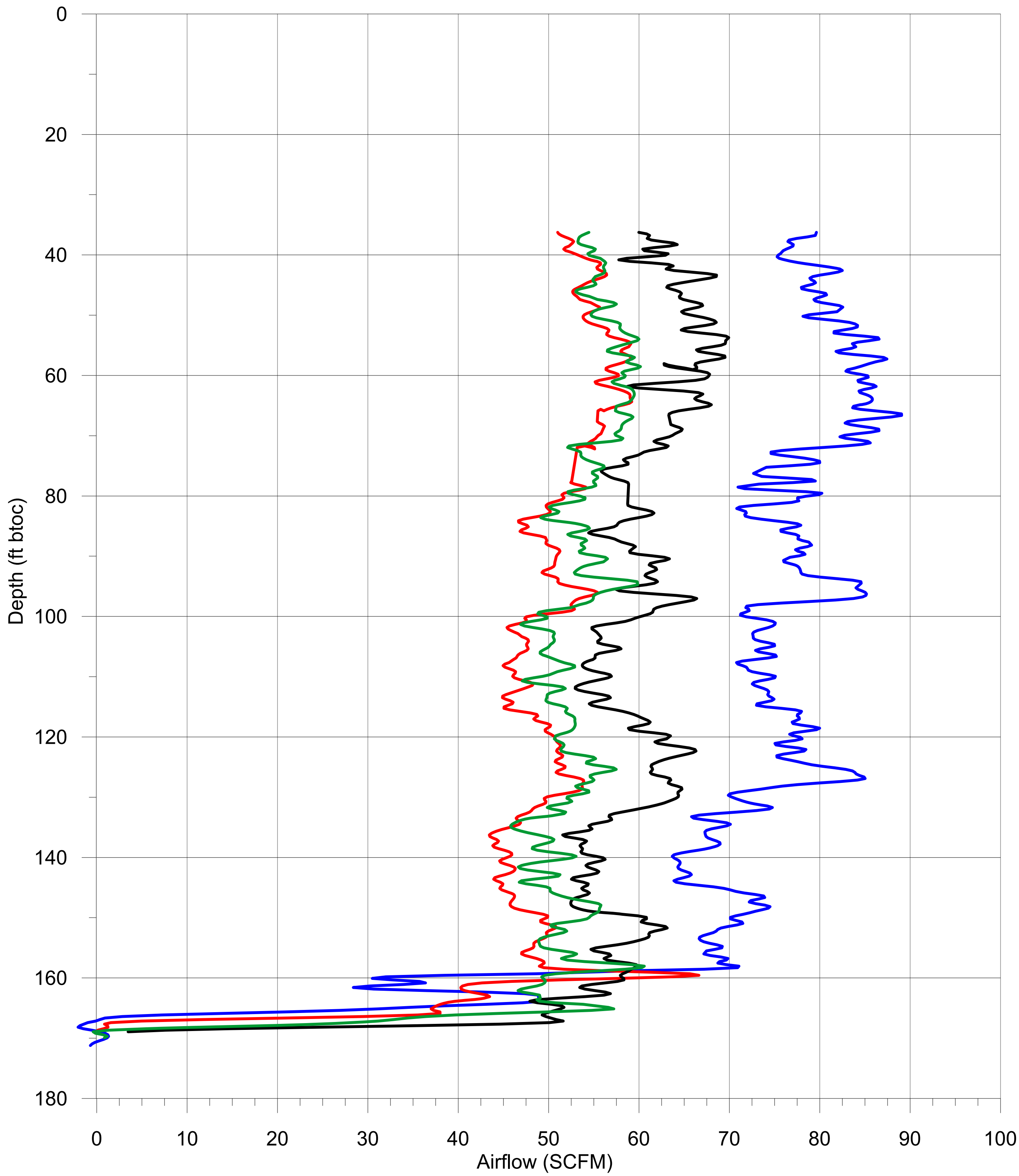

Notes:
1. SCFM = standard cubic feet per minute.
2. ft btoc = feet below top of casing.

8/26/2014
9/2/2014
9/12/2014
10/22/2014

Figure 3-4
Pneulog Airflow at HAR-19
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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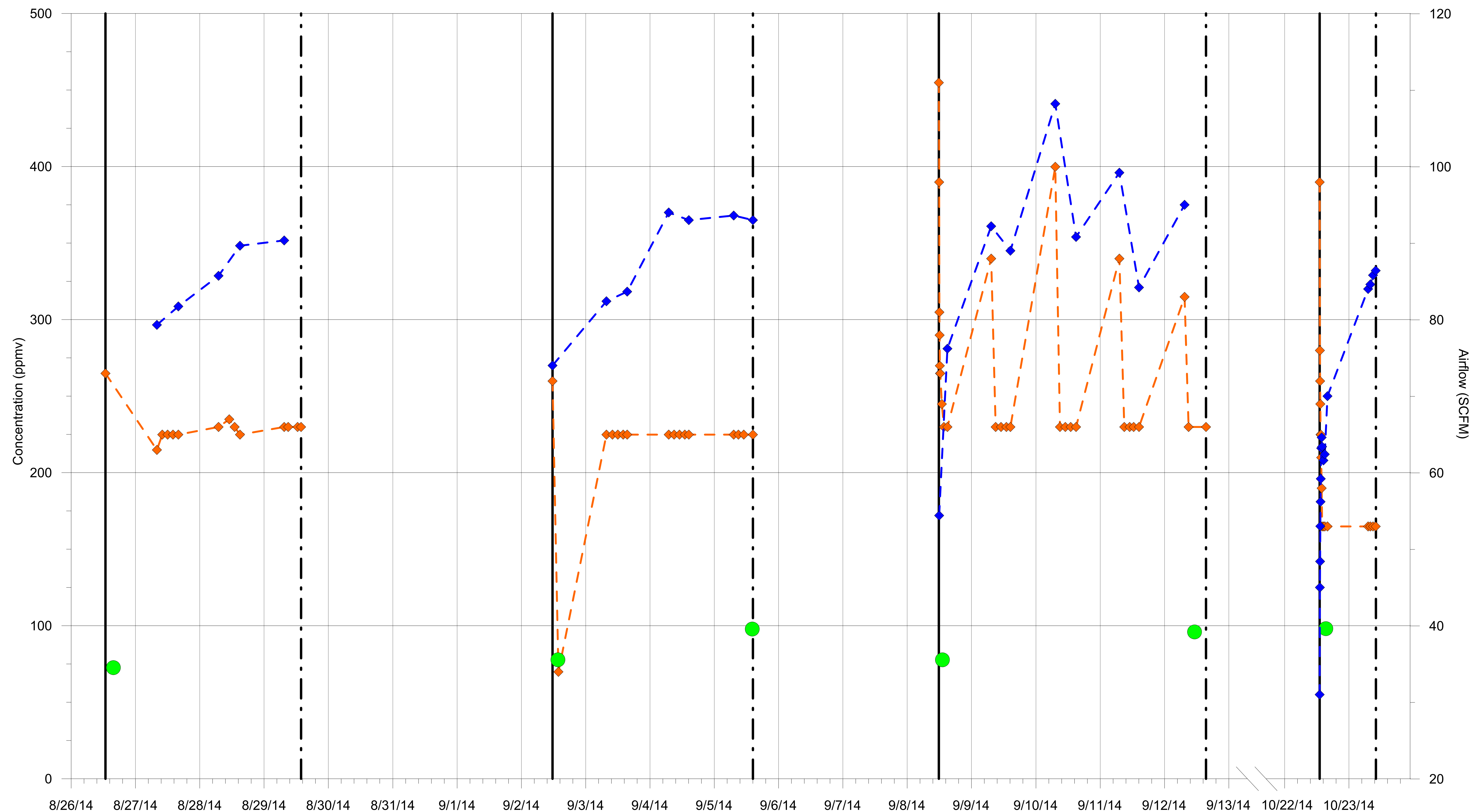

Notes:
1. ppmv = parts per million by volume.
2. SCFM = standard cubic feet per minute.
3. PID = photoionization detector.
4. Influent PID concentrations were collected between 8/27/14 and 10/23/14 as shown with the blue diamond symbol and blue-dotted line. However the 9/3/14 15:30 influent measurement was not directly collected; therefore, an estimated concentration was calculated from post-dilution PID readings
5.Total VOC concentrations (based on laboratory results in Appendix I, shown as the green filled circles) represents the sum of: 1,1,2-trichloro-1,2,2-trifluoroethane, dichlorodifluoromethane, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride.

Figure 3-5
Concentration and Airflow versus Time at HAR-19
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_concentration_airflow_time_har19_rev1.ai 1/15

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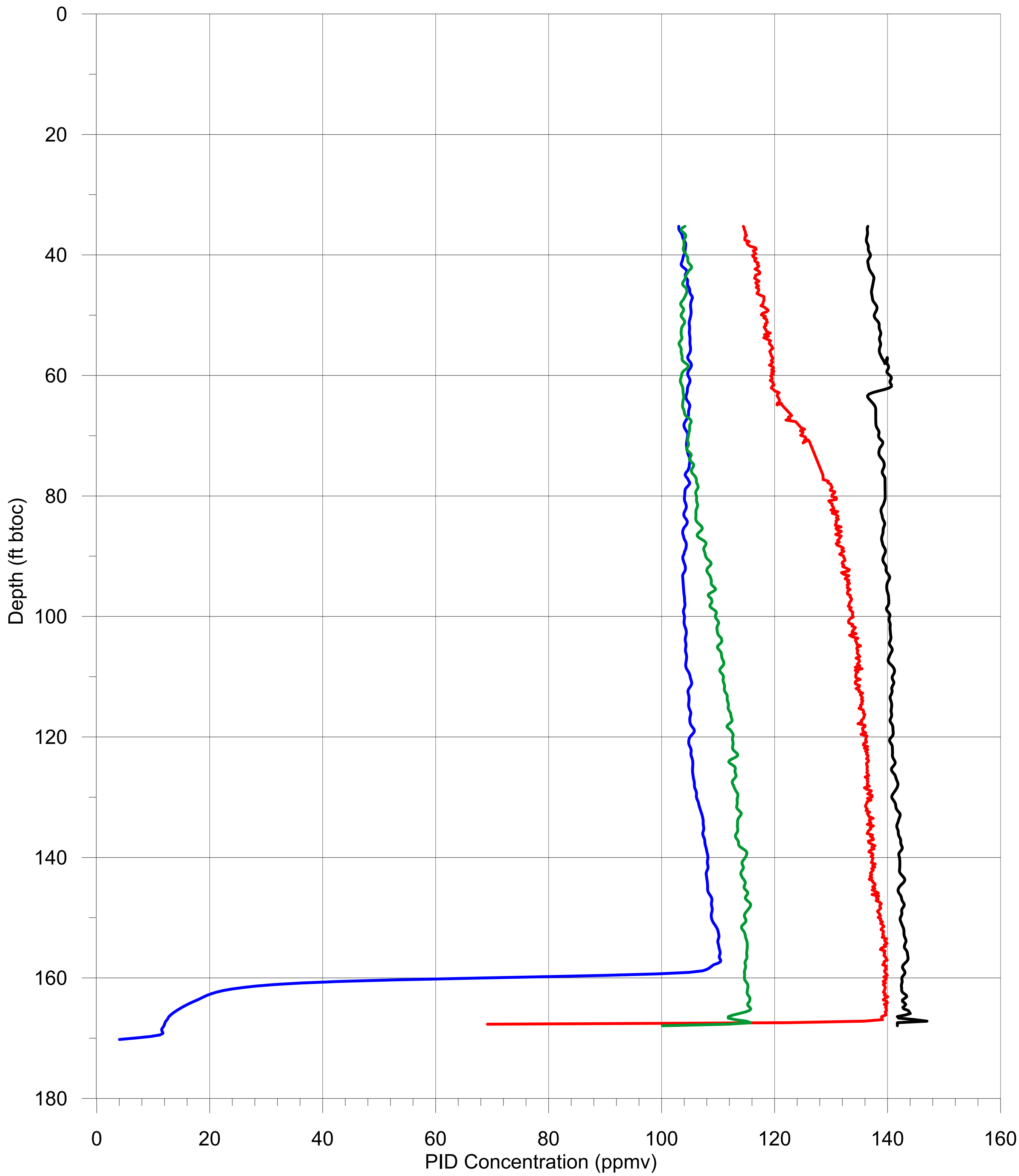

Notes:
1. PID = photoionization detector.
2. ppmv = parts per million by volume.
3. ft btoc = feet below top of casing.
4. PID measurements converted to equivalent TCE concentration.

Figure 3-6
Pneulog Concentration at HAR-19
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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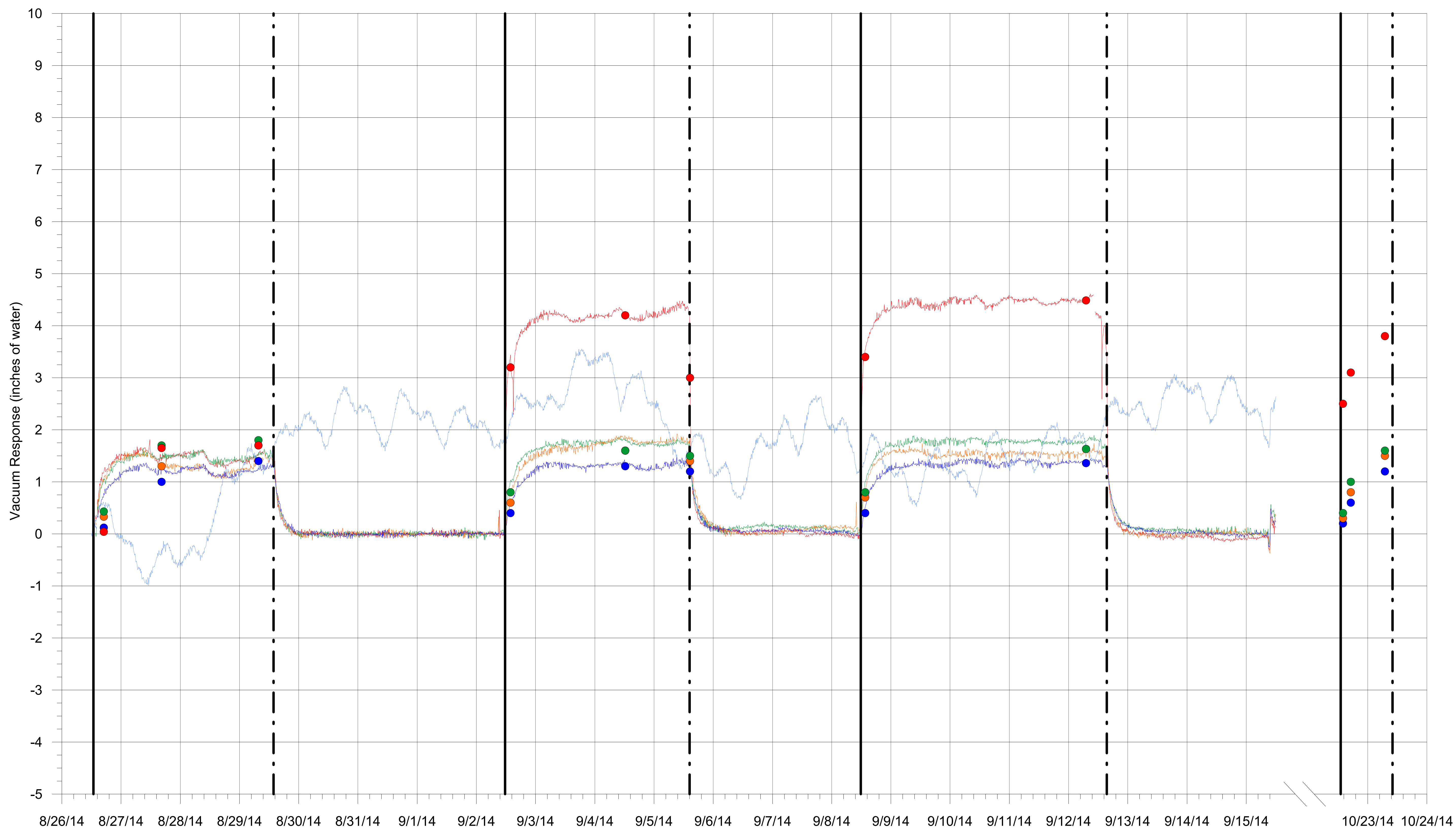
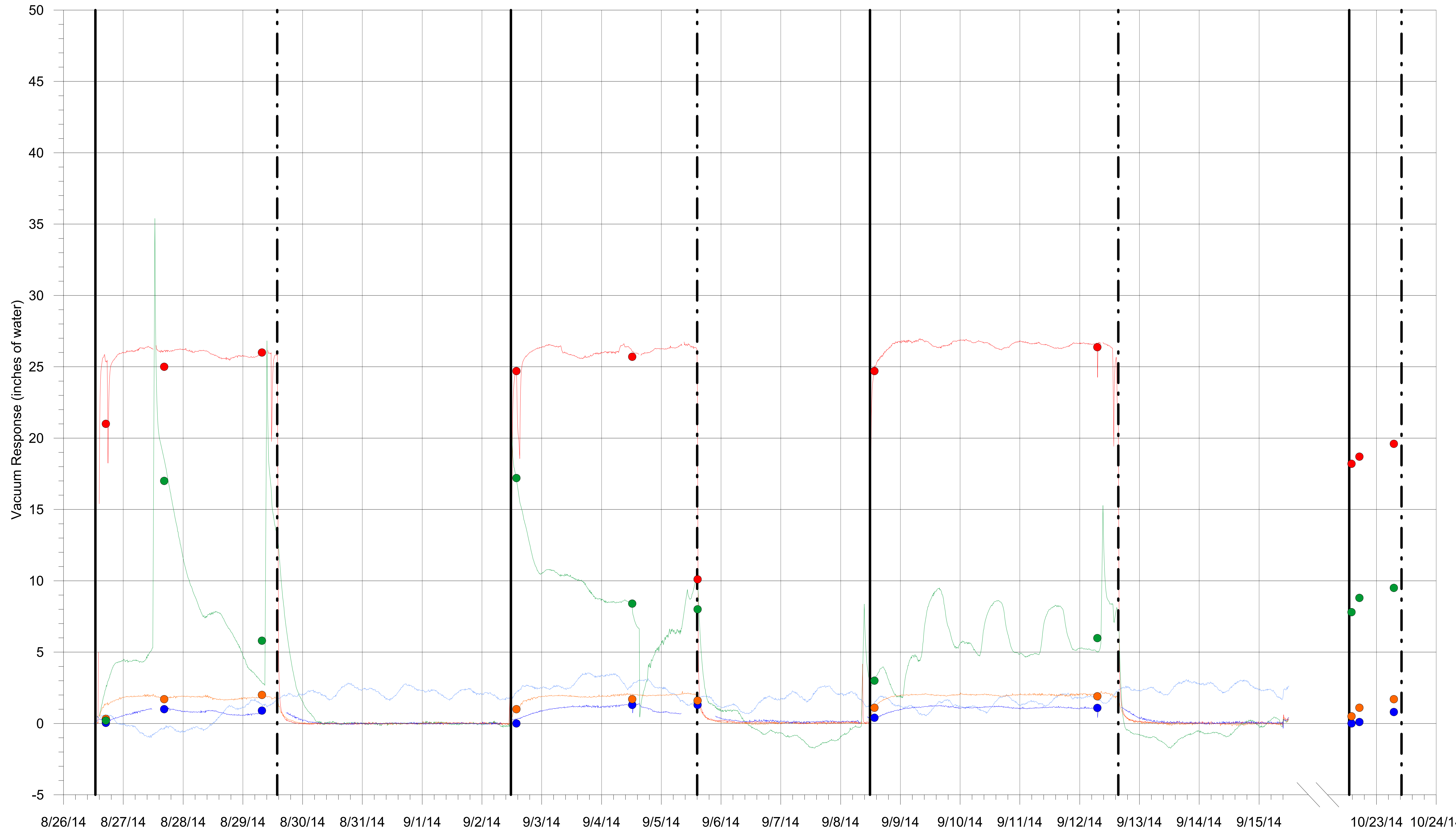


Notes:
1. ft bgs = feet below ground surface.
2. PZ-201 is located approximately 90 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
4. Circles represent manually measured vacuum data.

Figure 3-7
Vacuum Response at PZ-201
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz201_rev2.ai 6/15



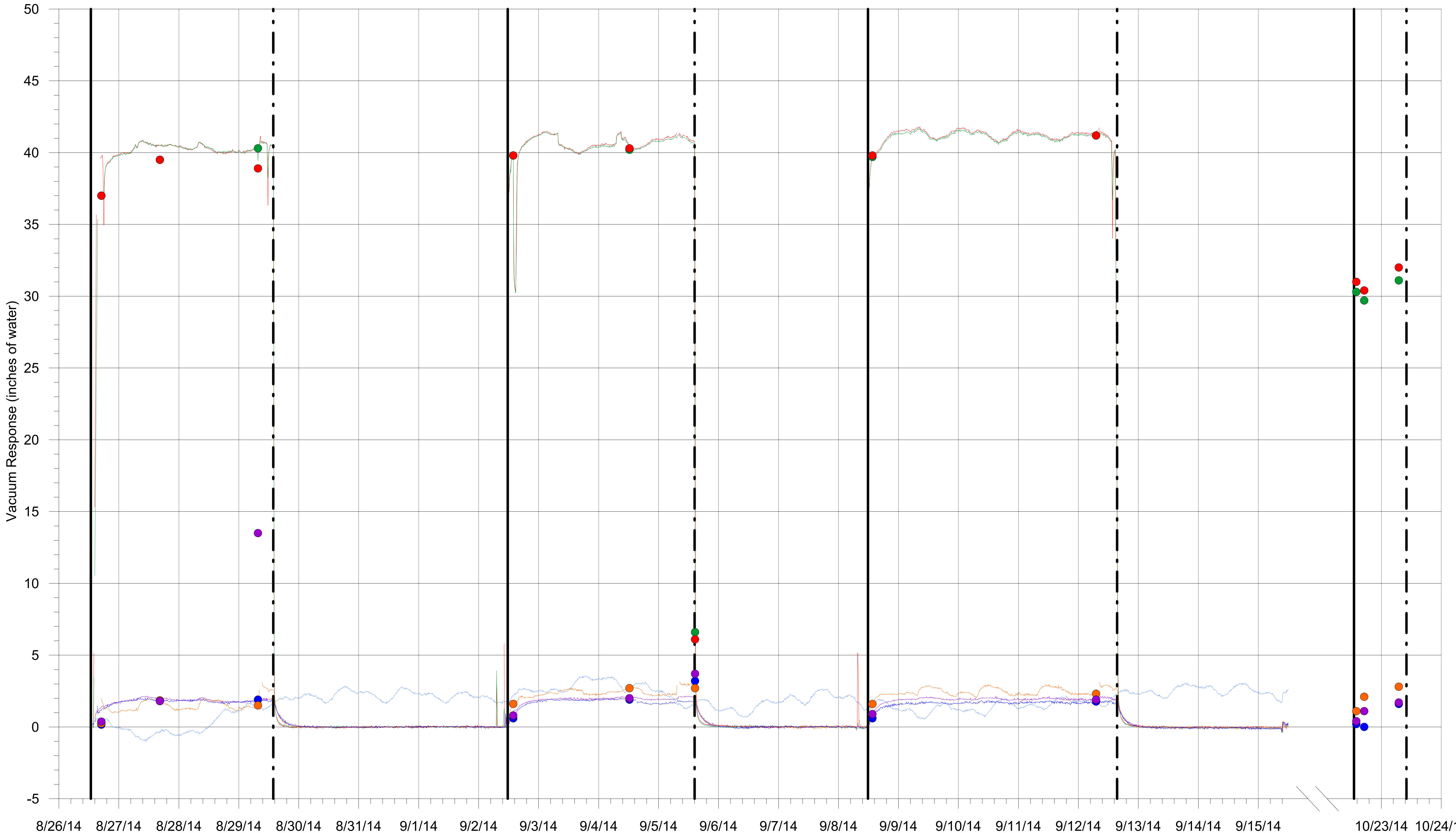
Notes:
1. ft bgs = feet below ground surface.
2. PZ-202 is located approximately 85 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
4. Circles represent manually measured vacuum data.

BaroLogger
System Start-up
System Shut-down

Well/Piezometer	Transducer Data	Manual Data
PZ-202a (50.9 to 60.9 ft bgs)		
PZ-202b (80.8 to 90.8 ft bgs)		
PZ-202c (116 to 131 ft bgs)		
PZ-202d (146.2 to 156.2 ft bgs)		

Figure 3-8
Vacuum Response at PZ-202
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz202_rev2.ai 6/15



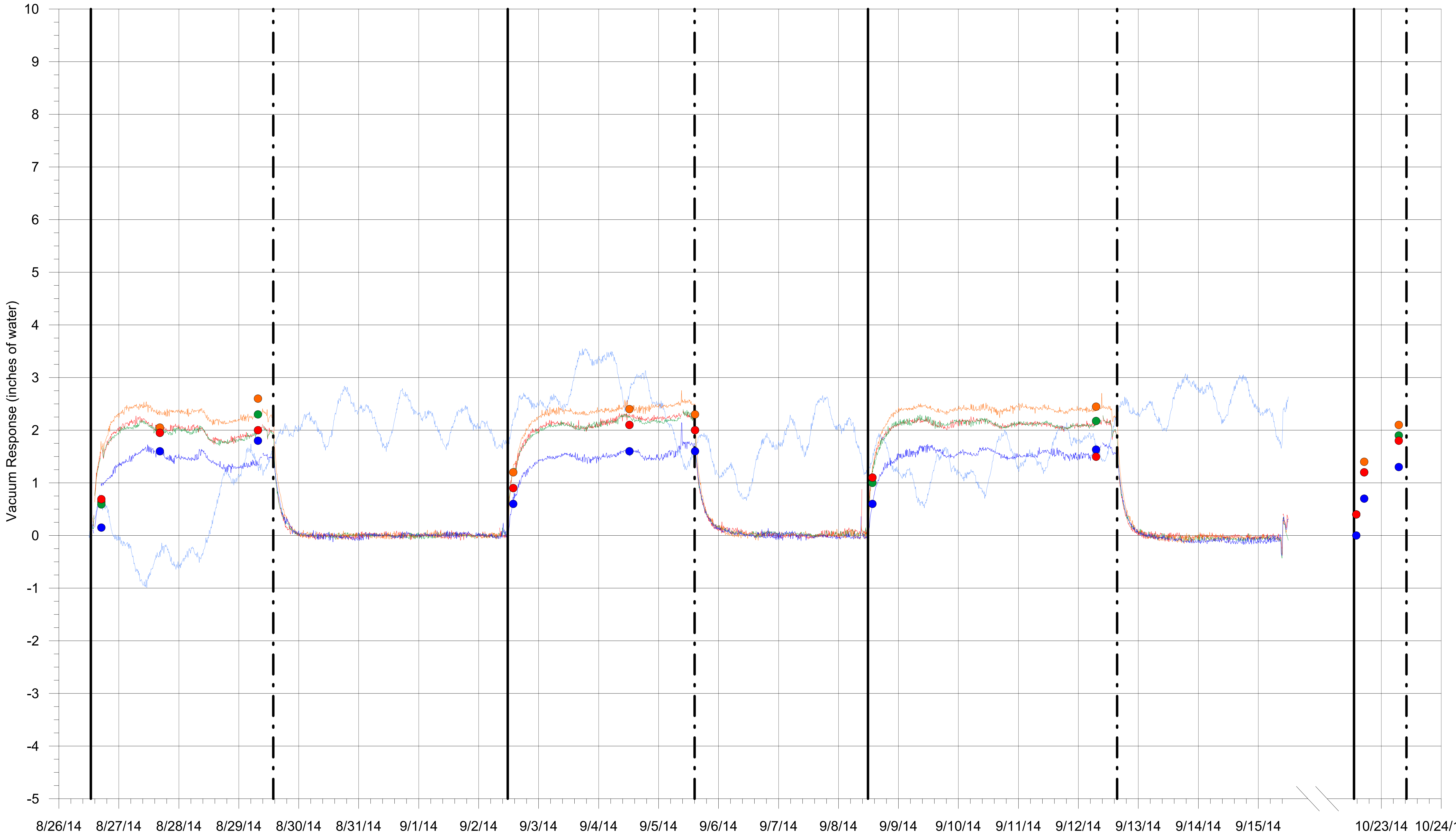
Notes:
1. ft bgs = feet below ground surface.
2. PZ-203 is located approximately 35 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
4. Circles represent manually measured vacuum data.

BaroLogger	
System Start-up	
System Shut-down	

Well/Piezometer	Transducer Data	Manual Data
PZ-203a (52 to 62 ft bgs)		
PZ-203b (84.8 to 99.8 ft bgs)		
PZ-203c (131 to 146 ft bgs)		
PZ-203d (154.9 to 164.9 ft bgs)		
PZ-203Av (70 to 75 ft bgs)		

Figure 3-9
Vacuum Response at PZ-203
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz203_rev3.ai 6/15



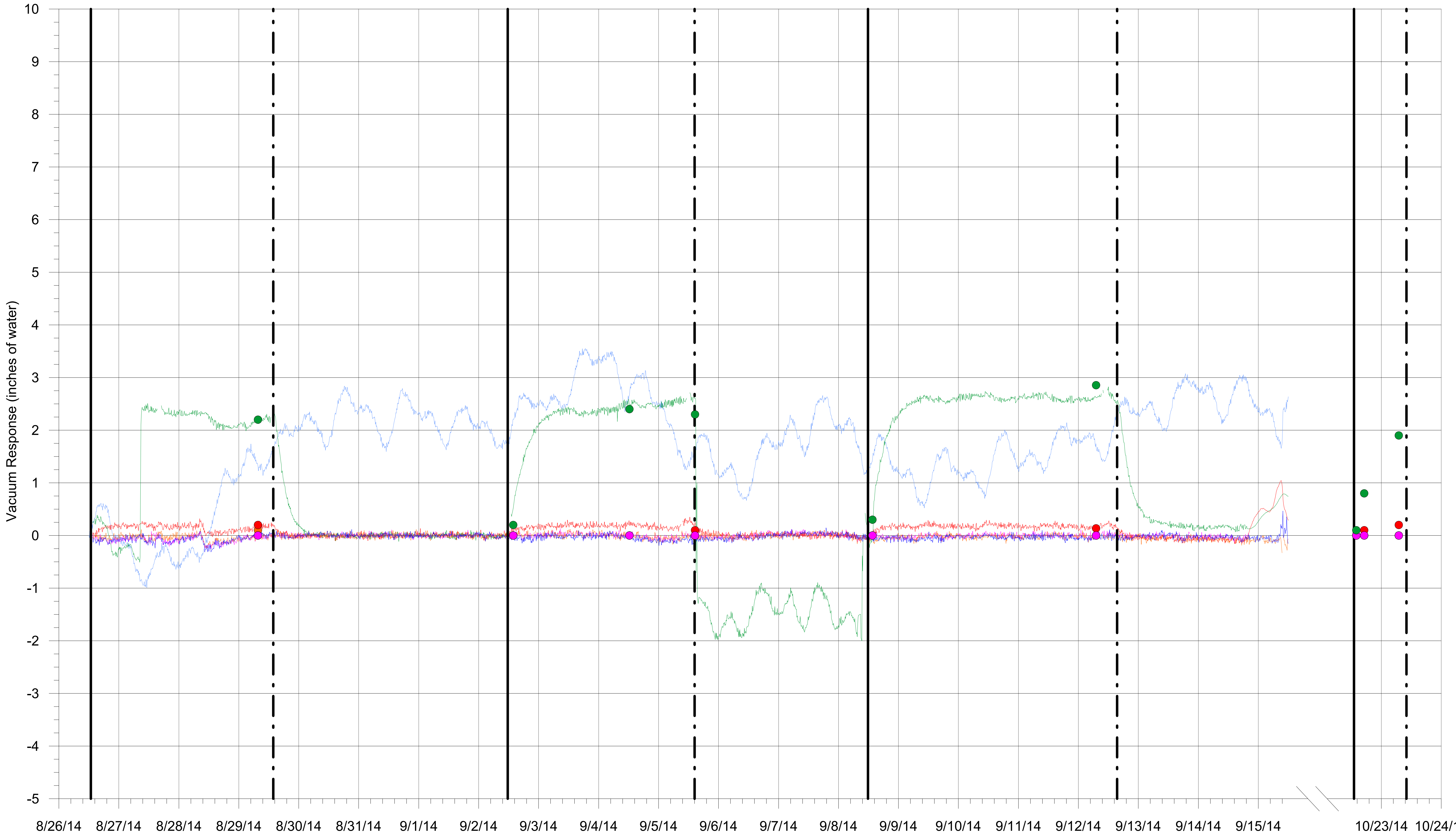
Notes:
1. ft bgs = feet below ground surface.
2. PZ-204 is located approximately 45 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
4. 10/22/14 and 10/23/14 data represent manual measurements (pressure transducers were not installed during rebound testing).

BaroLogger
System Start-up
System Shut-down

Well/Piezometer	Transducer Data	Manual Data
PZ-204a (50.2 to 60.2 ft bgs)		
PZ-204b (75.3 to 90.3 ft bgs)		
PZ-204c (122.4 to 137.4 ft bgs)		
PZ-204d (149 to 164 ft bgs)		

Figure 3-10
Vacuum Response at PZ-204
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz204_rev2.ai 6/15



Notes:
1. ft bgs = feet below ground surface.
2. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
3. Circles represent manually measured vacuum data.

BaroLogger
System Start-up
System Shut-down

Well/Piezometer	Transducer Data	Manual Data
HAR-20 (30 to 230 ft bgs)		
PZ-061 (5 to 15 ft bgs)		
PZ-070 (13 to 23 ft bgs)		
PZ-156 (104 to 114 ft bgs)		
RD-104 (30 to 60.5 ft bgs)		

Figure 3-11
Vacuum Response at Existing Wells
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_vacuum_response_existing_wells_rev2.ai 6/15

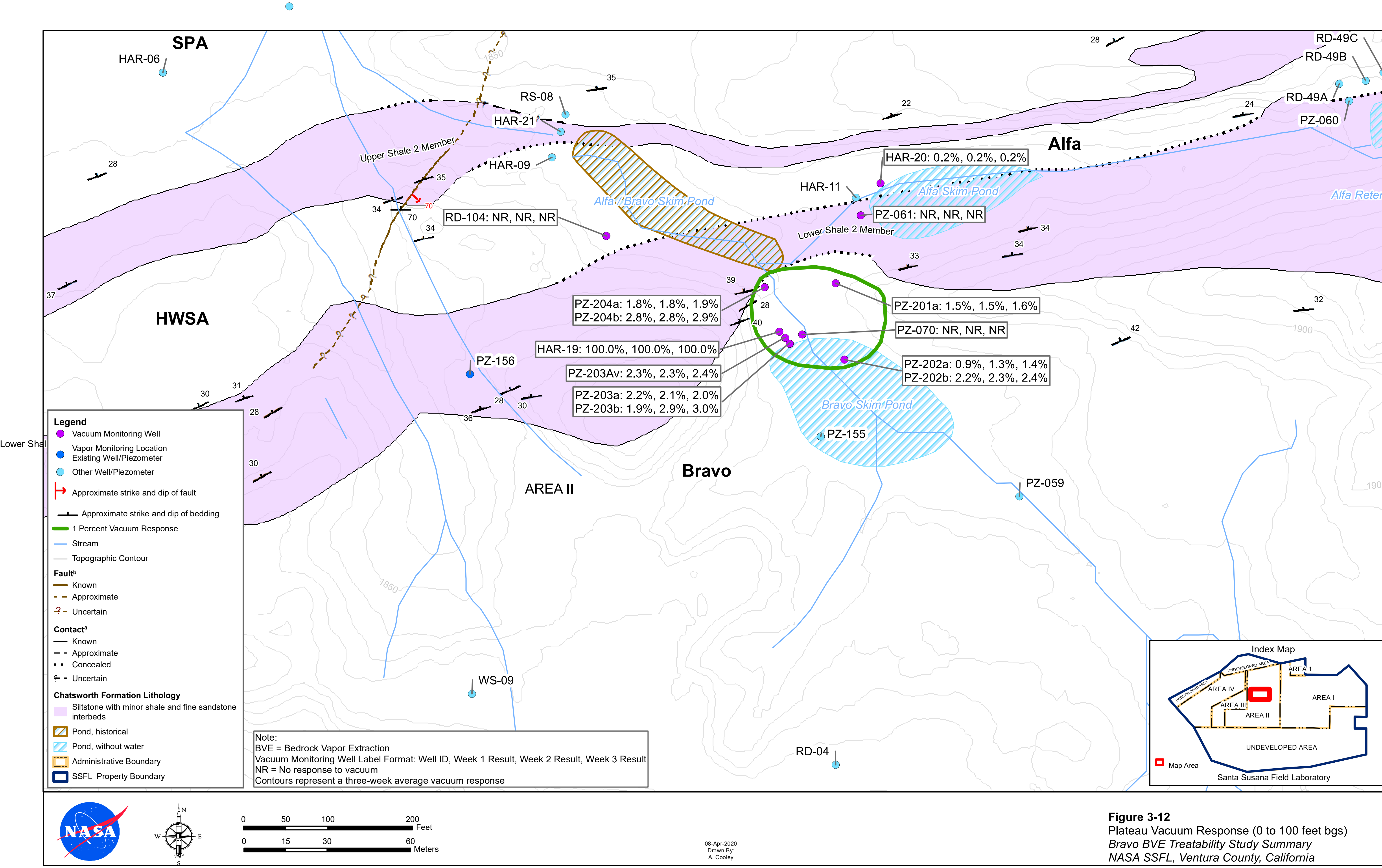


Figure 3-12
Plateau Vacuum Response (0 to 100 feet bgs)
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\TreatabilityStudy\Bravo_BVE_Vac_0_100.mxd

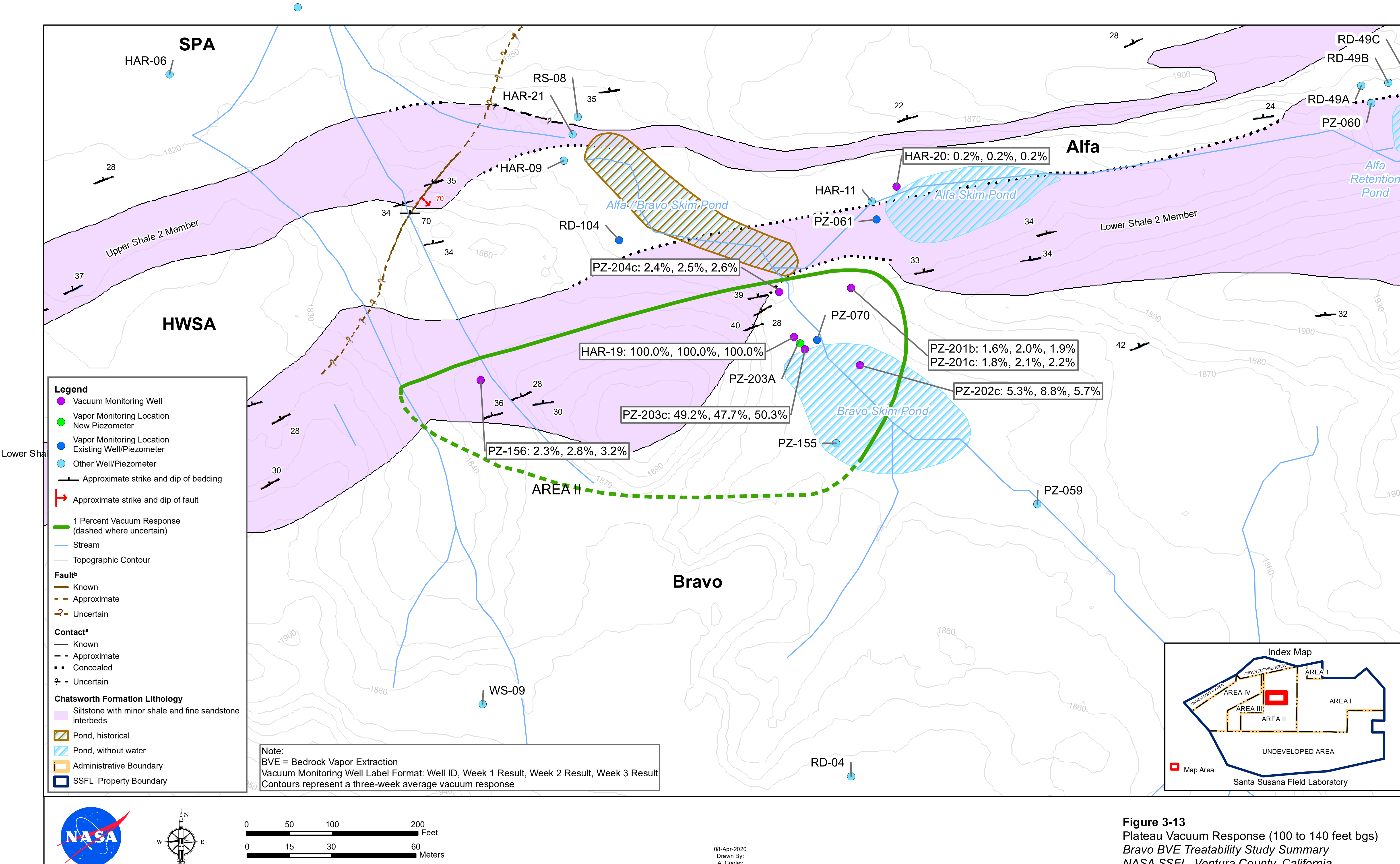


Figure 3-13
Plateau Vacuum Response (100 to 140 feet bgs)
Bravo BVE Treatability Study Summary
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\TreatabilityStudy\Bravo_BVE_Vac_100_140.mxd

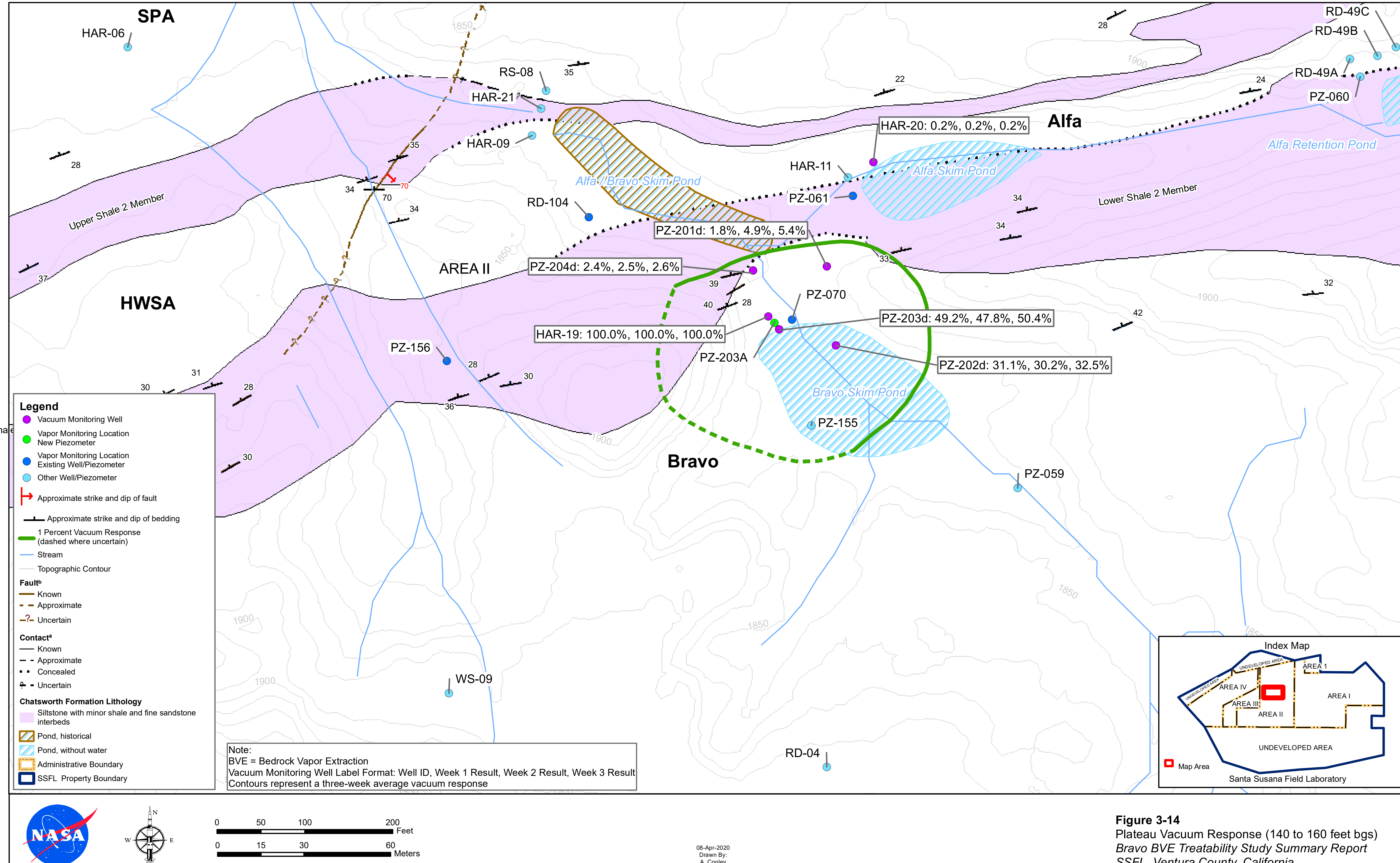
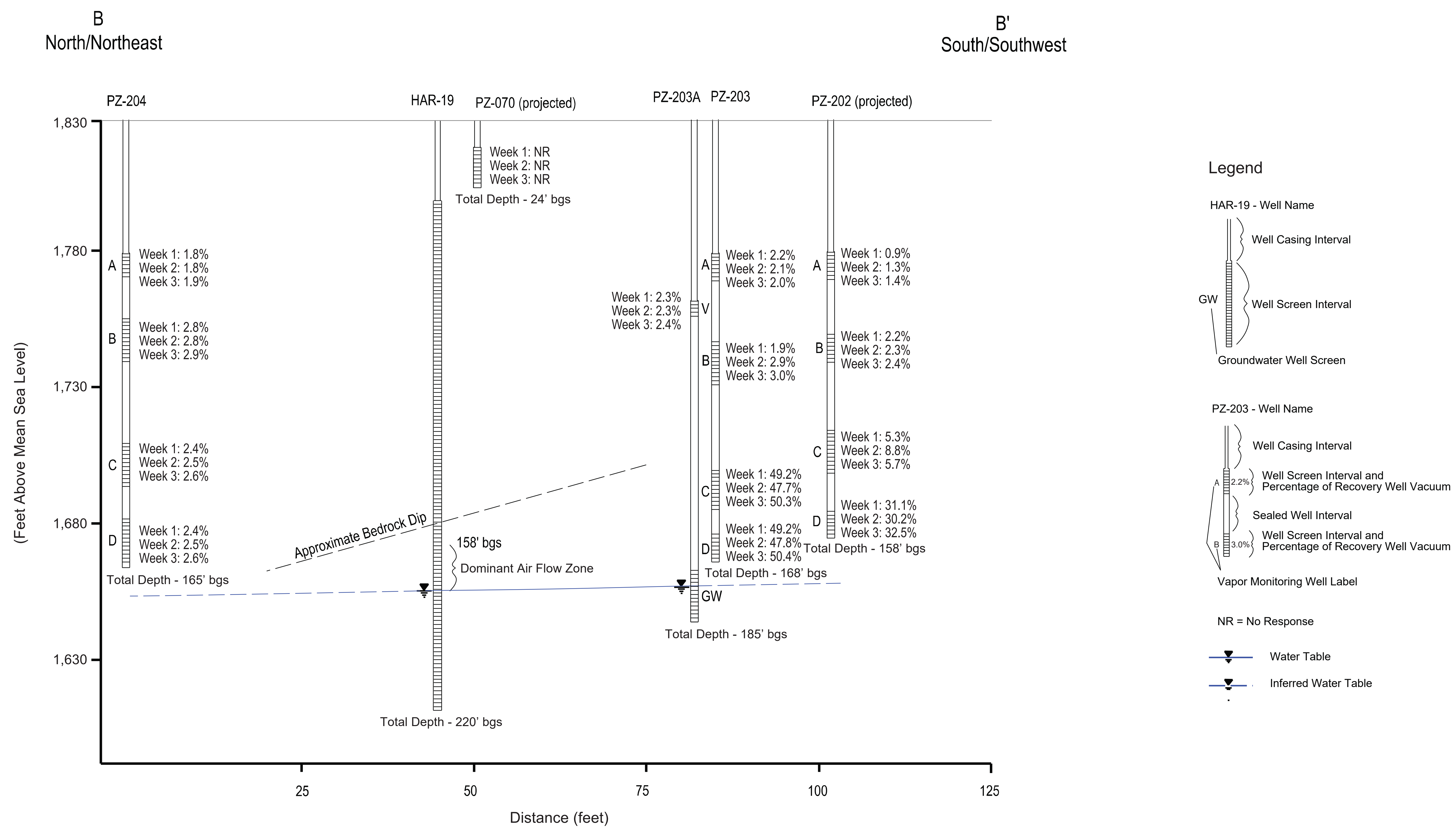


Figure 3-14
Plateau Vacuum Response (140 to 160 feet bgs)
Bravo BVE Treatability Study Summary Report
SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\TreatabilityStudy\Bravo_BVE_Vac_140_160.mxd



Notes:
1. PZ-202, PZ-204 and PZ-070 were dry during the July 2014 water level measurements.

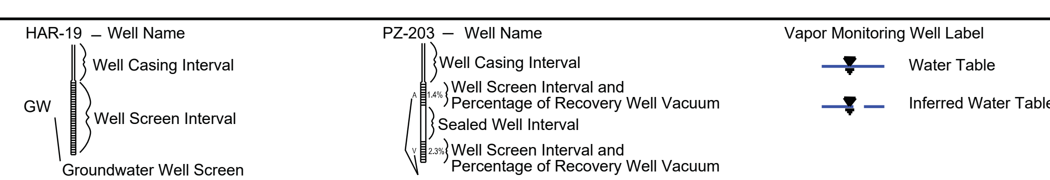
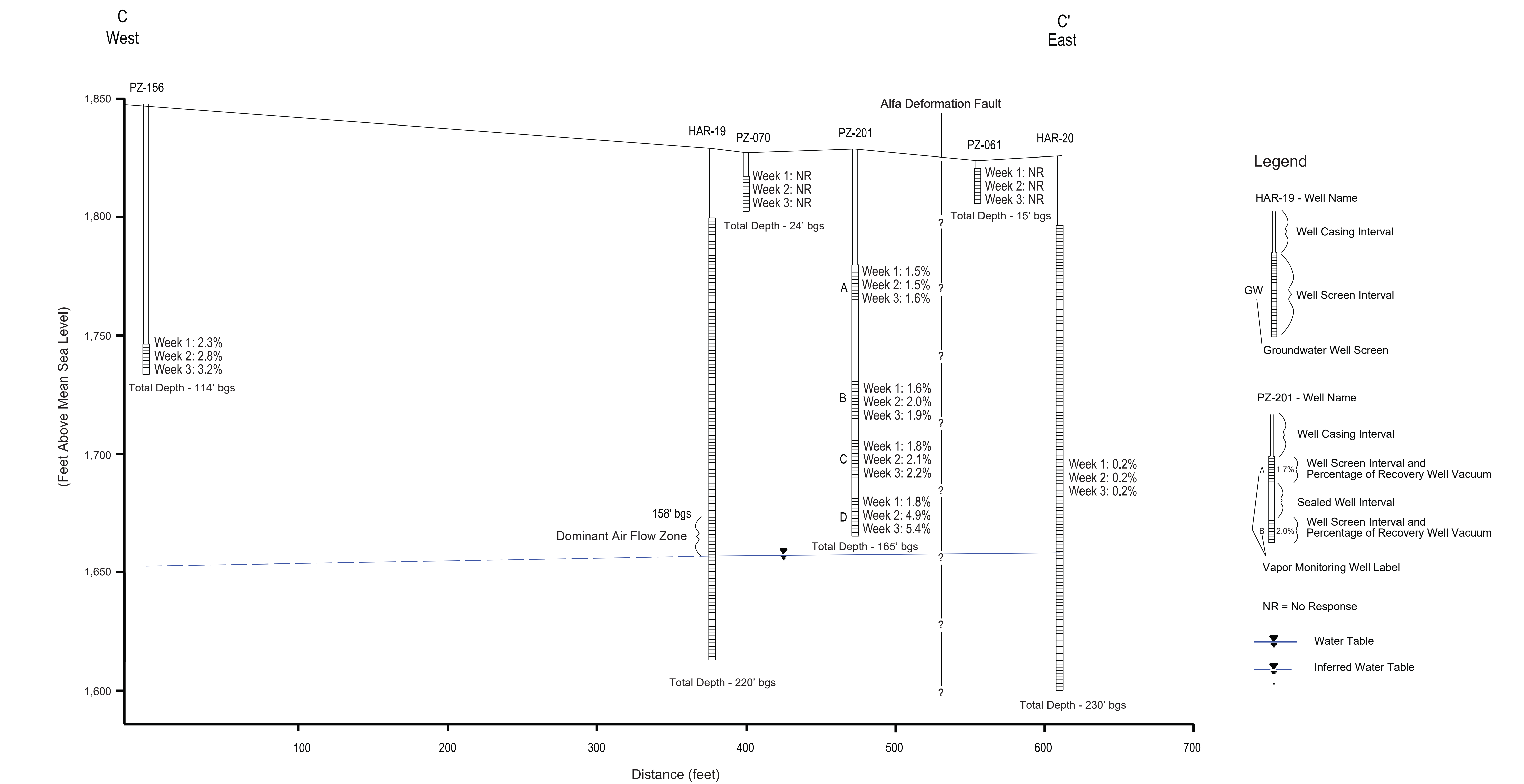


Figure 3-15
Cross Section B-B'
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

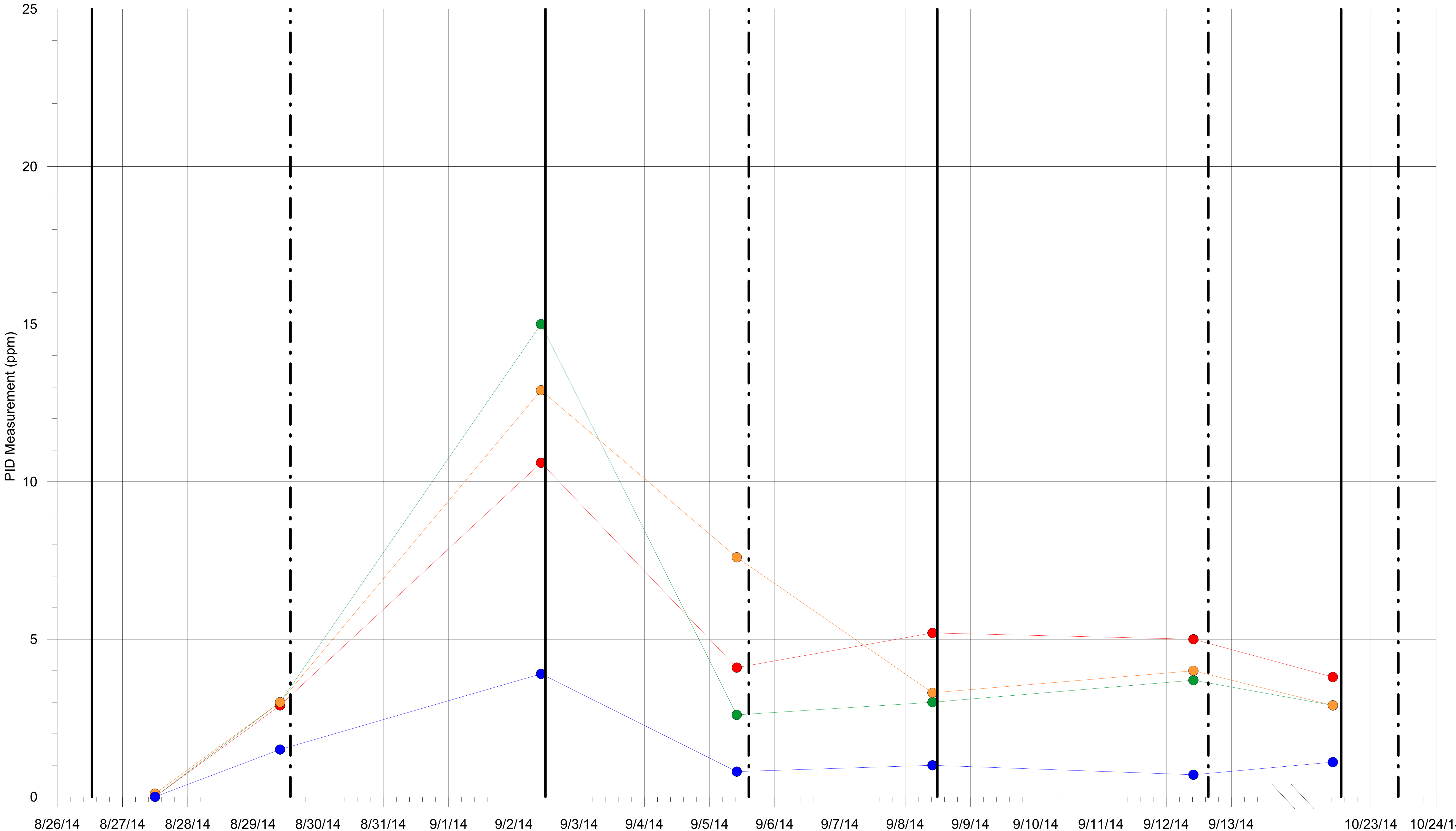
SCO474867.BV.01 SSFL_bravo_BB_cross_section_rev1.ai 6/15



Notes:
1. PZ-061, PZ-070, PZ-156 and PZ-201 were dry during the July 2014 water level measurements.

Figure 3-16
Cross Section C-C'
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_CC_cross_section_rev1.ai 6/15

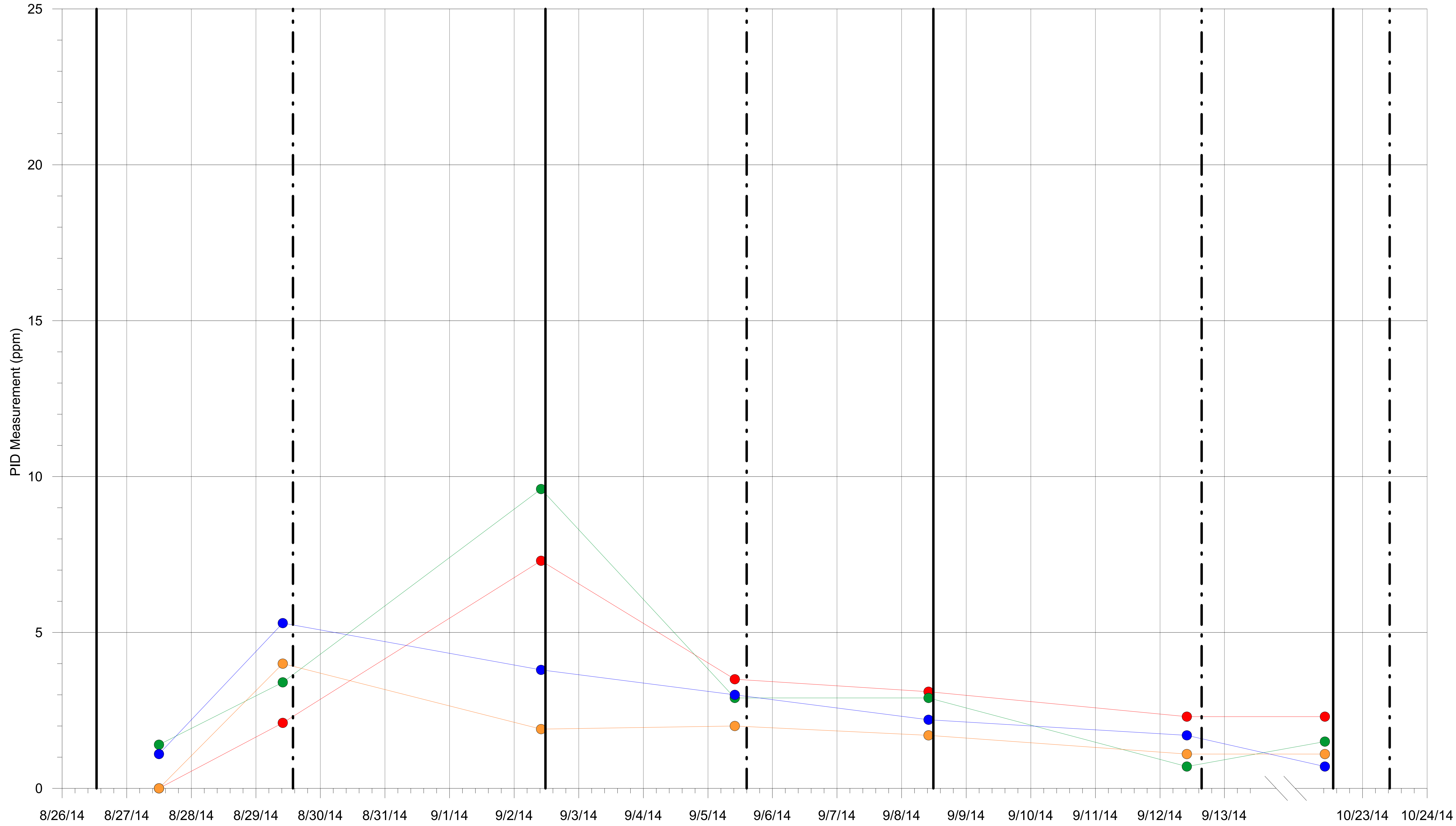


Notes:
1. PID = photoionization detector
2. ppm = parts per million
3. ft bgs = feet below ground surface
4. PZ-201 is located approximately 90 feet from BVE well HAR-19.

PZ-201a (55 to 65 ft bgs)
PZ-201b (100 to 115 ft bgs)
PZ-201c (124.9 to 139.9 ft bgs)
PZ-201d (149.8 to 164.8 ft bgs)
System Start-up
System Shut-down

Figure 3-17
Changes in PID at PZ-201
Bravo BVE Treatability Study Summary Report
Santa Susana Field Laboratory
Ventura County, California

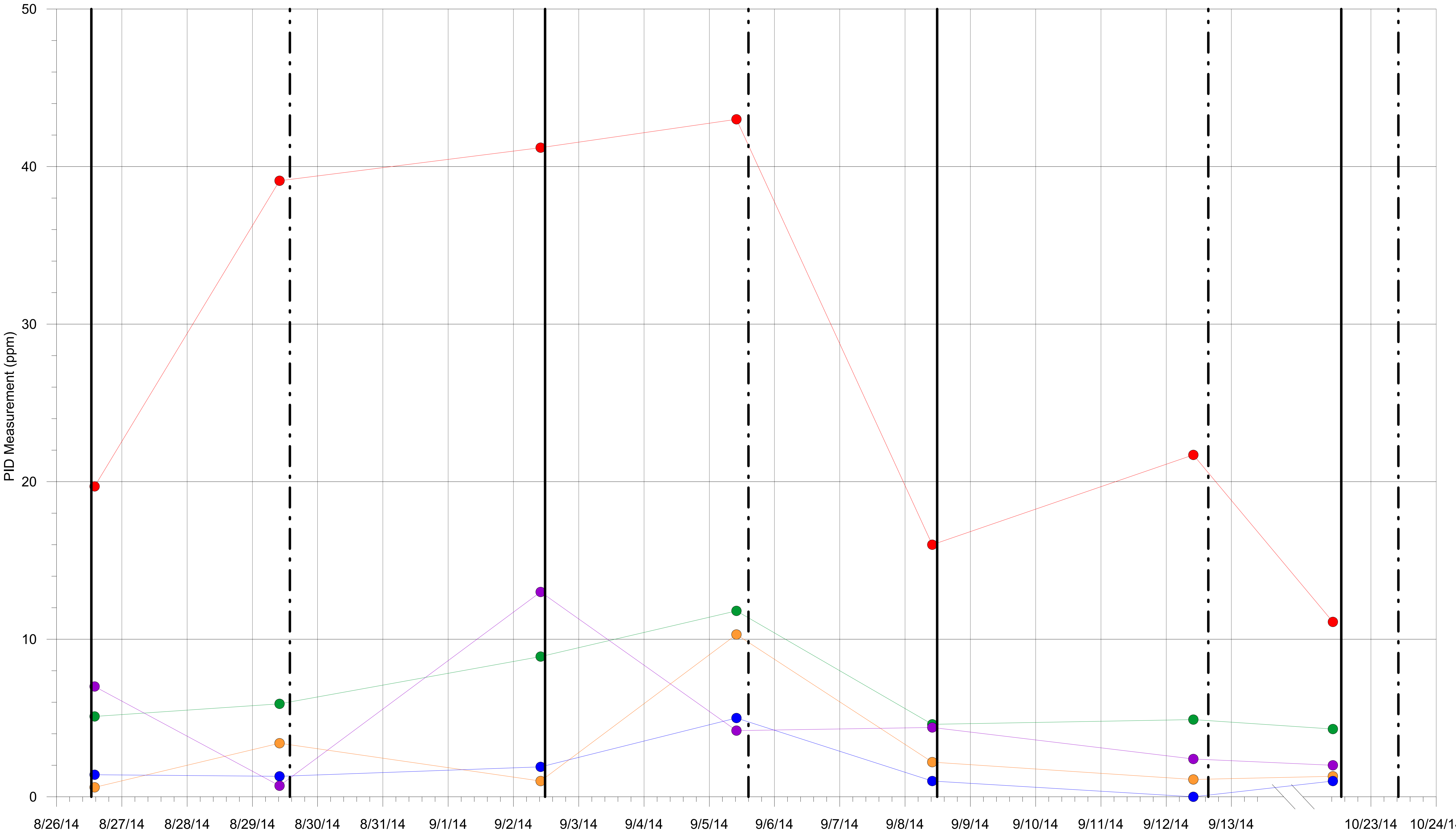
SCO474867.BV.01 SSFL_bravo_PID_pz201.ai 1/15



Notes:
1. PID = photoionization detector
2. ppm = parts per million
3. ft bgs = feet below ground surface
4. PZ-202 is located approximately 85 feet from BVE well HAR-19.

Figure 3-18
Changes in PID at PZ-202
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

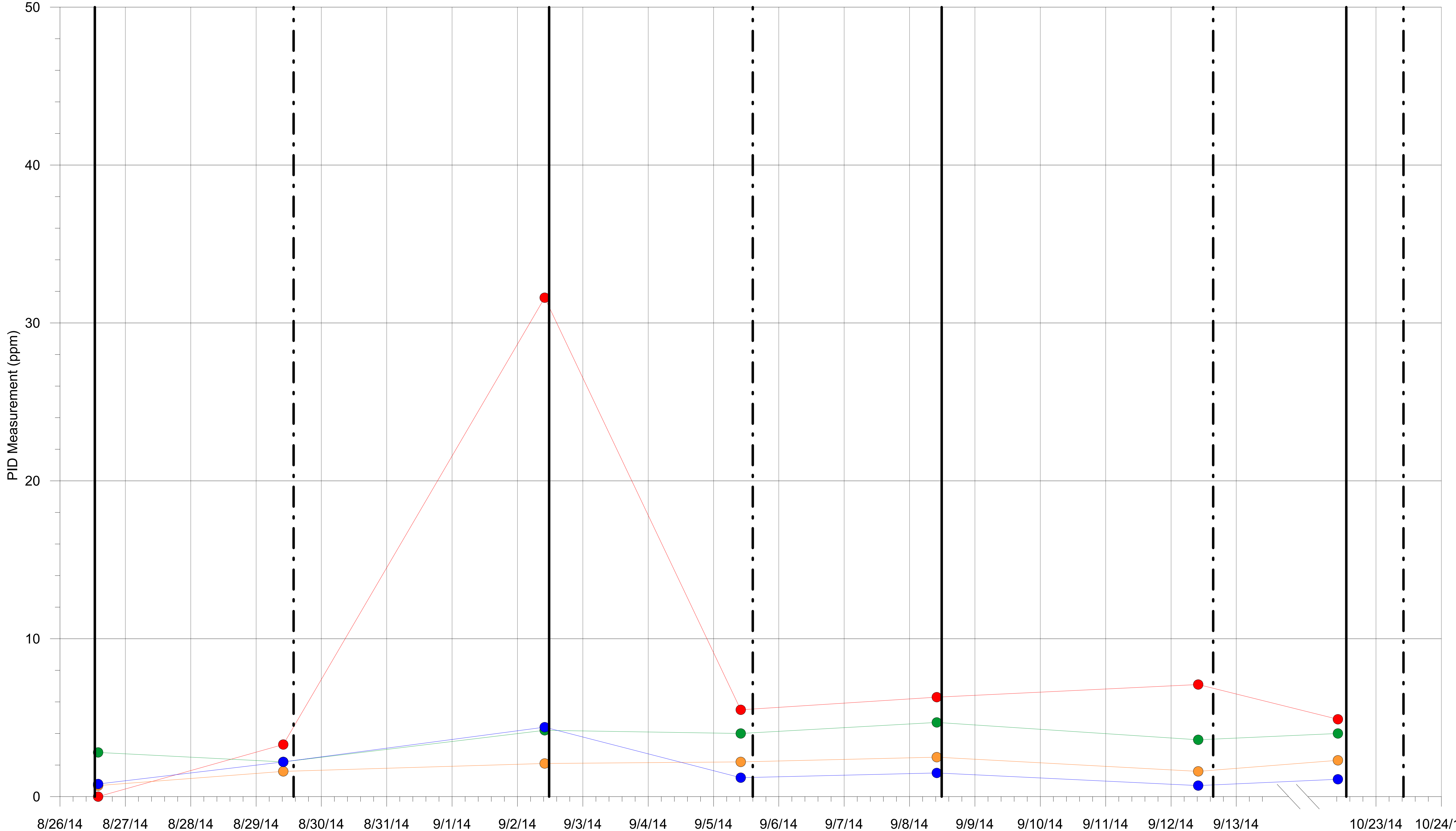
SCO474867.BV.01 SSFL_bravo_PID_pz202.ai 1/15



Notes:
1. PID = photoionization detector
2. ppm = parts per million
3. ft bgs = feet below ground surface
4. PZ-203 is located approximately 35 feet from BVE well HAR-19.

Figure 3-19
Changes in PID at PZ-203
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_PID_pz203.ai 1/15

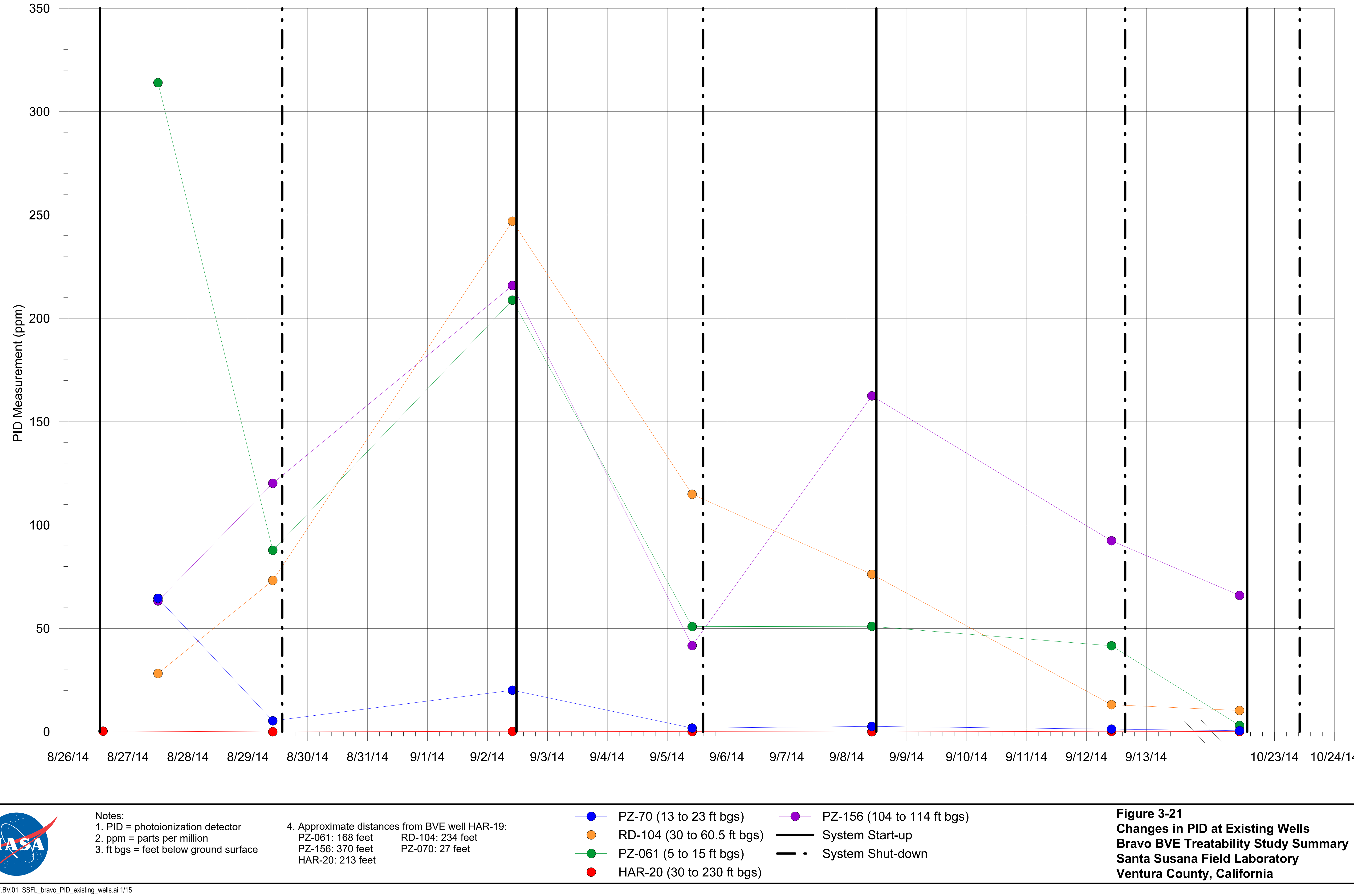


Notes:
1. PID = photoionization detector
2. ppm = parts per million
3. ft bgs = feet below ground surface
4. PZ-204 is located approximately 45 feet from BVE well HAR-19.

- PZ-204a (50.2 to 60.2 ft bgs)
- PZ-204b (75.3 to 90.3 ft bgs)
- PZ-204c (122.4 to 137.4 ft bgs)
- PZ-204d (149 to 164 ft bgs)
- System Start-up
- System Shut-down

Figure 3-20
Changes in PID at PZ-204
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

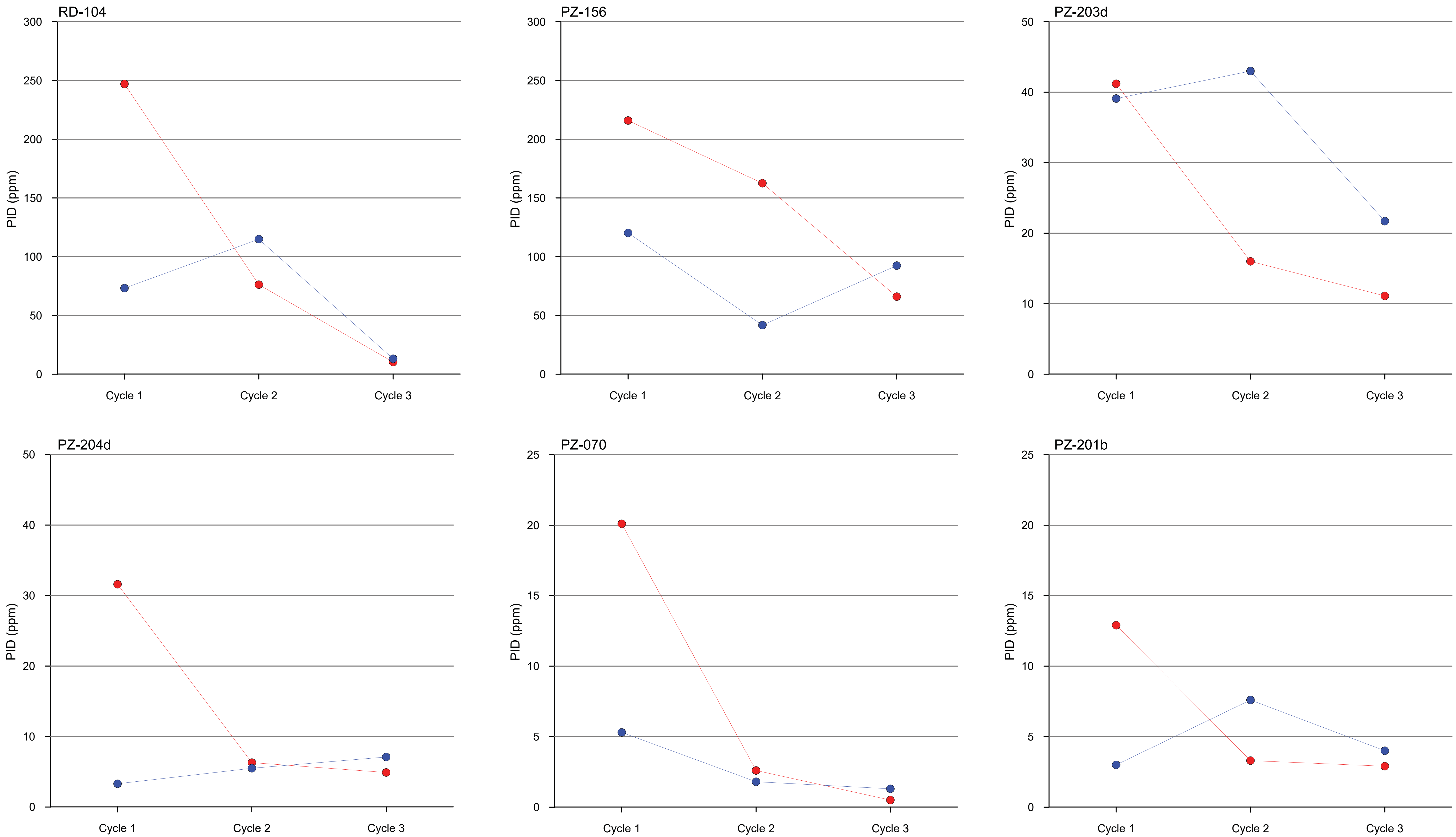
SCO474867.BV.01 SSFL_bravo_PID_pz204.ai 1/15



Notes:
1. PID = photoionization detector
2. ppm = parts per million
3. ft bgs = feet below ground surface
4. Approximate distances from BVE well HAR-19:
PZ-061: 168 feet
PZ-156: 370 feet
HAR-20: 213 feet
RD-104: 234 feet
PZ-070: 27 feet

Figure 3-21
Changes in PID at Existing Wells
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

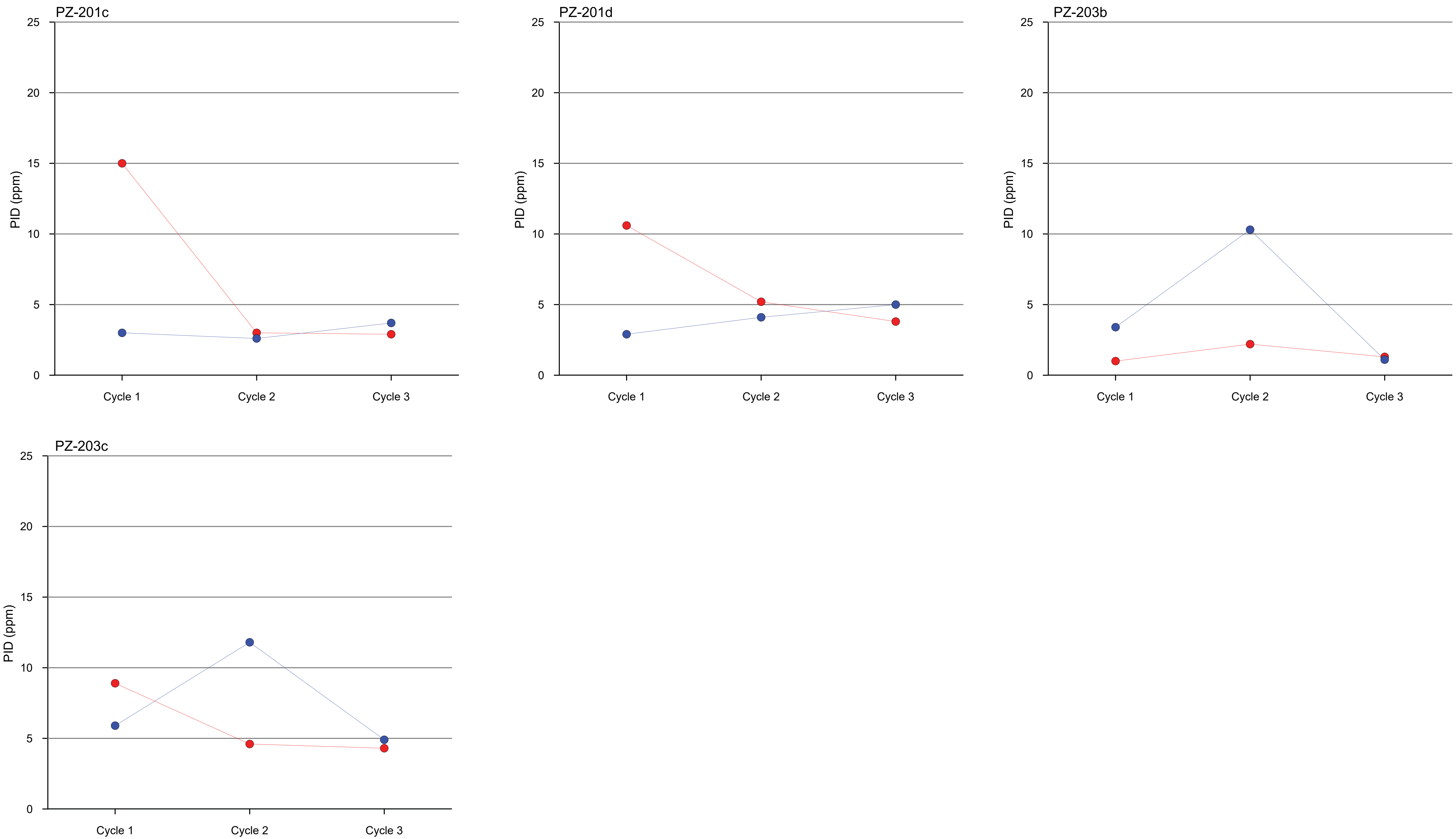
SCO474867.BV.01 SSFL_bravo_PID_existing_wells.ai 1/15



Notes:
1. PID = photo-ionization detector.
2. ppm = parts per million.
3. Cycles 1-3 for extraction refer to VOC measurements after vapor extraction for weeks 1-3.
Cycles 1-3 for rebound refer to pre-extraction VOC measurements for weeks 2, 3, and 9.

Extraction
Rebound

Figure 3-22
Extraction and Rebound PID Concentrations, Individual Piezometers
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California



Notes:
1. PID = photo-ionization detector.
2. ppm = parts per million.
3. Cycles 1-3 for extraction refer to VOC measurements after vapor extraction for weeks 1-3.
   Cycles 1-3 for rebound refer to pre-extraction VOC measurements for weeks 2, 3, and 9.

Extraction
Rebound

Figure 3-23
Extraction and Rebound PID Concentrations, Individual Piezometers
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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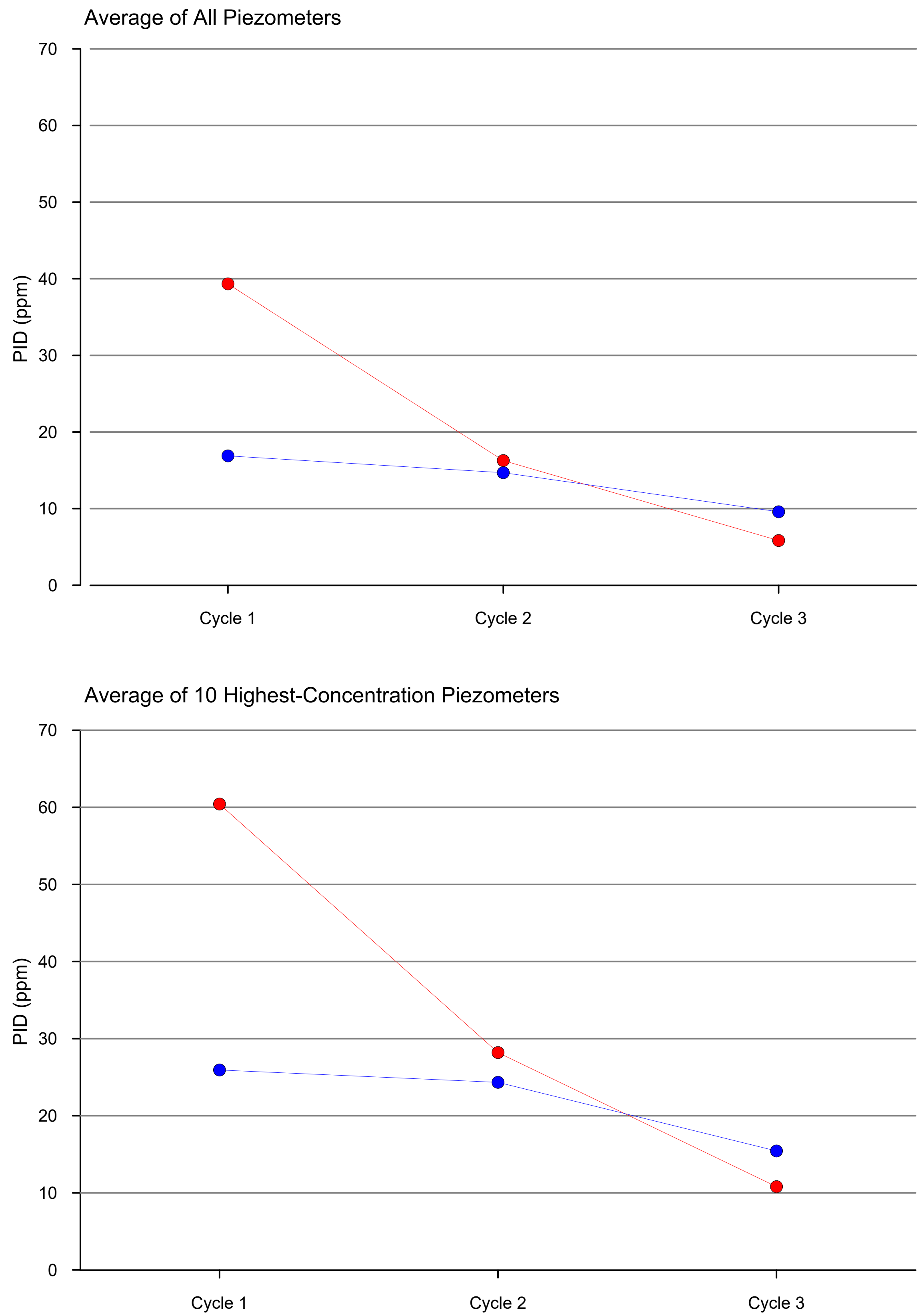

Notes:
1. PID = photo-ionization detector.
2. ppm = parts per million.
3. Cycles 1-3 for extraction refer to VOC measurements after vapor extraction for weeks 1-3. Cycles 1-3 for rebound refer to pre-extraction VOC measurements for weeks 2, 3, and 9.

Figure 3-24
Summary of Extraction and Rebound PID Concentrations
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

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Appendix A
Permits

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Amended

County of Ventura

WELL PERMIT

800 South Victoria Avenue Ventura, CA 93009

	Property Owner	Driller	Registered Inspector
Name	NASA, Attn: Allen Elliott	GREGG DRILLING & TESTING INC	John Lindquist
Address	AS01, Marshal SFC, AL 35812	2726 WALNUT AVENUE, SIGNAL HILL, CA 90755	2604 Vista Loop, Oxnard, CA 93036
Telephone	2565440662	(562) 427-6899	8054135813

Type of Work	Monitoring Well New (4) +1 1 Destruction	Sealing Zone	1		Main Use		Monitoring
SWN (Partial)	02N17W30B	Well ID	N/A		APN		6850051175
Fee	$320.00 + $80.00	Receipt No.	571977		Prep by:		B Council
Well Location	Santa Susana Field Lab	Proposed Construction	Well Depth	200 ft	Bore Dia.		12.00 in.
Basin	UNDEFINED		Perforations	From 100.00 ft. to 185.00 ft.			

BDC 08/26/2014

Conditions

1. Permit issue and expiration dates are as follows:

Issue Date: 06/20/2014
Expiration Date: 12/20/2014

The Contractor shall keep a copy of this approved permit at the work site.

2. Well Owner and his Driller ("Contractor") shall comply with all provisions of Ventura County Well Ordinance No. 4184, and all applicable State of California and local regulations pertaining to well construction, repair, modification and destruction.

3. Work shall be performed by a licensed water well contractor (C-57), who must also be registered with the Watershed Protection District, Groundwater Section ("District").

4. All work shall be inspected by a licensed Civil Engineer, Registered Geologist or Certified Engineering Geologist, who must also be registered with the Watershed Protection District, Groundwater Section ("District").

5. Contractor shall retain all drilling fluids and groundwater discharges within the drilling site, unless an NPDES permit has been obtained from the California Regional Water Quality Control Board, Los Angeles Region. The NPDES permit shall be obtained prior to drilling operations.

6. Sealing Requirements:

a. Bentonite grout, bentonite clay chips, neat cement or cement grout annular sealing material shall be placed from 2 feet above the perforations to 2 feet below ground surface.

Bentonite clay products used for sealing material must be specifically prepared for such use. Used drilling mud and /or cuttings from drilling shall not be used in sealing material. Bentonite chips shall be hydrated while placed and shall be placed by means of a grout pipe positioned within 2 feet of the base of the sealing zone. If the sealing depth is 10 feet or less bentonite chips may be placed by free-fall method.

All bentonite grout and cement sealing material shall be placed by means of a grout pipe positioned within 2 feet of the base of the sealing zone. For Sealing Zones 1 and 2, if the standing water level in the casing is below the base of the sealing zone and the sealing depth is 25 feet or less, a grout pipe will not be necessary.

b. Diameter of the well bore shall be a minimum of 4 inches larger than the outside diameter of the casing for the full depth of

Destruction Conditions

County of Ventura
WELL PERMIT

800 South Victoria Avenue; Ventura, CA 93009

Type of Work	Monitoring Well – Destruction (1)

Conditions

1. Permit issue and expiration dates are as follows:

Issue Date: 06/20/2014
Expiration Date: 12/20/2014

The Contractor shall keep a copy of this approved permit at the work site.

6. Borehole Destruction:

a. (If no casing was installed proceed to step b.) Measure the total depth of the monitoring well(s) and redrill to the total depth. Existing casing, seal and gravel envelope shall be removed.

b. Immediately after redrilling, bentonite clay grout, bentonite clay chips, neat cement or cement grout shall be placed from the bottom of the borehole to a depth of 5 feet below ground surface.

Bentonite clay products used for sealing material must be specifically prepared for such use. Used drilling mud and/or cuttings from drilling shall not be used in sealing material. Bentonite chips shall be hydrated as placed and shall be placed by means of a grout pipe positioned within 2 feet of the base of the borehole. If the sealing zone depth is 10 feet or less, bentonite chips may be placed by free-fall method.

All cement sealing material shall be placed by means of a grout pipe positioned within 2 feet of the base of the sealing zone. If there is no standing water in the borehole and the depth is 25 feet or less, a grout pipe will not be necessary.

c. Clean native soil or other suitable material shall be placed from a depth of 5 feet to ground surface.

7. Post Requirement:

Registered Inspector's Well Sealing Report: Within 30 days after work is completed, Registered Inspector shall submit a Registered Inspector's Well Sealing Report for the monitoring well(s). Mail to County of Ventura – Watershed Protection District, Groundwater Section ("District"); Attn: Barbara Council (Re: MW Sealing Report); 800 South Victoria Avenue; Ventura, Ca. 93009-1600. **Failure to submit documents within 30 days will preclude Property Owner and Registered Inspector from obtaining future permits until report is received and may result in the issuance of a Notice of Non-Compliance.**

8. The information contained in the Application for Well Permit becomes a part of this permit.

Ventura County Air Pollution Control District
669 County Square Drive
Ventura, California 93003
tel 805/645-1400
fax 805/645-1444
www.vcapcd.org
Michael Villegas
Air Pollution Control Officer

January 6, 2014

Mr. Peter Zorba
NASA Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Subject: Temporary Permit to Operate No. 08210-100

Dear Mr. Zorba:

Your application for Permit to Operate No. 08210-100 (dated November 13, 2013) for a temporary installation and operation of a pilot study "bedrock vapor extraction (BVE) system" controlled by a carbon adsorption system was received by the APCD on December 9, 2013.

This letter is a temporary operating permit for the emissions units. It authorizes the installation and operation of the pilot study "bedrock vapor extraction (BVE) system" and associated equipment and control system for a maximum duration of thirty (30) days over a six month period starting in February 2014 and ending in August 2014. The emissions units shall be operated in accordance with the applicable requirements of VCAPCD Rules and regulations, and subject to the following conditions:

1) The emissions from the pilot study "bedrock vapor extraction (BVE) system" shall be captured and controlled by a carbon adsorption system.

2) The ROC (reactive organic compounds) and total non-methane organic compounds emissions from the pilot study "bedrock vapor extraction (BVE) system" at the outlet of the carbon adsorption system shall not exceed 100 ppmv as methane as sampled and analyzed using the appropriate EPA and/or CARB methods and an approved PID or equivalent instrument calibrated with the appropriate gases and using appropriate correction factors. Sampling and analyzing using the appropriate EPA and/or CARB methods shall be conducted weekly (when operating). Testing using PID or equivalent shall be conducted once daily (when operating).

3) The maximum exhaust flow rate from the "bedrock vapor extraction (BVE) system" shall not exceed 669 SCFM.

4) All spent carbon shall be stored in closed containers and shall be disposed of in accordance with applicable regulations. All waste water collected from the "bedrock vapor extraction (BVE) system" shall be collected and stored in covered containers and shall be disposed of in accordance with applicable regulations. This permit does not grant permission for the storage, treatment or disposal of such waste water.

5) Permittee shall maintain records of the results of analyses and exhaust concentrations from the carbon adsorption system. Records shall be maintained for the duration of the project.

6) The blowers or fans shall be powered with an electric motor that receives its electrical power from the local utility grid, if available. Electrical generating engines may only be used as the source of electrical power if grid electricity is not available.

APCD Rule 19 requires that this temporary operating permit be readily accessible to inspection personnel from the Air Pollution Control District and be posted reasonably close to the subject equipment.

If you have any questions or wish to discuss this matter in further detail, please call me at 805/645-1421.

Sincerely,

Kerby E. Zozula, Manager
Engineering Division

c: Elizabeth Rehoreg, CH2MHILL
402 West Broadway, Suite 1450
San Diego, CA 92101

From: Kerby Zozula [mailto:kerby@vcapcd.org]
Sent: Thursday, June 26, 2014 2:23 PM
To: Lindquist, Jennifer/THO
Cc: Edwards, Olivia/LAS; Hartley, Jim/SAC
Subject: RE: NASA SSFL Temporary Permit to Operate Bedrock Vapor Extraction system

This email extends the expiration of Temporary Permit to Operate No. 08210-100 (dated January 6, 2014) from the end of August 2014 to October 31, 2014.

The temporary Permit to Operate is extended with the understanding that all other conditions of the temporary Permit to Operate remain in effect.

Please attach this email to the temporary Permit to Operate.

Regards,

Kerby

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From: Jennifer.Lindquist@CH2M.com [mailto:Jennifer.Lindquist@CH2M.com]
Sent: Thursday, June 19, 2014 2:13 PM
To: Kerby Zozula
Cc: Olivia.Edwards@CH2M.com; Jim.Hartley@CH2M.com
Subject: NASA SSFL Temporary Permit to Operate Bedrock Vapor Extraction system

Good afternoon

Per our recent conversation we are requesting an extension on the attached Temporary permit for operation of the Bedrock Vapor Extraction system. All other aspects of the permit remain the same, however we would like to change the end date on the permit to October 31, 2014.

Can you please respond to this email indicating this extension is acceptable to VCAPCD and that your email is acceptable confirmation of the changed end date.

Thank you

Jennifer L. Lindquist
CH2M HILL/THO
Office: 805-413-5812
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Appendix B
Description of Drilling Activities

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APPENDIX B

Drilling and Logging Program Details

This appendix provides a detailed discussion of the bedrock vapor extraction (BVE) drilling program conducted between July 16 and August 14, 2014. Drilling activities were conducted by Gregg Drilling & Testing, Inc., under the supervision of a California Registered Professional Geologist. Boreholes PZ-202 and PZ-203 were drilled using HQ rock core methods, while PZ-201, PZ-203A, and PZ-204 were drilled using air rotary methods.

B.1 Rock Coring and Lithologic Logging

The BVE drilling program began at PZ-203 with 2.5-inch diameter HQ wireline rock coring, using a CME-850 track-mounted drill rig. Rock core was drilled and retrieved in 5-foot runs, which were immediately delivered to the field geologist for lithologic logging and core sampling. The logging process followed the Rock Core Logging standard operating procedure (SOP) provided in Appendix A of the *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan* BVE IP (NASA, 2014c), and involved the following general steps:

- Scanning the length of core with a 10.6 electron volt (eV) photoionization detector (PID) calibrated to isobutylene
- Measuring the percent recovery of core and rock quality designation (RQD)
- Marking the core storage box with the run number, depth interval, and percent recovery
- Photographing the full length of each core run, and any significant fractures/zones of potential interest
- Completing the necessary information on the rock core log, including:
  - Lithologic characteristics (such as rock type, color, and weathering)
  - Descriptions of observed discontinuities (such as depth, type, and orientation)
  - Number of fractures per foot, core run length, percent recovery, and RQD
  - Other comments (driller remarks, PID readings, coring rate and water usage, collected samples and similar)

This logging process was followed for subsequent borings PZ-202 and PZ-202A, which were the only other locations to undergo rock coring during the BVE treatability study (TS). PZ-202A was drilled as a replacement hole for boring PZ-202, which was abandoned after attempts to retrieve a broken drill rod downhole were unsuccessful. Boring PZ-202A now houses completed piezometer PZ-202, and is located approximately 5 feet to the southeast of the original PZ-202 boring. Rock core logs for three cored borings are provided in Appendix C.

Air Coring versus Water Coring. Air coring was performed at PZ-203 with the intent of minimizing the amount of water introduced into the formation (and, therefore, into the diffused matrix and/or potential fractures of interest for vapor extraction). The process of air coring involves the use of water only to lubricate and cool the drill bit and as a medium to lift cuttings out of the borehole. During BVE air coring at PZ-203, the buildup of air pressure downhole while coring resulted in eruptions of injected water through the surface casing that proved challenging to contain. Furthermore, air coring yielded unexpectedly large volumes of both investigation-derived waste (IDW) and water lost to the formation. Additionally, mechanical issues related to the drilling method resulted in slow, difficult drilling overall. These complications resulted in a switch from air coring to water coring for borings PZ-202 and PZ-202A. This process eliminated the use of air by recirculating water through the borehole and drill stem. Although water coring ultimately reduced the volume of IDW, a significant amount of water continued to be introduced to the formation.

Table B.1-1 provides a summary of technical issues experienced during coring. Together, these issues led to a decision to halt further coring operations until an alternative drilling method could be arranged and approved by California Department of Toxic Substances Control (DTSC). During a status update call with DTSC on August 5, 2014, it was agreed that rock coring would not be performed at the remaining boring locations (PZ-201, PZ-203A, and PZ-204). It was agreed that the remaining borings would be drilled via air rotary with a borehole diameter of 8.5 inches. It was also determined that video logging of the boreholes would be performed to obtain information about bedrock fractures and to facilitate the selection of appropriate screen intervals prior to piezometer construction.

TABLE B.1-1
Summary of Technical Issues Encountered During Rock Coring
Bedrock Vapor Extraction Field Implementation Summary

Boring No.	Coring Method	Volume of Water Lost to Formation (gal)[a]	Technical Issue(s)
PZ-203	Air	5,625	• High volume of IDW generated (approximately 8,000 gal) • High volume of water lost to the formation, potentially suppressing the diffused matrix and/or saturating fractures • Buildup of downhole air pressure caused injected water to erupt through the surface casing; difficult to contain • Persistent drill rig chatter, causing a high degree of artificial/mechanical fracturing of the core • Low core recoveries • Quick wearing of equipment (broken bearing on core barrel extractor, multiple drill bit replacements) • Very slow drilling, with repeated starts/stops to minimize chatter, repair equipment, and refill the water supply truck
PZ-202	Water	2,812	• High volume of water lost to the formation • Drill rod broke off at 138 feet below ground surface, due to sand lock after being left in the formation overnight • Inability to retrieve broken equipment from the borehole led to abandonment and re-drilling at PZ-202A
PZ-202A	Water	2,812	• High volume of water lost to the formation • Introduction of bentonite downhole was required to prevent drill rods from locking in the formation

Notes:
[a] Volumes of water lost to the formation are highly approximate, and are based on estimates of water used while coring each boring and the cumulative IDW generated for coring activities.
gal = gallons
PZ = piezometer

B.2 Air Rotary Drilling and Video Logging

Three borings (PZ-201, PZ-203A, and PZ-204) were drilled with a borehole diameter of 8.5 inches via a Speed Star 50K truck-mounted air rotary drill rig. During air rotary drilling, periodic PID measurements were taken of drill cuttings exiting the top of the borehole and were recorded in the field book along with the approximate depth of the drill bit at the time of measurement. Drill cuttings were not formally logged, as they were pulverized to a state that meaningful lithologic information could not be obtained. However, drilling rates, changes in rig response, and significant color changes were noted in the field book, as applicable. Air rotary was also employed to ream borings PZ-202A and PZ-203 to 8.5 inches in diameter. No lithologic or observational data were collected during reaming activities, given that this information had already been obtained in the coring process.

The air rotary approach proved advantageous in terms of both technical and logistical feasibility. In contrast to rock coring, no water was used or introduced to the formation during air rotary drilling, eliminating concerns about potentially saturating fractures and/or matrix porosity involved in subsurface vapor transport processes. Additionally, the rate of drilling was significantly faster than coring, and total depth at all boreholes was reached within 4 hours without a need for subsequent reaming. The sole disadvantage of the method lied in the loss of intact rock cores, and therefore an inability to log detailed lithologic and discontinuity data.

To mitigate this issue meet the overall study objectives, downhole video logging was conducted to recover critical fracture information. Following completion of borehole drilling, a Well-Vu WV-300S downhole camera was used to view and record video of borehole walls throughout the entire length of borings PZ-201 and PZ-204 (PZ-203A was not video logged, given its proximity to the fully core-logged PZ-203). A geologist analyzed the videos and noted the depths and orientations of significant fractures, and any distinguishable lithologic variations. Video logs are provided in Appendix D.

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Appendix C
Rock Core Logs

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PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202	SHEET 1 OF 8

SOIL BORING LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

DRILLING EQUIPMENT AND METHOD : HQ Wireline, CME-850

WATER LEVELS : --- START : 7/25/14 0940 END : 7/29/2014 LOGGER : R. Lucich, J. Lindquist

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	SAMPLE RECOVERY (%)	SAMPLE TYPE	ANALYTICAL METHOD	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0				**Silty Sand (SM)** 0.0-9.0' - yellowish brown (10YR 5/4), dry, loose, fine to medium grained, subrounded, trace coarse rounded gravel to 15 mm		BZ = 0.0 ppm Note: Using Munsell soil color chart, and Sand-Gauge chart 1984 by U.F. McCollough
5							
							set surface casing at 8.5-9.0' bgs, moving materials to boring area
					Begin Rock Coring at 9.0 ft bgs See the next sheet for the rock core log		
10							
15							
20							

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PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-202	SHEET 2 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/25/14 09:40 — END : 7/29/2014 — LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES — DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY — ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS — SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
9.0 10	R-1 4 ft 40	100	- - - 0 1	9' - Driller noted soft material until 11.4'		**Concrete** 11.4-11.8' **Sandstone** 11.8-12.3' - yellowish brown (10YR 5/4), fine to coarse grained, minor bedding, subangular to subrounded, slightly weathered, medium strong irregular contact	R1 = 9.0-13.0' bgs 1316-1327 = 11 mins Driller noted soft material until 11.4' bgs PID = 0.0 ppm on surface and in fracture
13.0 15	R-2 5 ft 100	100	1 1 - - -	12.7-13.0' - Fracture, 60 deg, rough, planar, dark staining 13-13.2' - continuance of fracture at 12.7' 13.85' - Mechanical break 14.45' - 20 deg, rough, undulating, no staining 1. .15' - Mechanical break 16.35-16.83' - Mechanical break, at lithology contacts		**Sandstone** 12.3-13.0' - yellowish brown (10YR 5/4), fine grained, slightly weathered **Sandstone** 13.0-14.45' - yellowish brown (10YR 5/4), fine grained, slightly weathered **Sandstone** 14.45-16.5' - brown (10YR 4/3), fine to coarse grained, slightly weathered, weak, no bedding **Siltstone** 16.5-16.6' - yellowish brown (10YR 5/6), bed oriented ~ 20°, slightly weathered, weak, subrounded **Sandstone** 16.6-18.0' - gray brown (10YR 5/2), fine grained, unweathered, weak	R2 = 13.0-13.47' bgs 1347-1403 = 16 mins PID = 0.0 ppm for all fractures
18.0 20	R-3 5 ft 98		0 1 0 0 0	19.6' - Fracture, 60 deg, rough, undulating, slight silty infill, rust color staining 20.2-22.6' - Fracture zone, mechanical breaks ((>10), horizontal), some vertical from 21.65-22.6'		**Sandstone** 18.0-20.0' - gray brown (10YR 5/2), fine grained, unweathered, weak, coarsening downward - 1" layer pebbly siltstone **Siltstone** 20.7-20.8' - yellowish brown (10YR 5/4), bedding ~0° unweathered, weak **Sandstone** 20.8-23.0' - gray brown (10YR 5/2), fine grained, unweathered, weak, coarsening downward - trace granules 21.65-21.95'	R3 = 18.0-23' bgs 1417-1434 = 17 mins PID = 0.0 ppm for all fractures
23.0 25	R-4 5 ft 85		2 0 1 0 0	23.2-23.4' - minimal fracture zone, vertical, likely mechanical 23.55' - Fracture, 60 deg, rough, undulating, slight silty infill, no staining 23.7' - Fracture, 60 deg, rough, undulating, slight silty infill, no staining 24.05' - Mechanical break, horizontal 25.05' - Fracture, 50 deg, rough, undulating, slight silty infill, rust color staining 25.25-27.05' - Fracture zone ((>10), horizontal), likely mechanical break 26.35' - Fracture, 45 deg, rough, undulating, slight silty infill, rust color staining		**Sandstone** 23.0-23.25' - gray brown (10YR 5/2), fine grained, unweathered, weak, coarsening downward **Sandstone** 23.25-25.0' - dark yellowish brown (10YR 5/4), fine grained, slight mineral lamination observable **Sandstone** 25.0-27.25' - gray brown (10YR 5/2), fine grained, unweathered, weak, coarsening downward	R4 = 23.0-28.0' bgs 1444-1514 = 30 mins PID = 0.0 ppm for all fractures
28.0			-	28.15' - Mechanical break (horizontal)			R5 = 28.0-33.0' bgs 1523-1535 = 12 mins

PROJECT NUMBER: 474867.BV.02

BORING NUMBER: PZ-202 SHEET 3 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/25/14 09:40 | END : 7/29/2014 | LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
30	R-5 5 ft 100 (to 33.0)		-, -, -, -	28.45' - Mechanical break (horizontal) 29.05' - Mechanical break (horizontal) 29.85' - Mechanical break (horizontal)		**Sandstone** 28.0-33.0' - brown (10YR 4/3), fine to coarse grained, poorly sorted, slightly weathered, weak, subangular to subrounded, becomes fine to very coarse with 25% pebbles to 10 mm	PID = 0.0 ppm for all fractures
35	R-6 5 ft 94 (to 38.0)		-, 1, 1, 1, 1	33.5' - Mechanical break (horizontal) 34.25' - Fracture, 35 deg, along bedding, rough, planar, silty infill, rust color staining 35.75' - Fracture, 60 deg, smooth, undulating, across bedding, slight silty infill, minor rust staining, crossed by horizontal mechanical break at 35.75' 36.05' - Mechanical break (horizontal) 36.5' - Fracture, 30 deg, rough, undulating, silty infill, strong very dark brown staining 37.10' - Fracture (horizontal), 40 deg, possible mechanical break 37.20' - Fracture, 45 deg, smooth, undulating, moderate iron staining, possible slickensides 37.45' - Fracture, 45 deg, smooth, undulating, possible mechanical break		**Sandstone** 33.0-35.5' - brown (10YR 4/3), fine to coarse grained, poorly sorted, slightly weathered, weak, subangular to subrounded, becomes fine to very coarse with 25% pebbles to 10 mm **Siltstone** 35.5-37.7' - interbedded dark grayish brown (10YR 4/2), dark yellowish brown (10YR 4/4) and gray (7.5YR/6/1), some dark mineral orientation showing bedding, unweathered, weak	R6 = 33.0-38.0' bgs 1545-1605 = 20 mins
40	R-7 5 ft 102 (to 43.0)	95	1, 0, 0, 0, 0	38.0-38.2' - Fracture, 45 deg, no infill, black and orange staining 38.3', 41.1', 41.2', 41.4', 41.6', 41.7', 41.8', 42.0', 42.2', 42.5', 43.0' - Mechanical breaks		**Sandstone** 37.7-41.0' - olive brown (2.5Y 4/4), fine sand, subrounded to subangular, weak, no obvious bedding **Sandstone** 41.0-43.0' - olive brown (2.5Y 4/4), medium to coarse grained, subrounded to subangular, weak, no obvious bedding	7/28/14 R7 = 38.0-43.1' bgs 0728-0750 = 22 mins PID = 0.0 ppm for all fractures
45	R-8 5 ft 98 (to 48.0)	74	0, 0, 0, 1, 3	43.2' - Mechanical break 46.8-46.9' - Fracture, 20 deg, rough, planar, no staining 47.0-47.9', 47.2-47.6', 47.4-48.0' - Fractures (parallel), 75 deg, minor silt infill, some orange and black staining		**Sandstone** 43.1-44.2' - olive brown (2.5Y 4/4), coarse grained, subrounded to subangular, weak, no obvious bedding, contains ~25% pebble-sized angular fragments of gray igneous rock **Breccia** 44.2-45.0' - grayish brown (2.5Y 5/2),~40% coarse sand, ~60% angular fragments of brown and gray rock, pebble-sized, no bedding apparent, weak to medium hard	R8 = 43.1-48.0' bgs 0800-0816 = 16 mins PID = 0.0 ppm for all fractures
			1				R9 = 48.0-53.0' bgs 0830-0853 = 23 mins

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PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-202	SHEET 4 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/25/14 09:40 — END : 7/29/2014 — LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
50	R-9 5 ft 100 (53.0)	90	1, 1, 0, 0	48.5-48.8', 49.36-50.1' - Fractures (parallel), 75 deg, smooth, planar, no infill, black stains 50.9-51.2' - Fracture, 60 deg, smooth, planar, no infill, black staining 51.7' and 52.3' - Mechanical breaks		**Sandstone** 45.0-48.0' - olive brown (2.5Y 4/4), coarse grained, subrounded to subangular, weak, no bedding obvious, contains ~25% pebble-sized angular fragments of gray igneous rock **Sandstone** 48.0-53.0' - olive brown (2.5Y 4/4), fine sand, subrounded to subangular, weak, darker staining from 48.6-49.6', diffuse, parallel to bedding	PID = 0.0 ppm for all fractures
55	R-10 5 ft 100 (58.0)	88	0, 1, 2, 0, 0	54.8' - Fracture, <10 deg, smooth, planar, silt infill (1mm), orange staining 2 mm into rock on either side 55.1' - Fracture, 15 deg, smooth, planar, black staining 55.3-55.5' - Fracture, 45 deg, smooth, planar, silt/clay infill, black and orange staining 57.2' - Mechanical break		**Sandstone** 53.0-58.0' - olive brown (2.5Y 4/4), fine to medium grained, subangular to subrounded, weak, slightly weathered	R10 = 53.0-58.0' bgs 0902-0911= 9 mins PID = 0.0 ppm for all fractures
60	R-11 5 ft 106 (63.0)	100	0, 1, 0, 0, 0	59.4-59.5' - 30 deg, smooth, planar, no infill, orange and black staining		**Sandstone** 58.0-63.0' - olive brown (2.5Y 4/4), fine to medium grained, subangular to subrounded, weak, slightly weathered	R11 = 58.0-63.0' bgs 0922-0932= 10 mins PID = 0.0 ppm for all fractures
65	R-12 5 ft 100 (68.0)	100	1, 1, 0, 2, 2	63.7-64.0', 64.2-64.6', 66.9-67.2', 67.3-67.6' - Fractures, 60 deg, rough, angular, no infill, orange and black staining 65.0' - Mechanical break 66.3-66.4', 66.35-66.45' - Fractures, 15 deg, smooth, planar, no infilling, orange stains		**Sandstone** 63.0-68.0' - grayish brown (2.5Y 5/2), medium grained, slightly weathered, subangular to subrounded, no bedding visible, weak to medium strong	R12 = 63.0-68.0' bgs 0942-0957= 15 mins PID = 0.0 ppm for all fractures
			0				R13 = 68.0-73.0' bgs 1010-1018 = 8 mins

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PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-202 SHEET 5 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling LOCATION : SSFL, Ventura County CA

ELEVATION : DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 ORIENTATION : Vertical

WATER LEVELS : --- START : 7/25/14 09:40 END : 7/29/2014 LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
70	R-13 5 ft 100 73.0	100	3, 0, 0, 0	69.4-69.5' - Fracture, 30 deg, smooth, planar, silt infill, orange staining 69.6-70.0' - Fracture, 70 deg, smooth, undulating, no infill or staining 69.8-69.9' - Fracture, 30 deg, smooth, planar, no infill or staining		**Sandstone** 68.0-73.0' - grayish brown (2.5Y 5/2), medium to coarse grained, coarsening with depth, slightly weathered, subangular to subrounded, no bedding visible, weak to medium strong	PID = 0.0 ppm for all fractures
75	R-14 5 ft 96 78.0	100	1, 1, 0, 1, 2	73.6-73.7' - Fracture, 45 deg, rough, undulating, minor silt infill, orange staining 74.8-74.9' - Fracture, 30 deg, rough, planar, no infilling, orange and black staining 75.8-76.4' - Fracture, 70 deg, smooth, undulating, silt and clay infill, orange and green stains 77.3-77.5' - Fracture, 60 deg, smooth, undulating, no infill, minor orange staining		**Sandstone** 73.0-77.8' - grayish brown (2.5Y 5/2), medium to coarse grained, slightly weathered, subangular to subrounded, no bedding visible, weak to medium strong - zones of pebbles from 76.6-76.9' bgs, dipping ~40°	R14 = 73.0-78.0' bgs 1026-1039 = 13 mins PID = 0.0 ppm for all fractures
80	R-15 5 ft 104 83.0	84	4, 6, 2, 3, 1	77.6-77.8' - Fracture, 80 deg, smooth, undulating, clay and gypsum (?) infill 77.8-78.2' - Fracture, 75 deg, smooth, planar, silt infill, minor black and orange staining 78.5', 78.65', 78.7', 79.2', 79.25' - Fractures, 20 deg, rough, undulating, no infill, minor orange and black staining 79.2', 79.45', 79.5', 79.95' - Fractures, 45 deg, smooth, planar, no infill, abundant orange stains 80.78', 80.82' - Fractures, 10 deg, smooth, undulating, no infill, orange stains 81.3' - Fracture, 20 deg, rough, planar, no infill or staining 81.55' and 81.85' - Fractures (parallel), 45 deg, minor silt infill, minor orange and black staining 82.1-82.5' - Fracture, 75 deg, smooth, undulating, no infill, minor orange staining 82.5-83.0' - multiple mechanical breaks in silt/claystone		**Sandstone** 77.8-80.85' - grayish brown (2.5Y 5/2), medium to coarse grained, slightly weathered, subangular to subrounded, no bedding visible, weak to medium strong **Sandstone** 80.85-82.45' - grayish brown (2.5Y 5/2), medium grained, slightly weathered, subangular to subrounded, no bedding visible, weak to medium strong **Claystone** 82.45-82.8' - bluish gray (GLEY2 4/5B, shiny shearing surfaces visible throughout, randomly oriented bedding plane at ~40° **Siltstone** 82.8-83.0' - olive brown (2.5Y 4/4), multiple fractures in several directions, orange stains on each	R15 = 78.0-83.0' bgs 1049-1108 = 17 mins PID = 0.0 ppm for all fractures
85	R-16 5 ft 96 88.0	100	4, 0, 3, 0, 0	83.0-83.3', 83.1-83.4', 83.8-84.2', 84.8-85.3'' - Fractures, ~70 deg, smooth, planar, no infill, strong orange staining 83.35', 85.1' - Fractures, 10 deg, rough, undulating, no infill, minor orange staining 85.6-85.9' - Fracture, 60 deg, rough, undulating, no infill, minor orange staining		**Sandstone** 83.0-86.1' - gray (2.5Y 5/1), fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent	R16 = 83.0-87.8' bgs 1117-1130 = 13 mins PID = 0.0 ppm for all fractures
			0				R17 = 87.8-92.6' bgs 1140-1150 = 10 mins

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202	SHEET 6 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- START : 7/25/14 09:40 END : 7/29/2014 LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
90	R-17 5 ft 96 (to 93.0)	100	1, 1, 3, -	89.5-89.8', 89.9-90.3', 91.1-91.4' - Fractures, ~75 deg, smooth, planar, no infill, orange staining 91.4-91.6', 91.7-92.0', 92.2-92.5' - Fractures, ~60-70 deg, smooth, planar, minor silt infill, much orange staining		**Sandstone** 86.1-87.8' - olive brown (2.5Y 4/4), medium to coarse grained, slightly weathered, moderately hard, angular to subrounded grains - increased granules and pebbles of gray rock from 86.7-87.8' bgs **Sandstone** 87.8-89.0' - olive brown (2.5Y 4/4), medium to coarse grained, slightly weathered, moderately hard, angular to subrounded grains	R16 = 83.0-87.8' bgs 1117-1130 = 13 mins
95	R-18 5 ft 100 (93.0–98.0)	60	2, 3, 1, 3, 3	93.0-93.3', 94.7-94.95', 96.2-96.5', 96.4-96.7', 96.5-96.8', 97.0-97.3', 97.3-97.6', 97.5-97.8' - Fractures, 70 deg, rough, planar, no infill, orange and black stains 93.5-93.6', 94.5-94.6', 94.9-95.0', 95.6-95.8' - Fractures, 30 deg, rough, undulating, minor silt infill, minor orange staining		**Sandstone** 89.0-91.1' - gray (2.5Y 5/1), fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent **Sandstone** 91.1-92.6' - olive brown (2.5Y 4/4), medium to coarse grained, slightly weathered, moderately hard, angular to subrounded grains **Sandstone** 93.0-98.0' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent	R18 = 93.0-98.0' bgs 1256-1312 = 16 mins PID = 0.0 ppm for all fractures
100	R-19 5 ft 98 (98.0–103.0)	58	10+, 1, 4, 10+, 10+	98.0-98.3' - multiple fractures, various directions, rough, undulating, no infill, orange stains 98.6-98.8', 98.9-99.0', 99.8-100.0', 100.1-100.3', 100.3-100.4', 100.8-101.0', 101.6-101.8', 101.8-102.0', 102.7-102.9' - Fractures, 45 deg, smooth, undulating, silt infill, orange and black staining 100.9-101.0' - Fracture, 10 deg, rough, undulating, no infill, orange and black stains 101.8-102.1' - multiple fractures, various directions, rough, undulating, orange stains		**Sandstone** 98.0-100.8' - gray (2.5Y 5/1), fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent **Sandstone** 100.8-102.9' - olive brown (2.5Y 4/4), fine to medium grained, subangular to subrounded, weak, slightly weathered	R19 = 98.0-103.3' bgs 1312-1330 = 18 mins PID = 0.0 ppm for all fractures
105	R-20 5 ft 100 (103.0–108.0)	64	10+, 7, 5, 0, 1	103.0-103.6' - many fractures, varying angles, smooth, planar, no infill, orange and black staining 103.8-103.9, 104.0-104.1', 104.1-104.2', 104.3-104.4', 104.5-104.6', 104.6-104.7', 104.9-105.0', 105.2-105.3', 105.3-105.4', 105.9-106.0', 107.9-108.0' - Fractures, 30 deg, rough, undulating, minor silt infill, orange and black stains 104.4-104.8', 105.2-105.7', 105.6-106.1' - Fractures, 70 deg, smooth, planar, abundant orange and black stains		**Siltstone** 103.0-103.5' - dark grayish brown (2.5Y 4/2), slightly weathered, moderately strong, fine lamellae visible **Sandstone** 103.5-104.0' - olive brown (2.5Y 4/3), fine grained, subrounded to subangular, slightly weathered, moderately strong, no bedding visible **Sandstone** 104.0-108.0' - olive brown (2.5Y 4/3), medium to coarse grained, subrounded to subangular, slightly weathered, moderately hard, coarser layers visible - dipping ~40º at 105.5-105.8' bgs - gray from 106.9-107.8' bgs	R20 = 103.0-108.0' bgs 1340-1350 = 10 mins PID = 0.0 ppm for all fractures
	(108.0)		1				R21 = 108.0-113.0' bgs 1404-1411 = 7 mins

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/25/14 09:40 | END : 7/29/2014 | LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS – SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
110	R-21 5 ft 100 (113.0)	76	1, 2, 4, 3	108.0-108.1', 109.6-109.7', 110.2-110.3', 110.8-110.9', 111.1-111.2', 111.3-111.4', 111.7-111.8', 111.9-112.0', 112.2-112.3', 112.3-112.4', 112.9-113.0' - Fractures, rough, planar, no infill, some black staining		**Sandstone** 108.0-113.0' - olive brown (2.5Y 4/3), medium to coarse grained, subrounded to subangular, slightly weathered, moderately hard, coarser layers visible - angular granules and pebbles at 109.5-109.9' bgs	PID = 0.0 ppm for all fractures
115	R-22 5 ft 100 (118.0)	100	1, 0, 1, 1, -	113.0-113.1' - Fracture, 30 deg, rough, planar, no infill, orange and black stains 115.4-115.7 and 116.0-116.3' - Fractures (parallel), 70 deg, rough, planar, no infill, black and orange staining 117.7' - Mechanical break		**Sandstone** 113.0-118.0' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent	R22 = 113.0-118.0' bgs 1422-1431 = 9 mins PID = 0.0 ppm for all fractures
120	R-23 5 ft 100 (123.0)	94	0, 0, 0, 2, 1	121.6-121.7', 121.85-121.95', 122.2-122.3' - Fractures, 15 deg, rough, planar, some silt infill, orange and black surface stains		**Sandstone** 118.0-123.0' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent	R23 = 118.0-123.0' bgs 1445-1453 = 8 mins PID = 0.0 ppm for all fractures
125	R-24 5 ft 106 (128.0)	100	2, 1, 1, 1, -	123.7' and 123.95' - Fractures, <10 deg, rough, undulating, no infilling, white mineral stain 124.1-124.2' - Fracture, 30 deg, rough, undulating, no infill, white mineral stain 125.6' and 126.9' - Fractures, 10 deg, rough, undulating, no mineral stains 127.4' and 128.0' - Mechanical breaks		**Sandstone** 123.0-124.1' - olive brown (2.5Y 4/3), medium to coarse grained, subrounded to subangular, slightly weathered, moderately hard, coarser layers visible **Conglomerate** 124.1-125.2' - gray, 60% pebble size angular fragments of gray rock, 40% coarse sand, moderately hard **Sandstone** 125.2-128.3' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent	R24 = 123.0-128.0' bgs 1505-1518 = 13 mins PID = 0.0 ppm for all fractures
			0				R25 = 128.0-133.0' bgs 1530-1540 = 10 mins

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202	SHEET 8 OF 8

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- START : 7/25/14 09:40 END : 7/29/2014 LOGGER : R. Lucich, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
130	R-25 5 ft 102	100	2, 0, 1, 1	129.7-129.3', 129.75-129.85', 131.1-131.2', 132.3-132.4' - fractures along bedding planes, 30 deg, smooth, planar, no infill, some orange staining		**Sandstone** 128.3-129.1' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent **Sandstone** 129.1-131.1' - gray (2.5Y 5/1), fine grained, subangular to subrounded, slightly weathered, moderately hard, fine bedding noted, dipping ~30º	PID = 0.0 ppm for all fractures
133.0							
135	R-26 5 ft		2, 0, 0, 0, 2	133.3-133.4' - fractures along bedding planes, 30 deg, smooth, planar, no infill, some orange staining 133.4-133.5', 137.3-137.4', 137.8-137.9' - Fractures, 30 deg, smooth, planar, no infill or staining		**Sandstone** 131.1-132.4' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent **Sandstone** 132.4-133.4' - gray (2.5Y 5/1), fine grained, subangular to subrounded, slightly weathered, moderately hard, fine bedding noted, dipping ~30º **Sandstone** 133.4-134.3' - gray (2.5Y 5/1), fine grained, subangular to subrounded, slightly weathered, moderately hard, fine bedding noted, dipping ~30º	R26 = 133.0-138 1553-1603 = 10 mins PID = 0.0 ppm for all fractures
138.0							
140				138.1' - Fracture (horizontal), smooth, planar, no infill or staining		**Sandstone** 134.3-137.6' - mottled gray and olive brown, fine to medium grained, subrounded to subangular, slightly weathered, moderately hard, no bedding apparent **Sandstone** 137.6-138.8' - gray (2.5Y 5/1), fine grained, subangular to subrounded, slightly weathered, moderately hard, fine bedding noted, dipping ~30º Bottom of Boring at 138.0 ft bgs on 7/29/2014	TD = 138.0' bgs 7/29/14 - Borehole to be abandoned due to stuck augers downhole. Will re-core at PZ-202a.
145							

PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-202a SHEET 1 OF 9

SOIL BORING LOG

PROJECT : NASA SSFL BVE Drilling LOCATION : SSFL, Ventura County CA

ELEVATION : DRILLING CONTRACTOR : Gregg Drilling

DRILLING EQUIPMENT AND METHOD : HQ Wireline, CME-850

WATER LEVELS : --- START : 7/30/2014 END : LOGGER : K. Remmen

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	SAMPLE RECOVERY (%)	SAMPLE TYPE	ANALYTICAL METHOD	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0				Surface casing set at 8.0' bgs		Note: Between 0.0-138.0'; this log will only note fractures/lithology of interest or significant departures from original P2-202 log. Unless stated otherwise, sandstone is olive brown (2.5Y 4/4) or similar. Using Munsell soil color chart, and Sand-Gauge chart 1984 by U.F. McCollough
5							
					Begin Rock Coring at 8.0 ft bgs See the next sheet for the rock core log		
10							
15							
20							

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202a	SHEET 2 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/30/2014 — END : 8/1/2014 — LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
8.0–13.0 (10)	R-0 5 ft 0	0	-	8-13' - no core recovered, driller noted soft material			
13.0–18.0 (15)	R-1 5 ft 93	78	0 3 0 0 10+	14.0-14.5' - fracture, vertical (70%), rough, undulating, rust colored staining, 2 ~20 deg fractures along bedding planes 16.9-17.3' - Fracture zone, 70 deg (1), 30 deg (10+), rough, undulating, greenish and reddish silty infill, 30 deg fractures along bedding planes and concentrated in yellowish brown siltstone		**Sandstone** 13.0-18.0' - sandstone throughout, except: **Siltstone** 17.1-17.35' - same as 16.5-16.6' in original PZ-202 corehole	
18.0–23.0 (20)	R-2 5 ft 102	100	-	18.0-23.0' - Mechanical breaks		**Sandstone** 18.0-23.0' - sandstone throughout	5.1' recovery
23.0–28.0 (25)	R-3 5 ft 98	88	0 1 2 10+ 0	24.6-24.8' - Fracture, 30 deg, rough, undulating, rust colored staining 25.65-26.1' - Fractures, 70 deg (1), 30 deg (1), smooth, undulating, silty infill, bluish green and rust colored staining 26.6-27.1' - Fracture zone, 75 deg (1), horizontal to 30 deg (10+), smooth, undulating, thick silty clay infill, bluish green and rust colored staining		**Sandstone** 23.0-28.0' - sandstone throughout, zones of bluish-green/greenish gray discoloration (GLEY1 6/5G-1) between 24.0-25.0', 25.5-26.0', 26.3-27.3'	

PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-202a SHEET 3 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/30/2014 | END : 8/1/2014 | LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
30	R-4 5 ft 71 (to 33.0)	100	-	28.0-33.0' - Mechanical breaks		**Sandstone** 28.0-33.0' - sandstone throughout, coarse with ~15% granules	
35	R-5 5 ft 100 (33.0-38.0)	86	1, 0, 1, 0, 10+	33.65-33.8' - Fracture, 45 deg, smooth, undulating, brown clayey silt infill, dark grayish staining 35.9-36.1' - Fracture, 60 deg, rough, undulating, rust colored staining 37.2-38.0' - Fracture zone, 45 deg (2), horizontal to 30 deg (10+), smooth, undulating, slightly silty infill, rust colored staining, many are on bedding planes		**Sandstone** 33.0-36.8' - coarse with ~15% granules and trace pebbles **Siltstone** 36.8-38.0' - likely same as 35.5-37.7' on original corehole log, but more like a sandy siltstone (~40-50% very fine sand)	
40	R-6 5 ft 100 (38.0-43.0)	81	2, 0, 0, 1, 0	38.0-38.2' - Fractures (2), 45 deg, smooth, undulating, brownish rust colored staining 41.25-41.6' - Fracture, 60 deg, smooth, undulating, slight silty infill, some dark gray staining		**Sandstone** 38.0-42.4' - coarse with ~15% granules and trace pebbles, coarsens gradually to fine sandstone - ~10% granules and trace pebbles from 42.1-42.4' **Sand (SP)** 42.4-43.0' - medium to very coarse, loose, subangular	
45	R-7 5 ft 100 (43.0-48.0)	100	0, 0, 1, 0, 0	45.25-45.4' - Fracture, 45 deg, rough, undulating, rust colored staining		**Sandstone** 43.0-48.0' - sandstone throughout, medium to very coarse, approximately 10% granules and 10% pebbles from 44.0-48.0'	

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/30/2014 | END : 8/1/2014 | LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS – SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
50	R-8 5 ft 83 53.0	100	0 0 3 0 0	50.6-50.9' - Fracture, 60 deg (1), smooth, undulating, slight rust colored staining, perpendicular 30 deg mechanical breaks (2)		**Sandstone** 48.0-53.0' - sandstone throughout, very fine to fine, trace pebbles from 48.0-48.3' - ~80% pebbles from 48.3-49.2'	
55	R-9 5 ft 94 58.0	94	0 1 3+ 1 0	54.5-54.7' - Fracture, 45 deg, rough, undulating, silty infill, black and rust colored staining 55.8-56.2' - Fracture zone, 60 deg (1), vertical (2+; likely mechanical breaks), horizontal mechanical breaks (10+), 60 deg fracture is smooth, undulating, rust colored staining 56.9-57.1' - Fracture, 30 deg, smooth, undulating, silty/clayey infill, black and rust colored staining		**Sandstone** 53.0-58.0' - sandstone throughout - dark gray and rust colored banding/discoloration from 56.75-57.4'	
60	R-10 5 ft 76 63.0	100	-	58.0-63.0' - Mechanical breaks		**Sandstone** 58.0-63.0' - sandstone throughout, medium grained from 58.0-60.4' - very fine to fine from 60.4' downward (to 63.0')	7/31/14 water level before drilling = 32.0' bgs
65	R-11 5 ft 118 68.0	80	-	63.0-68.0' - Mechanical breaks		**Sandstone** 63.0-64.1' - very fine to fine grained **Sand (SP)** 64.1-64.3' - light olive brown (2.5Y 5/3), medium grained, loose, subangular, trace fines **Sandstone** 64.3-64.8' - very fine to fine grained **Sand (SP)** 64.8-66.1' - greenish gray (GLEY1 5/5GY), medium grained, loose, subangular, trace fines	top 1.2' of this run is from R10 (61.8-63.0')

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202a	SHEET 5 OF 9

CH2MHILL

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/30/2014 — END : 8/1/2014 — LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
70	R-12 5 ft 94 (73.0)	100	1, 0, 0, 0, 1	68.65-68.75' - Fracture, 30 deg, rough, undulating, rust colored staining and greenish discoloration ~ 1" surrounding 72.0-72.15' - Fracture, 45 deg, rough, undulating, slight silty clay infill, rust colored and greenish discoloration/ staining		**Sandstone** 66.1-67.6' - very fine to fine grained **Sandstone** 68.0-73.0' - sandstone throughout, medium to very coarse grained	
75	R-13 5 ft 105 (78.0)	100	-			**Sandstone** 73.0-78.0' - sandstone throughout, medium to very coarse - ~30% granules and trace pebbles from 74.0-78.0' (coarsens with depth)	upper 0.25' belongs to R12 interval (72.75-73.0')
80	R-14 5 ft 73 (83.0)	66	4, 1, 4, 10+, 0	78.2-78.3' - Fracture, 45 deg, rough, undulating, slight clay infill, rust colored staining 78.6-79.2' - Fracture zone, 45 deg (1), 80 deg (1), 60 deg (1), rough, undulating, slight silty infill, rust colored staining 79.8-79.9' - Fracture, 45 deg, smooth, undulating, silty infill, rust colored staining 80.3-80.4' - Fracture, 30 deg, rough, undulating, silty sandy infill, rust colored staining 80.7-80.9' - Fractures (3), 70 deg (1), 15 deg (1), 30 deg (1), rough, undulating, silty sandy infill, rust colored staining 81.25-81.5' - Fracture zone, 30 deg (10+), multiple vertical mechanical breaks, smooth, undulating, sandy infill, rust colored staining		**Sandstone** 78.0-83.0' - sandstone throughout, medium to very coarse, ~30% granules and trace pebbles from 78.0-78.7'	Driller: soft material near end of run
85	R-15 5 ft 100 (88.0)	92	0, 0, 0, 10+, 0	86.3-86.8' - Fracture zone, ~70 deg (10+), 0-30 deg (10+), smooth, undulating, sandy infill, black and rust colored staining		**Sandstone** 83.0-88.0' - sandstone throughout - some greenish gray (GLEY1 5/10GY) discoloration between 86.0-87.0'	

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-202a	SHEET 6 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling
LOCATION : SSFL, Ventura County CA
ELEVATION :
DRILLING CONTRACTOR : Gregg Drilling
CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850
ORIENTATION : Vertical
WATER LEVELS : ---
START : 7/30/2014
END : 8/1/2014
LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
90	R-16 5 ft 106 93.0	100	1 0 0 0 0	88.3-88.5' - Fracture, 45 deg, smooth, undulating, silty infill, dark rust colored and blackish staining		**Sandstone** 88.0-93.0' - sandstone throughout - fine to coarse, ~10% granules and 10% pebbles between 88.6-90.2'	
95	R-17 5 ft 100 98.0	95	0 0 0 0 1	97.3-97.45' - Fracture, 30 deg, rough, undulating, slight silty infill, rust colored staining		**Sandstone** 93.0-98.0' - sandstone throughout, gradual color change from grayish brown (2.5Y 5/2) to dark gray (GLEY1 4/N) between 93.0-94.1' - dark gray from 94.1-98.0', all fine to very coarse	
100	R-18 5 ft 90 103.0	91	0 0 0 0 2	102.0-102.2' - Fracture, 60 deg, rough, undulating, dark rust colored staining 102.3-102.4' - Fracture, 30 deg, smooth, undulating, thick clayey silt infill, dark brown staining		**Sandstone** 98.0-103.0' - sandstone throughout,dark gray (GLEY1 4/N) - olive brown discoloration between 99-9-100.1', 100.5-101.0'	
105	R-19 5 ft 104 108.0	77	1 10+ 0 10+ 4	103.0-103.1' - Fracture, 30 deg, smooth, undulating, silty infill, some dark yellowish staining 103.8-104.4' - Fracture zone, vertical (3), 30 deg (10+), smooth, undulating, thick silty infill, yellowish/rust colored staining 106.3-106.75' - Fracture zone, 30 deg (10 +), vertical (10+), rough, undulating, sandy infill, rust colored staining, some may be mechanical breaks along bedding planes		**Sandstone** 103.0-108.0' - sandstone throughout, dark gray (GLEY1 4/N) - vertical ~1" thick silty sand layer between 103.9-104.2' - zones of olive brown discoloration between 105.7-106.7' and 107.0-107.4'	

PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-202a SHEET 7 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/30/2014 | END : 8/1/2014 | LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
110	R-20 5 ft 98 113.0	80	1 1 2 1 0	107.2-108.0' - Fracture zone, 30 deg (3), 80 deg (1), rough, undulating, rust colored staining 108.2-108.3' - Fracture, 15 deg, rough, undulating, dark rusty/black staining 109.9-110.1' - Fracture, 45 deg, rough, undulating, dark rusty/black staining 110.2-110.4' - Fractures (2), 15 deg, rough, undulating, dark rusty/black staining 111.0-111.1' - Fracture, 15 deg, rough, undulating, dark rusty/black staining		**Sandstone** 108.0-113.0' - back to olive brown color, medium to coarse with trace granules	
115	R-21 5 ft 84 118.0	69	0 1 1 0 10+	114.2-114.5' - Fracture, 60 deg, rough, undulating, rust colored and dark gray staining 115.5-116.5' - Fracture, 80 deg, rough, undulating, silty infill, rust colored staining, broken up by multiple horizontal mechanical breaks 116.9-118.0' - Fracture zone, 70 deg (10 +), 30 deg (10+), rough, undulating, silty infill, rust colored staining, broken up by multiple horizontal mechanical breaks		**Sandstone** 113.0-118.0' - sandstone throughout, medium to very coarse with ~10% granules, trace pebbles	8/1/14 water level before drilling = 110.0' bgs rig chattering
120	R-22 5 ft 104 123.0	100	0 1 0 0 0	119.3-119.35' - Fracture, 15 deg, rough, undulating, rust colored staining ~1" surrounding fracture		**Sandstone** 118.0-123.0' - sandstone throughout, dark gray (GLEY1 4/N), color transition zone from olive brown to dark gray brown from 118.0-118.3', fine to very coarse with ~10% granules, 5% pebbles	upper 0.3' likely from R21 interval (117.7-118.0')
125	R-23 5 ft 74 128.0	51	3 3 2 10+ 0	123.1-123.3' - Fractures (2), horizontal (1), 30 deg (1), rough, undulating, dark rust and blackish staining 123.95', 124.25', 124.45' - Fractures, 15 deg, rough, undulating, sandy infill, rust colored staining 124.65-124.75', 125.3-125.4' - Fractures, 30 deg, rough, undulating, rust colored staining 125.15' - Fracture, horizontal, sandy infill, rust colored staining 126.3-126.7' - Fracture zone, vertical/~80 deg (1), 60 deg (1), 30 deg (10+), rough, undulating, sandy infill, brown staining		**Sandstone** 123.0-124.0' - sandstone throughout, dark gray (GLEY1 4/N), fine to very coarse with ~10% granules, 5% pebbles **Conglomerate** 124.0-125.5' - olive brown, pebbly **Sandstone** 125.5-128.0' - sandstone throughout, dark gray (GLEY1 4/N), fine to very coarse with ~10% granules, 5% pebbles	Driller: losing a lot of water to formation

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PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-202a SHEET 8 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling LOCATION : SSFL, Ventura County CA

ELEVATION : DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 ORIENTATION : Vertical

WATER LEVELS : --- START : 7/30/2014 END : 8/1/2014 LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
130	R-24 5 ft 106 133.0	77	10+ 10+ 2 0 0	127.75-127.8' - Fracture, 15 deg, rough, undulating, dark rust colored staining 128.5-129-2' - Fracture zone, vertical/70 deg (10+), 30-45 deg (10+), smooth, undulating, silty infill, dark rust colored staining 130.3-130.4', 130.9-131.0' - Fractures, 30 deg, rough, undulating, rust colored staining		**Sandstone** 128.0-128.5' - dark gray (GLEY1 4/N) with zones of olive brown discoloration between 127.7-128.0' 128.5-130.7', and 131.1-131.2', very fine silty sandstone between 131.7-133.0' with randomized dark gray (GLEY1 4/N) to very dark gray (GLEY1 3/N) banding	upper 0.3' likely from R23 interval (127.7-128.0') NOTE: add 0.2' to all fracture depths in this run, ruler was off
135	R-25 5 ft 98 138.0	90	0 0 3 2 0	135.4-136.9' - Fracture zone, 70 deg, (2), 30 deg (2), 45 deg (1), smooth, undulating, no infill, rust colored staining		**Sandstone** 133.0-134.0' - dark gray (GLEY1 4/N) to very dark gray (GLEY1 3/N) banding, very fine silty sandstone **Sandstone** 134.0-137.9' - dark gray (GLEY1 4/N), fine to medium with trace granules	Driller: no longer losing as much water
140	R-26 5 ft 102 143.0	65	0 0 10+ 10+ 10+	140.1-140.8' - Fracture zone, 80 deg to vertical (2), 30 deg (10+), 45 deg (10+),, smooth, undulating, 30 deg fractures follow bedding planes and are smooth and planar, slight silty infill, blackish staining 141.1-141.2', 141.6-141.7' - Bedding plane fractures, 30 deg, smooth, planar, slight silty infill, rust colored staining 141.8-142.2' - Fracture zone, 80 deg (1), 30 deg (10+), smooth, undulating, 30 deg fractures follow bedding planes and are smooth and planar, slight silty infill, blackish staining 142.25-142.35', 142.4-142.5', 142.6-142.7' - Fractures, 30 deg, smooth, planar, slight silty infill, rust colored staining		**Sandstone** 137.9-139.1' - dark gray (GLEY1 4/N), very fine to fine grained, thin bedding oriented 30º alternating to very dark gray (GLEY1 3/N), subangular, slightly weathered, weak, sound **Silty Clay (CL)** 139.1-139.4' - very dark gray (GLEY1 3/N), dry, firm to very hard, low plasticity **Sandstone** 139.4-143.0' - olive brown (2.5Y 4/3), very fine to fine grained, thin bedding oriented 30º, subangular, slightly weathered, discolored to light olive brown (2.5Y 5/3) between 139.5-139.7, dark gray (GLEY1 4/N) zones between 140.9-141.3', 142.5-142.6', no apparent bedding between 142.6-143.0'	Note: returning to full logging from this point forward R26 1251-1315 = 24 min upper 0.1' likely from R25 interval (137.9-138.0') PID = 0.0 ppm in all fractures
145	R-27 5 ft 100 148.0	48	4 10+ 10+ 10+ 1	143.3-143.6' - Fractures (4), 30 deg, smooth, undulating, slight silty infill, rust colored staining 144.1-144.6' - Fracture zone, 80 deg/vertical (2), horizontal to 30 deg (10+), few horizontal fractures may be mechanical breaks, silty sandy infill, rust colored staining		**Sandstone** 143.0-145.0' - dark gray (GLEY1 4/N), very fine to fine grained, subangular, slightly weathered, discolored **Sandstone** 145.0-148.0' - olive brown (2.5Y 4/3), fine to very coarse with trace	R27 1325-1345 = 20 mins sample collected at 144.9-145.4' (FD) PID = 0.0 ppm in all fractures

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PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-202a	SHEET 9 OF 9

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/30/2014 — END : 8/1/2014 — LOGGER : K. Remmen

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES — DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY — ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS — SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
150	R-28 5 ft 92	51	1 2 4 10+ 1	147.3-147.4' - Fracture, 30 deg, rough, undulating, slight silty/sandy infill, rust colored staining 147.6' - Mechanical break (horizontal) 148.1-148.5' - Fracture, 70 deg, rough, undulating, no infill, rust colored staining 149.3-149.4' - Fracture, 45 deg, rough, undulating, sandy infill, rust colored staining 149.55' - Fracture, ~10 deg, rough, undulating, sandy infill, rust colored staining 149.8' - Mechanical break (horizontal) 150.05' - Mechanical break (horizontal) 150.3' - Fracture, ~10 deg, rough, undulating, sandy infill, rust colored staining 150.4-150.5', 150.7-150.8', 150.8-150.9' - Fractures, 30 deg, smooth, undulating, slight silty infill, rusty staining		granules, no apparent bedding, slightly weathered, weak, moderately fractured, ~10% granules, 10% pebbles from 146.0-146.4', dark gray (GLEY1 4/N) between 146.4-148.0' **Sandstone** 148.0-148.1' - dark gray (GLEY1 4/N), fine to very coarse with trace granules, no apparent bedding, slightly weathered, weak, moderately fractured **Conglomerate** 148.1-149.5' - ~70% pebbles with fine to medium sandstone matrix, no apparent bedding, slightly weathered, strong, moderately fractured	R28 1st 2.0': 2:04-2:09 last 3.0': 2:40-2:50 = 15 mins (stopped to refill water truck) PID = 0.0 ppm in all fractures
153.0 155	R-29 5 ft 94	68	10+ 10+ 1 1 1	151.1-151.7' - Fracture zone, horizontal to vertical (10+), rough, undulating, sandy infill, dark rust colored staining 152.5-152.6 - Fracture, 45 deg, rough, undulating, sandy infill, rust colored staining 153.45-154.2' - Fracture zone, 80 deg (1), 60 deg (10+), 30 deg (10+), rough, undulating, rust colored staining 154.2', 154.6' - Mechanical breaks (horizontal) 154.9-155.05' - Fracture, 30 deg 155.9' - Fracture, rough, undulating, rust colored staining 156.2' - Mechanical break (horizontal) 156.2-156.9' - Fracture zone, vertical/75 deg (1), 30 deg (2; likely mechanical breaks), rough, undulating, sandy infill, rust colored staining 157.3-157.35' - Mechanical break, 15 deg 157.65-157.7' - Fracture, 15 deg, rough, undulating, rust colored staining		**Sandstone** 149.5-152.6' - olive brown (2.5Y 4/3), ~10% granules - trace pebbles from 151.8-152.6 **Sandstone** 153.0-154.6 - olive brown (2.5Y 4/3), fine to very coarse with ~20% granules, dark gray (GLEY1 4/N) from 154.6-155.7 **Conglomerate with Sandstone Matrix** 155.7-157.7' - ~70% pebbles with fine to medium sandstone matrix, no apparent bedding, slightly weathered, strong, moderately fractured	R29 PID = 0.0 ppm in all fractures sample collected at 152.2-156.6'
158.0 160 165						Bottom of Boring at 158.0 ft bgs on	

	PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-203	SHEET 1 OF 11

SOIL BORING LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

DRILLING EQUIPMENT AND METHOD : HQ Wireline, CME-850

WATER LEVELS : --- | START : 7/15/2014 | END : 7/24/2014 | LOGGER : K. Remmen

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	SAMPLE RECOVERY (%)	SAMPLE TYPE	ANALYTICAL METHOD	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	0				**Overburden: Silty Sand with Gravel (SM)** 0.0-7.0' - (10YR 5/4), dry, loose, fine grained to coarse, gravel up to 1.5 cm, well graded		Note: Using Munsell soil color chart, and Sand-Gauge chart 1984 by U.F. McCollough
5							
					Silty Sand (SM) 7.0-12.0' - (10Y 4/2), dry, loose, fine grained, poorly graded		
10							
					Begin Rock Coring at 12.0 ft bgs See the next sheet for the rock core log		
15							
20							

PROJECT NUMBER: 474867.BV.02

BORING NUMBER: PZ-203

SHEET 2 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling

LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION :

DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850

ORIENTATION : Vertical

WATER LEVELS : ---

START : 7/15/2014

END : 7/24/2014

LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
12.0–13.0	R-1 1 ft 17	0	0			surface casing set at 12.0' bgs R1 = 2 min - 10 gals R2 = 9 min - 45 gals
13.0–18.0 (15)	R-2 5 ft 71	60	1, 0, 0, 10+, N/A	13.4-13.5' - Fracture, horizontal, rough, planar, sandy disintegrated infill 15.6', 15.9' - Mechanical breaks 16.0-16.2' - Fracture zone, rough, undulating, sandy infill	**Sandstone** 12.83-13.0' - dark grayish brown (2.5Y 4/2), medium grained, no apparent bedding, subangular, slightly weathered, discolored **Sandstone** 13.0-16.5' - dark gray (5Y 4/1), very fine to fine grained from 13.0-13.4', medium to coarse grained from 13.4-16.5', and trace granules (13.4-16.5'), unweathered to slightly weathered, disintegrated at 13.4-13.5', 16.0-16.2', weak, sound	
18.0–23.0 (20)	R-3 5 ft 70	60	1, 1, 0, 1, 3	18.8' - Fracture, horizontal, rough, undulating 19.7-20.1' - Fracture, 60 deg, rough, undulating, brownish-yellow staining 20.6' - Mechanical break 21.6-22.2' - Fractures (4), 60 deg (1), 30 deg (3), brownish yellow staining, 60 deg are rough, undulating, 30 deg are smooth, planar	**Sandstone** 18.0-21.5' - dark gray (5Y 4/1), med to very coarse grained, slightly weathered and discolored at 18.3-18.7' and 19.2-16.6', very fine to fine grained at 18.3-18.7' and 19.2-19.6' 21.0-21.2' - siltstone, olive gray (5Y 4/2), laminae on 30º, discolored, 30% clay	R3 = 22 min - 110 gals 1355 sample taken at 19.6-19.85' PID = 0.0 ppm
23.0–28.0 (25)	R-4 5 ft 97	43	4, 2, 0, 1, 10+	23.25', 23.45', 23.65', 23.8', 24.0', 24.2' - Fractures, horizontal, rough, undulating, rust colored staining 24.4' - Mechanical break 26.55-27.2' - Fracture, 70 deg to 80 deg, rough, undulating, orientation of bedding is 30 deg opposing 27.2-27.25' - Fracture zone, 15 deg to 20 deg, rough, undulating, reddish brown staining 27.25-27.85' - Fracture, vertical, rough, undulating	**Sandstone** 23.0-26.5' - olive gray (5Y 4/2), medium to very coarse grained, no apparent bedding, subangular, slightly weathered, discolored from 25.4-26.5', weak, sound **Sandstone** 26.5-27.85' - dark greenish gray (GLEY1 4/1) on inside of core, olive (5Y 5/3) staining on outside of core, no apparent bedding, very fine grained with 10-15% silt, subangular, slightly weathered	R4 = 16 min - 80 gals PID = 0.0 ppm at mechanical break 1420 sample collected at 27.25-27.6' PID = 0.0 ppm R5 = 5 min - 60 gals
28.0– (30)	R-5 5 ft 32	0	10+, 10+, -, -	28.0-29.6' - Fracture zone, vertical (2), 80 deg (10+), rough, undulating, sandy infill, reddish brown staining	**Sandstone** 28.0-29.6' - dark greenish gray (GLEY1 4/5GY), medium to coarse grained, no apparent bedding, subangular, moderately weathered, reddish brown staining	

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-203 SHEET 3 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/15/2014 — END : 7/24/2014 — LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS – SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	33.0		-				Driller: chatter at 30.5-33.0' difficulty pulling core barrel, driller had to pull rods Driller: chatter due to apparatus above core barrel coming slightly unscrewed R6 = 15 min - 75 gals PID = 0.0 ppm at 33.7'
35	R-6 5 ft 88 38.0	78	1 2 3 1 0	33.3' - Fracture, horizontal, smooth, planar, no infilling 33.6-33.8' - mechanical break (hammer) 34.0' - Fracture, horizontal, smooth, planar, no infilling 34.1-34.5' - Fracture, 50 deg, rough, planar, black stain 34.5' - Fracture, horizontal, smooth, planar, 1-2 mm silt/clay infill (loose) 34.85-34.9' - Fracture, 10 deg, smooth, undulating, similar fractures at 35.4' and 35.8-35.9' and 36.35-36.4'		**Sandstone** 33.0-38.0' - olive brown (2.5Y 4/3), medium to coarse grained, increasing pebbles downward to 40% subangular pebbles at 36.2', subangular, slightly weathered, weak, medium to thick bedding	finished drilling for the day at 1730 at 38.0'
40	R-7 5 ft 98 43.0	100	0 0 0 0 0	38.15' 38.34', 38.59', 38.87', 40.48', 40.71', 41.0', 41.66', 41.95', 47.08', 42.40' - Mechanical breaks, horizontal, planar 39.65-39.72' - Fracture, 15 deg, smooth, undulating, no infilling or staining, mechanical break (?)		**Sandstone** 38.0-43.0' - light olive brown (2.5Y 5/4), medium to coarse grained in upper 0.9' (38.0-38.9'), fine to medium grained below (38.9-43.0'), subangular to subrounded, slightly weathered, medium to thick bedding, weak rock	R7 = 13 min - 65 gals begin drilling 7/18/14 WL = 33.75' TD = 36.62' rig chattering ad surface casing has a leak; circulated water coming up on sides of casing; casing shaking with drilling operations
45	R-8 5 ft 48.0		0 0 0 1 2	43.15' - Fracture, horizontal, smooth, planar, mechanical break 45.7' - mechanical break (hammer) 46.7-47.1' - Fracture, 70 deg, smooth, planar, gray clay infilling, 1 mm thick, orange staining and black dendritic stains, crumbles under mild pressure		**Sandstone** 43.0-48.0' - olive brown (2.5Y 4/3), quartz/feldspar, medium to very coarse, dominated by medium sand 43.0-44.5', coarse to very coarse 44.5-48.0' - 1.5" diameter by 1/4" thick clast at 44.2', gray chert - 2.5' diameter by 3/4" thick clast of brown volcanic or metamorphic rock	R8 = 15 min - 75 gals both clasts oriented length wise ~35º from horizontal sample taken at 46.9-47.4'
50	R-9 3 ft 22 51.0	0	0 1 -	47.1' and 47.2' - Fractures (2), 20 deg, rough, planar, discontinuous brown silt infill 48-51' - core consists of five pieces from 3/4-2.0" long, separated by 3 horizontal fractures that appear to be mechanical 1 x 60 deg fracture, smooth, planar, infilled with olive clay 1/8-1/4" thick, orange and black stains		**Sandstone** 48.0-51.0' - (olive brown (2.5Y 4/3)), medium to coarse, trace granules, weak	R9 = 10 min - 50 gals no core longer than 20º, possibly due to incompetent bedrock
	R-10		10+	51.0-52.0' - Fracture zone, 0-30 deg (10+), 60 deg (1), smooth and undulating (continued on next page)			R10 = 1 min - 5 gals

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PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-203 SHEET 4 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 ORIENTATION : Vertical

WATER LEVELS : --- START : 7/15/2014 END : 7/24/2014 LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY – ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS – SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	2 ft 83 (53.0)	28	2	(continued) rust colored staining on single 60 deg fracture at 51.5-51.65', 0-30 deg all likely mechanical breaks		**Silty Sandstone** 51.0-51.55' - dark greenish gray (GLEY1 4/10GY), silt to very fine sand, medium weathered, yellow brown staining, moderately fractured	
			10+	52.0-52.1' - Fracture, 30 deg, rough, undulating, brownish staining 52.5-52.6' - Fracture (30), rough, undulating, yellowish brown staining		**Sandstone** 51.55-52.65' - olive (5Y 4/3), very fine to fine sand, slightly weathered, yellow brown staining, distinct yellowish brown stain at 52.15', angled at 30º, weak, slightly fractured	R11 = 8 min - 40 gals (5 gpm) 1302-1310
			1	53.0-53.5' - very broken, but at least 2 x 30 deg fractures apparent, rough, planar, calcite or gypsum filling (white, 1-2 mm) to no filling			
55	R-11 5 ft 100	76	0	53.6' - Mechanical break (horizontal)			
			1	53.8-53.95' - Fracture, 45 deg, smooth, planar, no filling 54.3-54.5' - Fracture, 45 deg, rough, undulating, no infill or staining		**Sandstone** 53.0-58.0' - olive brown (2.5Y 4/3), quartz and feldspar, fine to medium grained at 53.0-54.6', medium to coarse at 54.6-58.0', slightly weathered, weak to medium strength, thick bedding, fining upwards	
	(58.0)		10+	54.85', 55.15', 56.0', 56.35' - Mechanical breaks, horizontal 56.35-56.75' - 60 deg fracture, smooth, planar, gray clay infill with orange stains on surface			
			10+	56.9, 57.15' - Mechanical break, horizontal 57.55-58.0' - core broken in multiple pieces, but one 30 deg fracture apparent, smooth, planar, orange staining on surface		**Sandstone** 58.0-60.2' - dark greenish gray (GLEY1 4/10Y), medium to very coarse grained, increasing granules at 60.0', chert pebbles (trace), weak	R12 = 22 min - 110 gals (maybe less) 1323-1345
60			6	58.0-59.0' - fractures and mechanical breaks (10+), 0-45 deg, some with 1 mm clay and orange staining			
	R-12 5 ft 95	48	1	59.0-59.2' - Fracture, 75 deg, rough, undulating, no staining or infill		**Sandstone** 60.2-63.0' - olive brown (2.5Y 4/3), fine to medium grained, subangular to subrounded, weak, thick to medium bedding	
			1	59.2-59.4' - Fracture, 45 deg, perpendicular to fracture at 59.0-59.2, rough, undulating, orange staining			
	(63.0)		1	59.5-60.2' - Fracture zone (3-4 apparent), 75 deg to 45 deg, rough, undulating, 1-2 mm gray clay infill with orange stains			
			4	60.5' - Mechanical break, horizontal 60.8-61.0' - Fracture, 50 deg, rough, undulating, no infill, orange stains		**Sandstone** 63.3-65.4' - olive brown (2.5Y 4/3), fine to medium grained from 63.0-63.9', fine to very coarse from 63.9-65.4' with trace granules, little pebbles at 64.6-64.9', subangular, slightly weathered, yellowish staining from 63.0-63.7', weak, slightly to moderately fractured	R13 = 14 min - 70 gals 1419-1433 Driller: producing a lot of water, unsure weather a water-bearing formation hit, or excess water in fractures from previous runs
65			2	61.45' - Mechanical break, horizontal			
	R-13 5 ft 48	48	2	61.8-62.3' - Fracture, 70 deg, rough, planar, calcite or gypsum infill (1-2 mm), tan clay infilling (1 mm), black dendritic and orange staining			
			N/A	63.3', 63.6', 63.75', 63.9', 64.2', 64.35', 65.3' - Mechanical breaks, horizontal			Note: excluding mechanical breaks from RQD calculation
	(68.0)		N/A	65.3-65.4 - Mechanical break, 30 deg, rough, undulating			PID = 0.0 ppm at mechanical break
			1	68.4', 68.8', 69.3', 71.4', 71.9', 72.4', 72.8' - Mechanical breaks, horizontal 68.9-69.1' - Fracture, 45 deg, planar, slickensides, clay infilling with black dendritic staining		**Sandstone** 68.0-73.0' - olive brown (2.5Y 4/3), fine to medium, slightly weathered, weak, massive except for thin bedding or staining from 69.4-69.8'	R14 = 22 min less ~10 for discussion with driller = 12 mins, ~40-60 gals water 1517-1539 sample taken at 68.7-69.1' PID = 0.0 ppm at mechanical break (69.3')
70			0				
	R-14 5 ft 100	98	0				
			0				

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-203	SHEET 5 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- — START : 7/15/2014 — END : 7/24/2014 — LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	73.0		0				
75	R-15 5 ft 100 78.0	100	0 0 0 0 0	73.3', 73.6', 74.1', 74.8', 75.3', 75.6', 76.1', 76.3', 76.5', 76.8', 76.9', 77.1', 77.25', 77.5', 77.7' - Mechanical breaks, horizontal 73.2-73.4' - Fracture, 45 deg, smooth, planar, no infill, some black staining 73.5-73.6' - Fracture, 30 deg, smooth, planar, no infill or staining		**Sandstone** 73.0-78.0' - olive brown (2.5Y 4/3), fine to medium, slightly weathered, weak, thin bedding or stains from 73.2-74.3'	R15 = 11 min, ~ 55 gals 1604-1615 WL before drilling 7/21 = 74.3'
80	R-16 3 ft 87 81.0	100	0 1 0	78.1', 78.2', 78.35', 78.53', 78.7', 78.9', 79.1', 79.35', 79.9', 80.4' - Mechanical breaks, horizontal 79.7-79.8' - Fracture, 60 deg, rough, undulating, no staining		**Sandstone** 78.0-80.6' - olive brown (2.5Y 4/3), fine to medium grained, no apparent bedding, subangular, slightly weathered, rust colored staining from 79.0-79.2', weak, moderately fractured	R16 = 10 min - 50 gals 0910-0920 sample collected 79.55-79.85' at 1120 drill rig chattering Driller: unknown issue with air circulation down hole "air not coming back up", pulling out rods PID = 0.0 ppm at mechanical break
	R-17 2 ft 90 83.0	100	0 1	81.35', 81.5', 81.75', 82.05', 82.25', 82.35', 82.55', 82.8' - Mechanical breaks, horizontal 82.6-82.7' - Fracture, 60 deg, rough, undulating, no staining		**Sandstone** 81.0-82.8' - olive brown (2.5Y 4/3), fine to medium grained, no apparent bedding, subangular, slightly weathered, coarsens slightly from 82.0-82.8', no staining	R17 = 7 min - 35 gals 1125-1132 PID = 0.0 ppm difficulty removing core barrel, driller pulling rods
85	R-18 5 ft 5 88.0	0	0 N/A N/A N/A N/A	83.05', 83.15' - Mechanical breaks (horizontal)		**Sandstone** 83.0-83.25' - dark gray (GLEY1 4/N), medium to very coarse grained with approximately 20-25% granules, no apparent bedding, subangular	R18 = 15 min - 75 gals 1330-1345 drill rig chattering Driller: drill moved through run very quickly only 3 pieces recovered, all <1.5" diameter, driller needed to pull rods again to retrieve core barrel; appears to be issue with coupling
90	R-19 2.5 ft 0 90.5	0	N/A N/A	88.0-90.0' - no recovery, possible fracture zone		**No Recovery** 88.0-90.0'	R19 no recovery, appears to correlate with log for nearby HAR-19 losing water to formation
	R-20 2.5 ft	0	N/A	90.0-93.0' - no recovery		**No Recovery** 90.0-93.0'	R20 = 7 min - 35 gals no recovery Driller: losing water to formation

PROJECT NUMBER:	BORING NUMBER:
474867.BV.02	PZ-203 SHEET 6 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- START : 7/15/2014 END : 7/24/2014 LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES — DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY — ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS — SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	0 93.0						
95	93.0–97.0 R-21 4 ft 0	0	N/A	93.0-97.0' - no recovery		**No Recovery** 93.0-97.0'	R21 = 30 min - 150 gals no recovery 0415-0445 PID = 16.8 ppm at mechanical break 99.5-99.7'
	97.0–99.5 R-22 2.5 ft 114	19	4 2 3	97.0-97.2' - Fractures (2), vertical, rough, undulating, yellow brown staining 97.2' - Mechanical break,horizontal, 97.2-97.45' fracture, vertical, rough, undulating, yellow brown staining 97.4-97.45' - Fracture, 30 deg, rough, undulating 97.95-98.05' - Fracture, 30 deg, rough, undulating 98.1-99.6' - Fracture zone, vertical (1), 60 deg (2), 30 deg (1), 30-60 deg mechanical breaks (3), rough, undulating, clayey to sandy infill, yellowish brown staining, hydroalteration present on vertical fracture surface, vertical fracture extends from 98.1-99.6'		**Sandstone** 97.0-99.35' - light olive brown (2.5Y 5/3), fine to medium grained, coarsening with depth, subangular, no apparent bedding, slightly weathered, discolored, weak **Sandstone** 99.35-99.85' - predominately dark greenish gray (GLEY1 4/5GY), fine to very coarse grained, subangular, no apparent bedding, slightly weathered, discolored, weak	WL before drilling on 7/22 = 87.4' R22 = 8 min - 40 gals 1017-1025 Rig chattering Driller: feels like going through cobbles pulling rods again change bit collect samples: 99.0-99.5', 99.5-99.7' PID = 93.0 ppm at mechanical break (hammer) at 99.0-93.0' PID = 4.4 ppm at 60 fracture from 99.4-99.6' PID = 16.8 ppm at mechanical break at 99.5-99.7'
100	99.5–102.0 R-23 2.5 ft 94	66	0 1 0	100.15-100.7' - Fracture, vertical/80 deg, rough, undulating, clayey infill, yellow-orange staining		**Sandstone** 99.85-99.95' - predominately dark greenish gray (GLEY1 4/5GY), fine to very coarse grained, subangular, no apparent bedding, slightly weathered, discolored, weak **Sandstone** 99.95-102.3' - light olive brown (2.5Y 5/3), medium to very coarse grained with approximately 10% granules, distinct bedding from 100.9-102.3' at 30°, conglomerate pebble beds with interstitial fine to medium sands at 100.9-101.1' and 101.45-101.8', very dark grayish brown (2.5Y 3/2) banding from 101.8-102.3', weak sound	R23 = 22 min - 110 gals 1038-1100 PID = 0.0 ppm at mechanical break (hammer) at 100.1
105	102.0–107.0 R-24 5 ft 99	85	N/A 1 1 1 2	102.45' - Mechanical break, horizontal 103.0-103.15' - Fracture, 30 deg, rough, undulating, medium yellowish staining 103.4', 107.05' - Mechanical breaks, horizontal 104.85-104.90' - Fracture, 15 deg, rough, undulating, rust colored staining 105.8-105.9' - Fracture, 30 deg, rough, undulating, silty clayey infill, rust colored staining 106.0-106.15' - Fracture, 45 deg, rough, undulating, silty clayey infill, rust colored staining 106.75-106.90' - Fracture, 45 deg, rough, undulating, silty clayey infill, rust colored staining		**Sandstone** 102.3-107.2' - light olive brown (2.5Y 5/3), medium to very coarse grained with approximately 10% granules, conglomerate bed at 103.0-104.7', dark greenish gray (GLEY1 4/5GY) bands from 105.0-105.65, 106.3-106.6', and 106.9-107.0'	R24 = 11 min - 55 gals 1130-1149 PID = 0.0 ppm at 104.55' (mechanical break) PID = 14.0 ppm at fracture at 104.85' sample taken at 104.9-105.2' PID = 0.0 ppm at 105.1' (mechanical break)
110	107.0–112.0 R-25 5 ft 101	73	1 0 1 2 1	107.95-108.05'' - Fracture, 45 deg, rough, undulating, some orange staining 109.85-109.90' - Fracture, 20 deg, smooth, planar, orange staining 1/8-1/4" into gray rock on either side of fracture 110.1-110.2' - Fracture, 15 deg, rough, undulating, irregular orange staining in surrounding rock		**Sandstone** 107.25-108.8' - light olive brown and dark greenish gray, medium to very coarse grained, subangular, slightly weathered, abundant pebbles size rock fragments in lower 6", weak to medium strong	R25 = 16 min - ~80 gals 1204-1220
	112.0						

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-203	SHEET 7 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : — DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 — ORIENTATION : Vertical

WATER LEVELS : --- START : 7/15/2014 END : 7/24/2014 LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT
	R-26 2.5 ft 16 (to 114.5)	0	0, 0, 0
115	R-27 2.5 ft 84 (to 117.0)	17	1, 3, 1
120	R-28 5 ft 106 (to 122.0)	88	1, 2, 1, 2, 1
125	R-29 5 ft 110 (to 127.0)	100	2, 0, 0, 1, 0
130	R-30 5 ft 104 (to 132.0)	100	2, 1, 0, 2, 3

DISCONTINUITIES – DESCRIPTION (DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS)

110.5-110.7' - Fracture, 45 deg, smooth, planar, orange surface staining, 1/8" thick clay infill
110.8-111.3' - Fracture, 75 deg, smooth, planar, gray clay infill 1/6" thick
111.85', 111.95', 110.9' - Mechanical break, horizontal
112.0' - Fracture, 75 deg, smooth, planar, gray clay infill 1/6" thick
112.25-112.65' - Mechanical breaks (10+)
114.5-114.85' - Fracture, vertical/~80 deg, perpendicular to bedding, smooth, undulating, no staining, mechanical breaks (10+)
115.0-115.2' - Fracture, vertical/~80 deg, rough, undulating, no staining
115.3' - Mechanical break, horizontal
115.3-115.5' - Fracture, 45 deg, perpendicular to bedding, smooth, planar, clay infill, no staining
115.7-116.1' - Fracture, vertical/~80 deg, rough, undulating, perpendicular to bedding, rust colored staining, multiple parallel, incomplete fractures
116.5-116.6' - Fracture, 30 deg, rough, undulating, silty clayey infill, rust colored staining, mechanical breaks (10+)
117.4', 117.5', 117.6', 122.0', 124.3', 117.4-117.7' and 117.8
118.1' - Fracture, 60 deg, rough, undulating, minor orange and black surface staining
118.5-118.6' - Fracture (parallel to bedding), 30 deg, smooth, planar, orange and black stains (minor)
119.2-119.3' - Fracture, 15 deg, smooth, undulating, orange/black stains
119.8-119.9' - Fracture, 15 deg, smooth, undulating, orange/black stains
120.3-120.4' - Fracture, 60 deg, rough, undulating, abundant black staining
122.0-122.1' - Fracture, 30 deg, rough, planar, abundant orange staining
122.3' - Fracture, 30 deg, rough, planar, orange staining
122.85', 123.2', 123.85', 126.55', 127.0', 127.9' - Mechanical breaks, horizontal
122.9-123.3' - Fracture, 75 deg, rough, planar, orange and black staining
125.1-125.2' - Fracture, 30 deg, rough, undulating, orange staining
127.2-127.55' - Fracture, 70 deg, rough, planar, very small calcite (?) crystals across surface, both sides
127.6-128.0', 128.7-129.1' - Fractures, 70 deg, rough, undulating, 1/16" clay infilling, no staining
130.0-130.15' - Fracture, 45 deg, rough, planar, silt infilling (1/16" thick)
130.4-130.8' - Fracture, 70 deg, rough, undulating, 1/16" clay infilling, no staining

SYMBOLIC LOG

LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)

Sandstone
108.8-112.25' - dark greenish gray (GLEY1 4/5G/1), fine to medium grained, subrounded to subangular, slightly weathered, weak to medium strong

Sandstone
112.25-112.65' - very dark bluish gray (GLEY2 3/5B), very fine to medium grained, no apparent bedding, subangular, highly weathered (likely mechanical)

Sandstone
114.5-114.9' - (very dark bluish gray (GLEY2 3/5B), very fine to medium grained, ~30º bedding, subangular, highly weathered

Sandstone
114.9-115.3' - dark greenish gray (GLEY1 4/5G/1), fine to medium grained, subrounded to subangular, slightly weathered, weak to medium strong

Siltstone
115.3-115.45' - very dark bluish gray (GLEY2 3/5B), bed oriented ~30º

Sandstone
115.45-115.9' - light olive brown (2.5Y 5/4), interbedded with very dark gray (2.5Y 3/1), very fine to medium grained, bedding ~30º, subangular, slightly weathered, weak, moderately fractured

Sandstone
115.9-116.6' - light olive brown (2.5Y 5/3), fine to medium grained, bedding ~30º, subangular, slightly weathered, weak, sound

Sandstone
117.0-122.3' - light olive brown (2.5Y 5/3), fine to medium grained, bedding ~30º, subangular, slightly weathered, weak, sound, coarser layer with very coarse sand at 118.25-118.5', dark bluish gray from 121.0-121.4'

Sandstone
122.3-127.0' - light olive brown to dark bluish gray, medium to coarse grained, lightly weathered, moderately strong, coarse zones with pebbles at 122.8-123.2', 123.6-123.8', 125.1-125.7'

Sandstone
127.0-132.5' - light olive brown to dark bluish gray, medium to coarse grained, lightly weathered, moderately strong, fine to medium grained at 130.132.0'

COMMENTS (SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.)

R26 = 40 min - 200 gals
Driller: hard drilling rig chattering
Driller: barrel o-ring busted, caused law recovery, replaced o-ring

R27 = 6 min - 30 gals
1520-1526

PID = 0.0 ppm in all fractures
sample collected at 115.7-116.2'
(1545)
R28 = 10 min (30-50 gpm)
1538-1548
PID = 0.0 ppm in all fractures

R29 = 13 min - 40-50 gals
1604-1617
PID = 0.0 ppm in all fractures

R30 = 7 min - ~30-35 gals
1630-1637
PID = 0.0 ppm in all fractures

PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-203	SHEET 8 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA (Bravo Area)
ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling
CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical
WATER LEVELS : --- | START : 7/15/2014 | END : 7/24/2014 | LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES — DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
135	R-31 5 ft 90 (137.0)	71	0, 0, 1, 4, 1	131.25', 131.35', 131.4-131.5' - Fractures, 30 deg, rough, planar, silt infill 131.6-131.9' - Fracture, 70 deg, smooth, planar, gypsum or calcite infilling 134.9-135.0' - Fracture, 60 deg, rough, undulating, silty clay infill, no staining 134.9-135.2' - fracture, vertical/~80 deg, rough, undulating, silty infill, rust colored staining 135.1-135.5' - Fracture, 60 deg, rough, undulating, clayey infill, no staining 135.2-135.4' - Fracture, 45 deg, rough, undulating, clayey infill, no staining 135.7-135.8' - Fracture, 30 deg, rough, undulating, clayey infill, no staining 136.1' - Mechanical break, horizontal 136.8-136.9' - Fracture, 30 deg, rough, undulating, clayey infill, yellowish staining		**Sandstone** 132.5-137.1' - light olive brown to dark bluish gray, medium to coarse grained, lightly weathered, moderately strong, coarse zones with pebbles at 133.6-135.2', 135.8-136.9'	7/23/14 DTW = 128.7' before day's drilling R31 = 10 min - 50 gals 0825-0835 PID = 0.0 ppm in mechanical break at 133.65' PID = 2.0 ppm in mechanical break at 134.25' PID = 11.5 ppm in fracture at 135.3' PID = 16.4 ppm in fracture at 135.7 collected sample (0900) 135.55-135.90'
140	R-32 5 ft 102 (142.0)	94	2, 0, 1, 1, 0	137.1-137.55' - Fracture, vertical/~80 deg, rough, undulating, silty clayey infill, yellowish red staining 137.8-137.9' - Fracture, 30 deg, rough, undulating, silty clayey infill, yellowish red staining 139.1-139.2' - Fracture, 45 deg, rough, undulating, silty infill, rust colored staining 140.15' - Fracture, horizontal, rough, undulating, yellowish/greenish staining		**Sandstone** 137.1-142.2' - light olive brown to dark bluish gray, medium to coarse grained, lightly weathered, moderately strong, coarse zones with pebbles at 137.1-138.8', 141.7-142.2', chert clast at 139.75'	R32 = 15 min - 75 gals PID = 1.3 ppm at fracture (137.1-137.55') PID = 0.0 ppm at fracture (137.8-137.9') PID = 2.7 ppm at fracture (139.1-139.2') collect sample at 139.7-140.3' (0945) PID = 71.5 ppm at fracture at 140.15'
145	R-33 5 ft 100 (147.0)	60	3, 10+, 3, 10+, 10+	142.6-142.9' - Fracture zone, horizontal (1), 45 deg (1), 30 deg (1), rough, undulating (horizontal, 45 deg), smooth, planar (30 deg), rust colored staining (horizontal, 45 deg) 143.4-143.8' - Fracture zone, horizontal (10+), rough, undulating, rust colored staining 144.3-144.45' - Fracture, 45 deg, rough, undulating, silty/clayey infill, rust colored staining 144.9-145.0' - Fractures (2), 30 deg, rough, undulating, rust colored staining 145.3-145.6' - Fracture zone, 70 deg (2), 45 deg (1), others (10+), rough, undulating, sandy/silty infill, rust colored staining 146.0-147.2' - Fracture zone, vertical (1), 45 deg (1), others (horizontal - 30 deg; 10+), rough, undulating, sandy infill		**Sandstone** 142.2-143.5' - dark gray (GLEY1 4/N), fine to very coarse with ~30% pebbles, no apparent bedding, subangular, slightly weathered, very dark gray (GLEY1 3/N) siltstone from 142.8-142.9' oriented ~30º **Siltstone** 143.5-143.8' - very dark gray (GLEY1 3/N), some black mottling, oriented roughly 20º **Sandstone** 143.8-147.2' - light olive brown (2.5Y 5/3), fine to coarse, trace granules, few dark gray (GLEY1 4/N) bands from 143.8-144.2' at ~45º, subangular, slightly weathered, weak, moderately fractured	R33 = 10 min - 50 gals 0917-0927 PID = 0.0 ppm in all fractures
150	R-34 5 ft 100 (152.0)	48	4, 1, 1, 5, 4	147.2-147.3' - Mechanical breaks (3) 147.45', 147.5' - Fractures, ~10 deg, rough, undulating, sandy infill, rust colored staining 147.7-147.8' - Fracture, 45 deg, parallel to bedding, rough, undulating, no infill, rusty staining 147.9' - Fracture, 30 deg, parallel to bedding, rough, undulating, no infill, rusty staining		**Sandstone** 147.2-152.2' - light olive brown (2.5Y 5/3), fine to coarse, trace granules, subangular, slightly weathered, weak, moderately fractured, distinct 45º thin bedding from 149.0-152.2', color alternates from light olive brown (2.5Y 5/3) to dark gray (GLEY1 4/N) from 149.0-149.7', few coarse pebbles from 149.1-149.2'	R34 = 8 min - 40 gals 0942-0950 PID = 0.0 ppm in all fractures

PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-203	SHEET 9 OF 11

CH2MHILL

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 ORIENTATION : Vertical

WATER LEVELS : --- START : 7/15/2014 END : 7/24/2014 LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES – DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CASING ROD DROPS, TEST RESULTS, ETC.
155	R-35 5 ft 100 157.0	62	10+ 1 1 10+ 10+	148.6-148.7', 147.2', 149.3', 150.0-150.1', 150.2-150.3', 150.5-150.6', 150.7-150.8', 150.75-150.85', 151.1-151.2', 151.3-151.4', 151.6-151.7', 151.8-151.9' - Fractures, ~10 deg, rough, undulating, sandy infill, rust colored staining 152.2-152.5' - Fracture zone, ranging horizontal to vertical/85 deg (10+), rough, undulating, silty clayey infill, rust colored staining 152.7-152.9' - Fracture zone, ranging horizontal to vertical/85 deg (10+), rough, undulating, silty clayey infill, rust colored staining 153.9-154.2' - Fractures (2), ~30 deg, rough, planar, silty/sandy infill, rust colored staining		**Sandstone** 152.2-157.2' - light olive brown (2.5Y 5/3), fine to coarse, trace granules, subangular, slightly weathered, weak, moderately fractured, chert clasts at 152.9, 154.4' and 156.55' (approximately 40-50 mm in width), trace pebbles from 155.6-156.6'	R35 = 13 min - 65 gals 1004-1017 PID = 0.0 ppm in all fractures Collect sample at 155.4-155.7 (1055)
160	R-36 5 ft 92 162.0	80	10+ 10+ 2 0 0	155.2-156.7' - Fracture zone, ranging from approximately horizontal to vertical/85 deg (10+), one prominent vertical/85 deg fracture from 155.7-156.3, all are rough and undulating, silty/sandy infill, rust colored staining, vertical fracture at 155.7-156.3' has spherical nodules on face 157.55-158.5' Fracture zone, horizontal (1), 45 deg (10+), vertical/80 deg (2), rough, undulating, some silty/sandy infill, rust colored staining 158.8', 160.75', 161.0' - Mechanical breaks, horizontal 159.2-160.1' - Fracture zone, vertical/75 deg (2), rough, undulating, sandy infill, rust colored staining		**Sandstone** 157.2-159.7' - light olive brown (2.5Y 5/3), medium to coarse with trace granules, approximately 10% pebbles from 159.0-159.7', large chert nodules (>50 mm) at 157.2' and 157.5', subangular, no apparent bedding, slightly weathered, discolored to dark gray (GLEY1 4/N) from 158.4-159.3', band of rust colored staining at 158.55', weak, moderately fractured **Sandstone** 159.7-162.0' - dark gray (GLEY1 4/N), medium to very coarse, ~15% granules, trace pebbles, subangular, no apparent bedding, slightly weathered, weak, slightly fractured, ~30º oriented greenish staining (GLEY1 5/10GY) and transition to light olive brown (2.5Y 5/3) at 161.85-162.0'	R36 1029-1052 PID = 0.0 ppm in all fractures
165	R-37 5 ft 54 167.0		2 10+ 10+ N/A N/A	160.4' - Fracture, ~15 deg, rough, undulating, silty/sandy infill, likely mechanical break, no staining 162.2-162.7' - Fractures (2), 60 deg (1), 30 deg (1), rough, undulating, silty infill, rust colored staining 162.9-164.7' - Fracture zone, horizontal (10+) to vertical (10+), rough, undulating, rust colored staining, some greenish staining at 163.3-163.7, prominent ~80 deg fracture from 162.9-163.4' with white to yellowish clayey infill that appears almost plasticity		**Sandstone** 162.7-167.0' - light olive brown (2.5Y 5/3), medium to coarse with trace granules, increasing coarse sand and pebbles from 163.4-167.0' from (~25%), subangular, no apparent bedding, slightly weathered	R37 = 17 min 1153-1210 PID = 0.0 ppm at fracture (162.3-162.6') PID = 16.8 ppm at fracture (162.9-163.4') collected sample at 163.0-163.4 (1245) PID = 0.7 ppm at fracture (163.6') PID = 0.1 ppm at fracture zone (164.5-164.7) Driller: lost core near the bottom
	R-38 2 ft 33 169.0	0	10+ N/A	167.0-167.4' - Fracture zone, horizontal (10+, likely mechanical breaks) to vertical/80 deg (10+), rough, undulating, rust colored staining 167.4-167.65' - Fracture, vertical/80 deg, rough, undulating, rust colored staining		**Sandstone** 167.0-167.4' - light olive brown (2.5Y 5/3), medium to coarse with trace granules, increasing coarse sand and pebbles (~25%), subangular, no apparent bedding, slightly weathered **Conglomerate with Sandstone Matrix** 167.4-167.65' - dark gray (GLEY1 4/N), approximately 75% pebbles, subangular, no apparent bedding, slightly weathered, very strong	R38 1315-1327 Driller: very hard drilling, need to change bit switched to water-only coring at 167.0', used 1800 gallons from 167.0-177.0'
170	R-39 3 ft 103 172.0	100	1 1 0	169.1', 170.2', 170.6' - Mechanical breaks 169.7-169.8' - Fracture, 30 deg, rough, undulating, yellowish brown staining 170.4' - Fracture, 30 deg, rough, undulating, yellowish brown staining			

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
474867.BV.02	PZ-203	SHEET 10 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling
LOCATION : SSFL, Ventura County CA (Bravo Area)
ELEVATION :
DRILLING CONTRACTOR : Gregg Drilling
CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850
ORIENTATION : Vertical
WATER LEVELS : ---
START : 7/15/2014
END : 7/24/2014
LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS
	R-40 5 ft 84		1	171.7-172.1' - Fracture zone, horizontal (10+) to vertical (10+), rough, undulating, likely mechanical breaks
			10+	172.25', 172.4', 172.5', 172.85', 173.05', 173.2', 173.3', 173.6', 173.9', 174.1', 174.65', 175.0' - Mechanical breaks, horizontal
175			1	172.6-172.7' - Fracture, 60 deg, rough, undulating, yellowish brown staining, black mottling
			1	173.4-173.7' - Fracture zone, 30 deg (10+) to vertical (10+), rough, undulating, silty infill, rust colored staining
	177.0		0	174.3-174.4' - Fracture, 60 deg, smooth, undulating, no infill, no staining 175.1-175.2' - Fracture, 30 deg, rough, undulating, silty infill, yellowish staining
	R-41 1.5 ft 106	N/A	N/A	177.0-178.6' - soft material, mechanical breaks throughout
	178.5		N/A	
	R-42 4.5 ft 64	100	0	178.6-178.85' - Fracture zone (10+), likely mechanical breaks
180			2	179.05' - Fracture, horizontal, rough, undulating, some silty infill, rust colored staining
			0	179.2', 179.35', 179.45', 179.65', 180.05', 180.25', 180.65', 181.05', 181.2' - Mechanical breaks, horizontal
			0	179.9' - Fracture, horizontal, rough, undulating, some silty infill, rust colored staining
	183.0		N/A	
	R-43 5 ft 76	92	0	183.0-186.0' - zone of mechanical breaks (10+), horizontal
185			0	
			0	
			1	186.5-186.7' - Fracture, 60 deg, rough, undulating, no staining
	188.0		N/A	
190				

LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS
Conglomerate with Sandstone Matrix 169.0-170.2' - dark gray (GLEY1 4/N), approximately 75% pebbles, subangular, no apparent bedding, slightly weathered, very strong, some calcite veins
Sandstone 170.2-172.1' - dark gray (GLEY1 4/N), medium to very coarse, ~15% granules, trace pebbles, subangular, no apparent bedding, slightly weathered, weak, slightly fractured, light olive brown (2.5Y 5/3) and greenish gray (GLEY1 5/10GY) discoloration from 171.9-172.1'
Sandstone 172.1-175.4' - dark gray (GLEY1 4/N), medium to very coarse, ~15% granules, trace pebbles, subangular, no apparent bedding, slightly weathered, weak, slightly fractured, light olive brown (2.5Y 5/3) zone between 172.2-173.2', fine to medium grained from 174.3-175.4, distinct zone of hydroalteration with crystallization (white to yellow brown) from 175.05-175.2' surrounded by approximately 0.1' of light olive brown discoloration
Silty Sandy Clay (CL) 175.4-176.2' - dark greenish gray (GLEY1 4/5GY), moist, low plasticity
Silty Sand 177.0-178.6' - greenish gray (GLEY1 5/10Y), very fine to fine, 25-50%, silt, wet, loose, subrounded
Sandstone 178.6-181.3' - dark gray (GLEY1 4/N), medium to very coarse, with ~10% granules, ~20% pebbles, coarsens with depth, no apparent bedding, subangular, slightly weathered, very stong, moderately fractured
Siltstone 181.3-181.55' - very dark gray (GLEY1 3/N), bed oriented ~45º, unweathered, weak
Siltstone 183.0-183.2' - very dark gray (GLEY1 3/N), bed oriented ~45º, unweathered, weak

COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
R39 = 38 min 1510-1548
no longer using air rig chattering
PID = 0.0 ppm in all fractures
R40 = 33 min 1605-1638
collect sample 175.0-175.4 (1730)
7/24/14 DTW = 147.4'
R41 = 5 min 0810-0815
soft material, RQD does not apply
R42 = 53 min 1130-1223
PID = 0.0 ppm in all fractures
R43 = 13 min 1235-1248
PID = 0.0 ppm in all mechanical breaks and fractures
collect sample at 186.5-186.9 (1420)

PROJECT NUMBER: 474867.BV.02	BORING NUMBER: PZ-203	SHEET 11 OF 11

ROCK CORE LOG

PROJECT : NASA SSFL BVE Drilling | LOCATION : SSFL, Ventura County CA (Bravo Area)

ELEVATION : | DRILLING CONTRACTOR : Gregg Drilling

CORING EQUIPMENT AND METHOD : HQ Wireline, CME-850 | ORIENTATION : Vertical

WATER LEVELS : --- | START : 7/15/2014 | END : 7/24/2014 | LOGGER : K. Remmen, J. Lindquist

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
						Sandstone 183.2-186.6' - dark gray (GLEY1 4/N), medium to very coarse, with ~10% granules, ~20% pebbles, coarsens to a conglomerate at ~184.2-186.6', conglomerate is same as that seen in 167.4-167.65', no apparent bedding, subangular, slightly weathered, very stong, moderately fractured	
195						**Sandstone** 186.6-186.8' - dark gray (GLEY1 4/N), fine to medium throughout with ~10% granules, ~20% pebbles, no apparent bedding, subangular, slightly weathered, very stong, moderately fractured	
						Bottom of Boring at 188.0 ft bgs on 7/24/2014	
200							
205							
210							

Appendix D
Summary of Air Rotary Drilling and Video Logging

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TABLE D-1

Summary of Air Rotary Drilling and Video Logging at PZ-201

Bravo Bedrock Vapor Extraction Treatability Study Summary

Date	Start Time	End Time	Start Depth (ft bgs)	End Depth (ft bgs)	Field Observations	Additional Downhole Video Observations
8/12/2014	13:20	13:32	0	19	Start Drilling	
8/12/2014	13:35	13:49	19	39		
8/12/2014	14:02	14:15	39	59	Rig chatter at 50 ft bgs	
8/12/2014	14:20	14:35	59	79	Rig chatter at 72 ft bgs	
8/12/2014	14:40	14:53	79	99		
8/12/2014	14:58	15:21	99	119	Slower drilling (harder rock) 105-119 ft bgs	
8/12/2014	15:24	15:44	119	139		Possible fracture at 126 ft bgs, large void within boring wall at 132 ft bgs
8/12/2014	15:49	16:04	139	159		Fractures at 150 ft bgs
8/12/2014	16:07	16:18	159	167	End Drilling; total borehole depth	Infilled fractures at 161 ft bgs

PID Detections

Date	Time	Depth (ft bgs)	Value Detected (ppm)		
			Breathing Zone	Top of Hole	Cuttings
8/12/2014	13:25	15	0.0	0.0	-
8/12/2014	13:42	23	0.0	0.0	-
8/12/2014	13:48	38	0.0	0.0	-
8/12/2014	14:04	44	0.0	0.0	-
8/12/2014	14:09	52	0.0	0.0	-
8/12/2014	14:20	60	0.0	0.0	-
8/12/2014	14:28	72	0.0	0.0	-
8/12/2014	14:32	75	0.0	0.0	-
8/12/2014	14:43	83	0.0	0.0	-
8/12/2014	14:46	86	0.0	0.0	-
8/12/2014	14:50	96	0.0	0.0	-
8/12/2014	14:59	100	0.0	0.0	-
8/12/2014	15:02	105	0.0	0.0	-
8/12/2014	15:11	111	0.0	0.0	-
8/12/2014	14:14	115	0.0	0.0	-
8/12/2014	15:20	118	0.0	0.0	-
8/12/2014	15:27	121	0.0	0.0	-
8/12/2014	15:32	127	0.0	0.0	-
8/12/2014	15:43	138	0.0	0.0	-
8/12/2014	16:03	157	0.0	0.0	-
8/12/2014	16:08	163	0.0	0.0	-
8/12/2014	16:15	165	0.0	0.0	-
8/12/2014	16:17	167	0.0	0.0	-

Notes:
Dominant lithology is sandstone
No groundwater present in borehole
ft bgs = feet below ground surface
PID = photoionization detector
ppm = parts per million

TABLE D-2

Summary of Air Rotary Drilling and Video Logging at PZ-204

Bravo Bedrock Vapor Extraction Treatability Study Summary

Date	Start Time	End Time	Start Depth (ft bgs)	End Depth (ft bgs)	Field Observations	Additional Downhole Video Observations
8/13/2014	09:20	10:25	0	19	Very hard material at 1.5 ft bgs, Rig chatter at 9 ft bgs, 5 minute break at 10:15 due to PID detection >30 ppm	Fractures and larger annulus at 12 ft bgs
8/13/2014	10:28	10:40	19	39		
8/13/2014	10:43	10:58	39	59		
8/13/2014	11:01	11:23	59	79		
8/13/2014	11:26	11:42	79	99		Large open fractures at 80 ft bgs
8/13/2014	11:45	12:10	99	119		Small fracture at 100 ft bgs
8/13/2014	13:15	13:37	119	139		
8/13/2014	13:40	14:04	139	159		
8/13/2014	14:07	14:15	159	165	Total borehole depth	

PID Detections

Date	Time	Depth (ft bgs)	Value Detected (ppm)		
			Breathing Zone	Top of Hole	Cuttings
8/13/2014	10:12	12	1.2	31.0	0.0
8/13/2014	10:25	16	0.2	1.0	0.0
8/13/2014	10:29	20	0.1	3.8	39.7
8/13/2014	10:35	29	0.5	1.0	8.9
8/13/2014	10:40	37	0.0	0.0	6.5
8/13/2014	10:46	49	0.0	0.0	6.8
8/13/2014	10:53	55	0.0	0.0	2.6
8/13/2014	11:02	61	0.0	0.0	6.1
8/13/2014	11:07	69	0.0	0.0	1.9
8/13/2014	11:17	74	0.0	0.0	1.6

Notes:

Dominant lithology is sandstone

No groundwater present in borehole

ft bgs = feet below ground surface

PID = photoionization detector

ppm = parts per million

TABLE D-3

Summary of Lithologic Logging and Video Logging at HAR-19

Bravo Bedrock Vapor Extraction Treatability Study Summary

Depth (ft bgs)	Lithology	Field Observations	Additional Downhole Video Observations
0	Clayey silty sandstone (0-20 ft bgs)		
20	Silty sandstone (20-30 ft bgs)		
30			
40			Very rough borehole (51-174 ft bgs)
60			
80		Quick drilling, possible fracture zone (87-89 ft bgs)	(none noted on video)
100			
120	Sandstone (30-220 ft bgs)		
140			
160		Saturated, poor cutting return and slow drilling (169 ft bgs)	Possible fractures at (163 and 171 ft bgs)
			Standing water (179 ft bgs)
180			Possible fracture (195 ft bgs)
200			
220		Total borehole depth (220 ft bgs)	

Notes:

ft bgs = feet below ground surface

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Appendix E
Well Completion Diagrams

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CH2MHILL	PROJECT NUMBER 474867.BV.02	WELL NUMBER PZ-201 SHEET 1 OF 1

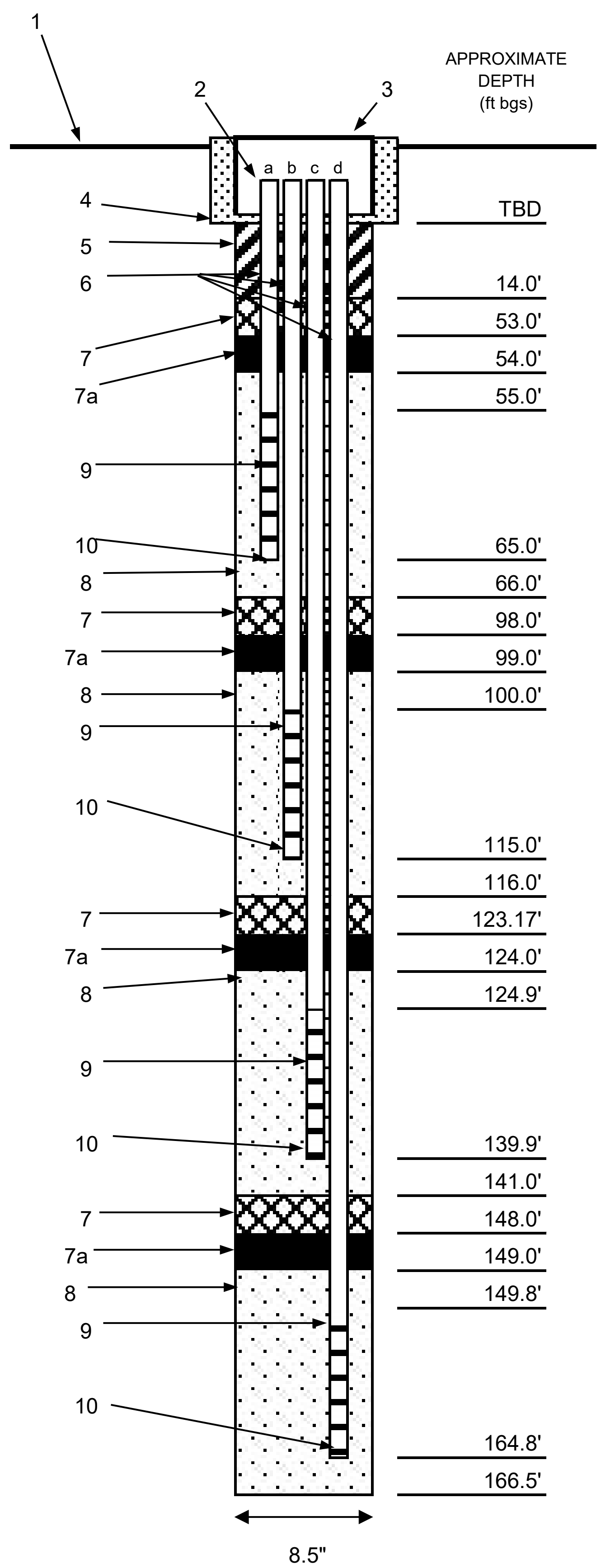
NESTED PIEZOMETER COMPLETION DIAGRAM

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County, CA

DRILLING CONTRACTOR : Gregg Drilling — COORDINATES : N 267252.4, E 1789425.7

DRILLING METHOD AND EQUIPMENT USED : HQ Wireline, CME-850

WATER LEVELS (ft bgs) : a: dry, b: 113.72', c: dry, d: 164.6' (8/21/14) — START : 8/21/14 — END : 10/30/14 — LOGGER : K. Remmen/LAC



1- Ground elevation at well:	1832.09 feet above mean sea level
2- Top of casing elevation:	TBD
3- Wellhead protection cover type:	12" flush-mounted well box (Emco Wheaton)
4- Concrete well vault diameter:	2 feet
5- Grout	Portland Cement/Bentonite Grout
a) Grout mix used:	(West Coast & QuikGel)
b) Method of placement:	Grout pipe
c) Quantities of materials used:	7 bags/0.25 bags
6- Diameter/type of well casing:	1" Schedule 80 Blank PVC
7- Type of seal and quantities used:	Bentonite Chips (Enviroplug Medium)/44 bags
7a	#8 Bentonite (Enviroplug)/2 bags
8- Type/quantity of filter material:	#3 Sand (Cemex Lapis Lustre)/49.5 bags
9- Screen type/slot size/details:	Schedule 80 PVC screen/0.020" slot size 10' screened intervals use single 10' slotted PVC section, 15' screened intervals use one 10' and one 5' slotted PVC section
10- End cap type/size:	PVC end cap/3" long
Centralizer type/depths:	Bow-spring, placed at bottom and top of screened intervals
Development:	
a) Method:	N/A
b) Duration:	N/A
c) Final field parameters:	N/A
b) Purged volume:	N/A

Comments:

1) Vapor piezometer cluster installed for Bedrock Vapor Extraction (BVE) Treatability Study (does not intersect the water table as of November 2014).

2) All material bags were 50 lbs, except Portland cement (47 lbs).

3) Probes placed on 8/21/14. Well vault constructed on 10/30/14.

ft bgs - feet below ground surface; N/A - not applicable; TBD - to be determined

CH2MHILL

PROJECT NUMBER	WELL NUMBER
474867.BV.02	PZ-202 SHEET 1 OF 1

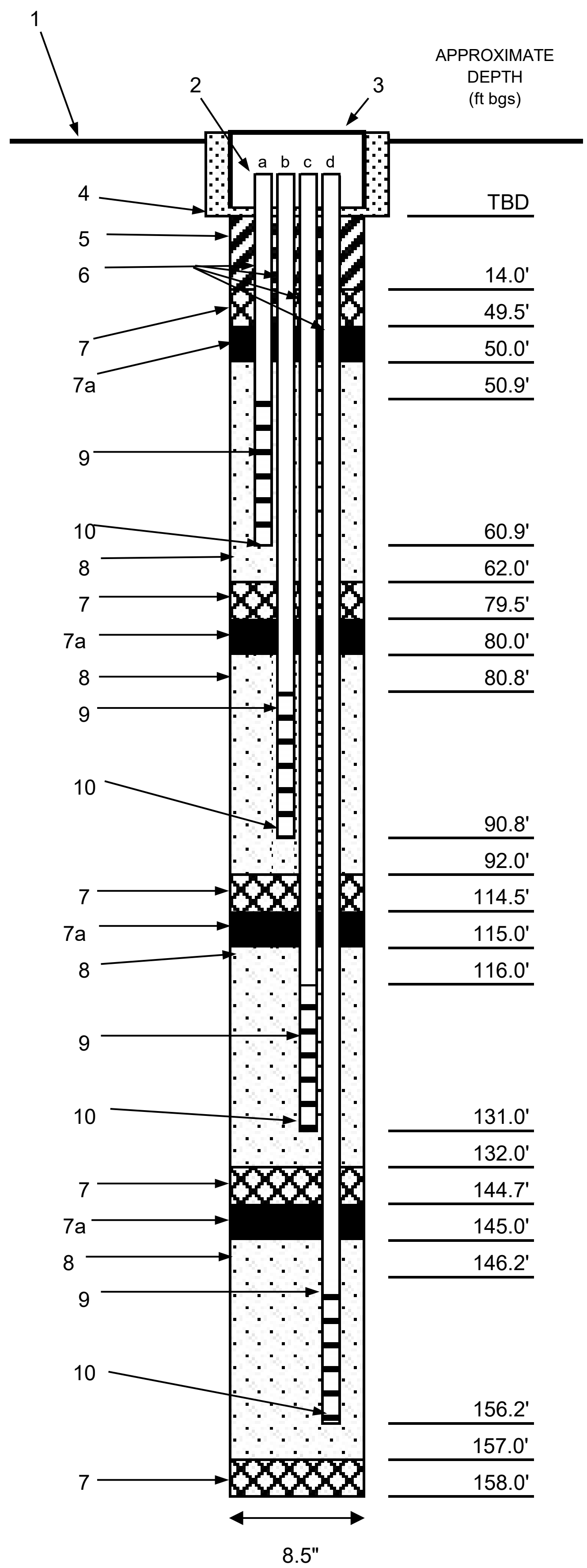
NESTED PIEZOMETER COMPLETION DIAGRAM

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County, CA

DRILLING CONTRACTOR : Gregg Drilling — COORDINATES : N 267161.5, E 1789435.2

DRILLING METHOD AND EQUIPMENT USED : HQ Wireline, CME-850

WATER LEVELS (ft bgs) : a: 60.76', b: 88.57', c: 127.6', d: dry (8/21/14) — START : 8/14/14 — END : 10/30/14 — LOGGER : K. Remmen/LAC



1- Ground elevation at well: 1829.28 feet above mean sea level

2- Top of casing elevation: TBD

3- Wellhead protection cover type: 12" flush-mounted well box (Emco Wheaton)

4- Concrete well vault diameter: 2 feet

5- Grout: Portland Cement/Bentonite Grout
- a) Grout mix used: (West Coast & QuikGel)
- b) Method of placement: Grout pipe
- c) Quantities of materials used: 7 bags/<0.25 bags

6- Diameter/type of well casing: 1" Schedule 80 Blank PVC

7- Type of seal and quantities used: Bentonite Chips (Enviroplug Medium)/42.5 bags

7a #8 Bentonite (Enviroplug)/2 bags

8- Type/quantity of filter material: #3 Sand (Cemex Lapis Lustre)/40 bags

9- Screen type/slot size/details: Schedule 80 PVC screen/0.020" slot size 10' screened intervals use single 10' slotted PVC section, 15' screened intervals use one 10' and one 5' slotted PVC section

10- End cap type/size: PVC end cap/3" long

Centralizer type/depths: Bow-spring, placed at bottom and top of screened intervals

Development:
- a) Method: N/A
- b) Duration: N/A
- c) Final field parameters: N/A
- b) Purged volume: N/A

Comments:

1) Vapor piezometer cluster installed for Bedrock Vapor Extraction (BVE) Treatability Study (does not intersect the water table as of November 2014).

2) All material bags were 50 lbs, except Portland cement (47 lbs).

3) Probes placed from 8/14/14 - 8/15/14. Well vault constructed on 10/30/14.

ft bgs - feet below ground surface; N/A - not applicable; TBD - to be determined

PROJECT NUMBER	WELL NUMBER
474867.BV.02	PZ-203 SHEET 1 OF 1

CH2MHILL

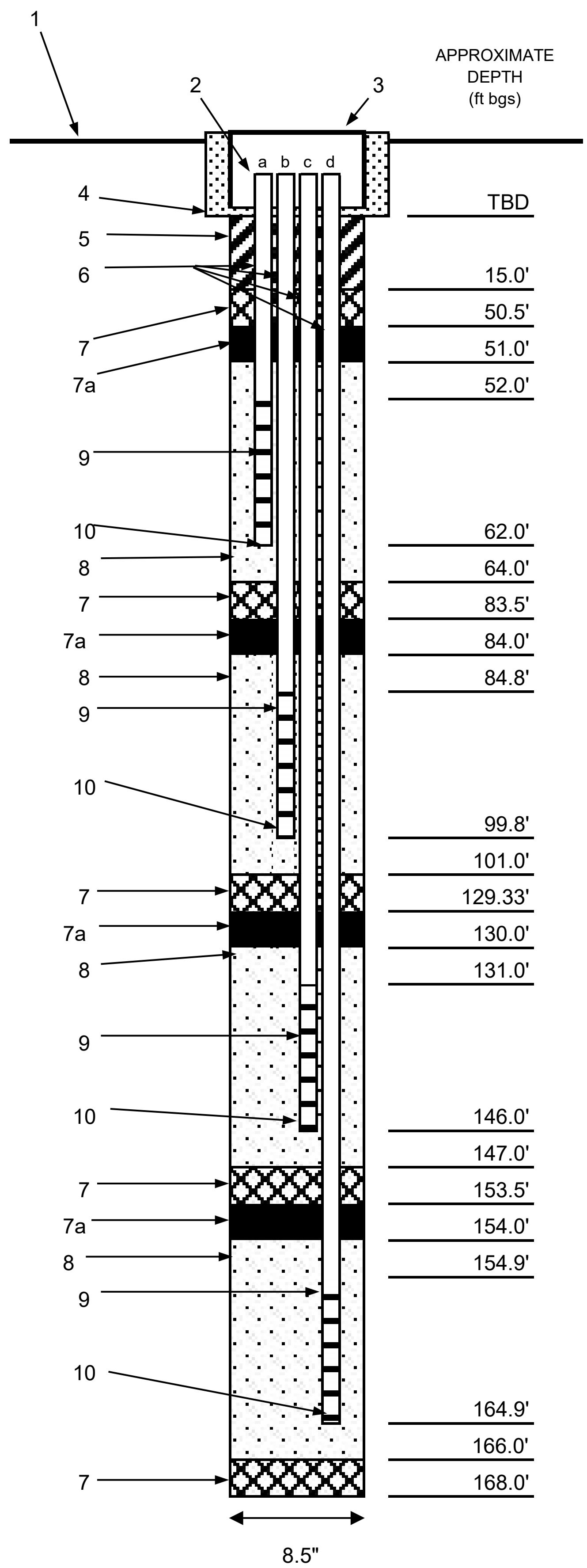
NESTED PIEZOMETER COMPLETION DIAGRAM

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County, CA

DRILLING CONTRACTOR : Gregg Drilling — COORDINATES : N 267177.7, E 1789377.6

DRILLING METHOD AND EQUIPMENT USED : HQ Wireline, CME-850

WATER LEVELS (ft bgs) : a: 59.9', b: dry, c: dry, d: dry (8/21/14) — START : 8/18/14 — END : 10/30/14 — LOGGER : K. Remmen/LAC



1- Ground elevation at well:	1829.54 feet above mean sea level
2- Top of casing elevation:	TBD
3- Wellhead protection cover type:	12" flush-mounted well box (Emco Wheaton)
4- Concrete well vault diameter:	2 feet
5- Grout	Portland Cement/Bentonite Grout
a) Grout mix used:	(West Coast & QuikGel)
b) Method of placement:	Grout pipe
c) Quantities of materials used:	7 bags/<0.25 bags
6- Diameter/type of well casing:	1" Schedule 80 Blank PVC
7- Type of seal and quantities used:	Bentonite Chips (Enviroplug Medium)/48 bags
7a	#8 Bentonite (Enviroplug)/2 bags
8- Type/quantity of filter material:	#3 Sand (Cemex Lapis Lustre)/44.5 bags
9- Screen type/slot size/details:	Schedule 80 PVC screen/0.020" slot size 10' screened intervals use single 10' slotted PVC section, 15' screened intervals use one 10' and one 5' slotted PVC section
10- End cap type/size:	PVC end cap/3" long
Centralizer type/depths:	Bow-spring, placed at bottom and top of screened intervals
Development:	
a) Method:	N/A
b) Duration:	N/A
c) Final field parameters:	N/A
b) Purged volume:	N/A

Comments:

1) Vapor piezometer cluster installed for Bedrock Vapor Extraction (BVE) Treatability Study (does not intersect the water table as of November 2014).

2) All material bags were 50 lbs, except Portland cement (47 lbs).

3) Probes placed on 8/18/14. Well vault constructed on 10/30/14.

ft bgs - feet below ground surface; N/A - not applicable; TBD - to be determined

PZ-203_WCD

CH2MHILL	**PROJECT NUMBER** 474867.BV.02	**WELL NUMBER** PZ-203A SHEET 1 OF 1

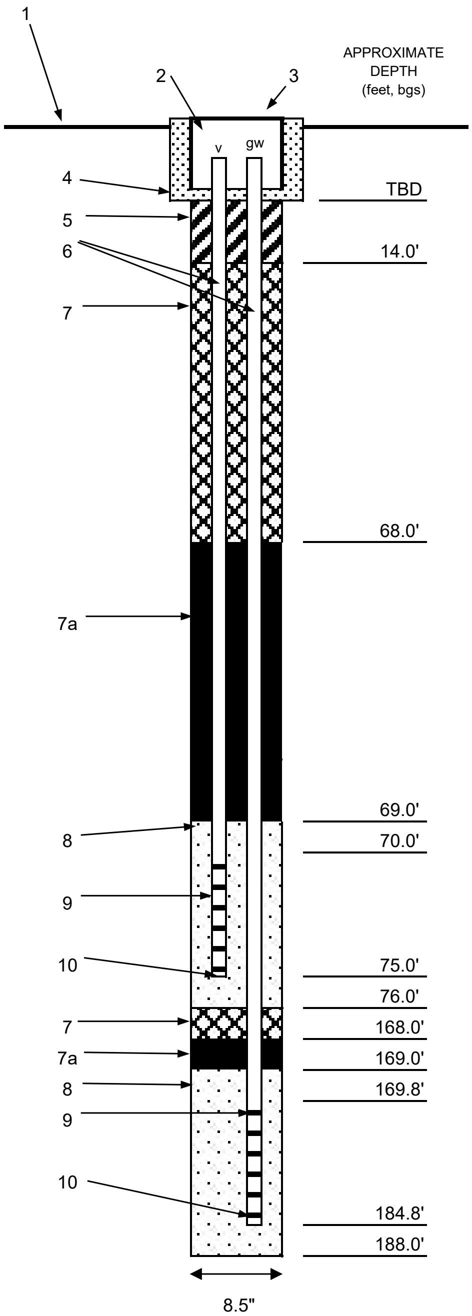
NESTED PIEZOMETER COMPLETION DIAGRAM

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County, CA

DRILLING CONTRACTOR : Gregg Drilling — COORDINATES : N 267184.9, E 1789372.2

DRILLING METHOD AND EQUIPMENT USED : HQ Wireline, CME-850

WATER LEVELS : v: 74.6', gw: 172.79' (8/21/14) — START : 8/19/14 — END : 10/30/14 — LOGGER : K. Remmen/LAC



1- Ground elevation at well: 1829.64 feet above mean sea level

2- Top of casing elevation: TBD

3- Wellhead protection cover type: 12" flush-mounted well box (Emco Wheaton)

4- Concrete well vault diameter: 2 feet

5- Grout: Portland Cement/Bentonite Grout
- a) Grout mix used: (West Coast & QuickGel)
- b) Method of placement: Grout pipe
- c) Quantities of materials used: 6 bags/<0.25 bags

6- Diameter/type of well casing: 1" Schedule 80 Blank PVC

7- Type of seal and quantities used: Bentonite Chips (Enviroplug Medium)/44 bags

7a: #8 Bentonite (Enviroplug)/2 bags

8- Type/quantity of filter material: #3 Sand (Cemex Lapis Lustre)/6 bags - "v"; #2/12 Sand (Cemex Lapis Lustre)/13 bags - "gw"

9- Screen type/slot size/details: Schedule 80 PVC screen/0.020" slot size; 10' screened intervals use single 10' slotted PVC section, 15' screened intervals use one 10' and one 5' slotted PVC section

10- End cap type/size: PVC end cap/3" long

Centralizer type/depths: Bow-spring, placed at bottom and top of screened intervals

Development:
- a) Method: Bailing
- b) Duration: 2 hours
- c) Final field parameters: WL: 180.00; Turb: NA; Color: mod. Cloudy; Temp: 19.5; pH: 6.63; Sp. Cond: 1.56
- b) Purged volume: 20 gallons

Comments:

1) Vapor probe/groundwater piezometer cluster installed for Bedrock Vapor Extraction (BVE) Treatability Study ("v" does not intersect the water table as of November 2014).

2) All material bags were 50 lbs, except Portland cement (47 lbs).

3) Probe and piezometer placed 8/19/14 to 8/20/14. Well vault constructed on 10/30/14.

ft bgs - feet below ground surface; N/A - not applicable; TBD - to be determined

	PROJECT NUMBER	WELL NUMBER
CH2MHILL	**474867.BV.02**	**PZ-204** SHEET 1 OF 1

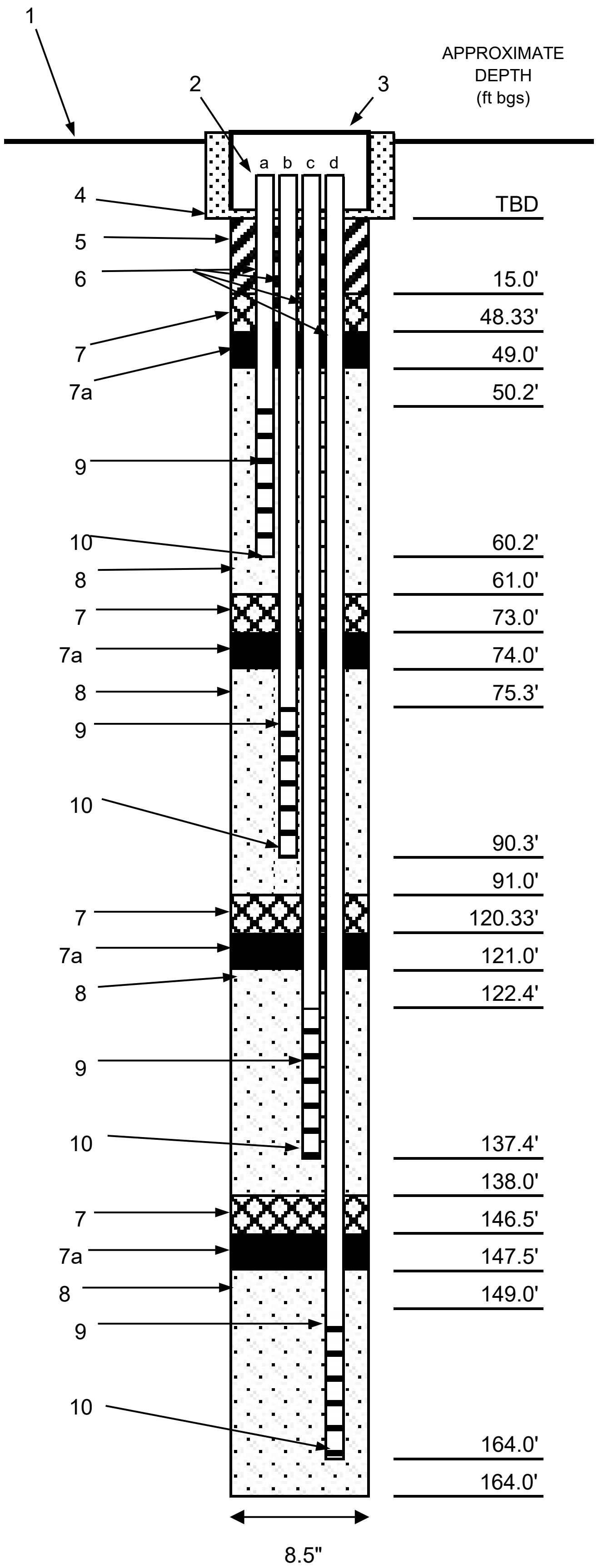
NESTED PIEZOMETER COMPLETION DIAGRAM

PROJECT : NASA SSFL BVE Drilling — LOCATION : SSFL, Ventura County, CA

DRILLING CONTRACTOR : Gregg Drilling — COORDINATES : N 267244.7, E 1789347.7

DRILLING METHOD AND EQUIPMENT USED : HQ Wireline, CME-850

WATER LEVELS (ft bgs) : a: dry, b: dry, c: 133.28', d: ~162.0' (8/21/14) — START : 8/20/14 — END : 10/30/14 — LOGGER : K. Remmen/LAC



1- Ground elevation at well:	1828.05 feet above mean sea level
2- Top of casing elevation:	TBD
3- Wellhead protection cover type:	12" flush-mounted well box (Emco Wheaton)
4- Concrete well vault diameter:	2 feet
5- Grout	Portland Cement/Bentonite Grout
a) Grout mix used:	(West Coast & QuikGel)
b) Method of placement:	Grout pipe
c) Quantities of materials used:	6 bags/0.25 bags
6- Diameter/type of well casing:	1" Schedule 80 Blank PVC
7- Type of seal and quantities used:	Bentonite Chips (Enviroplug Medium)/40 bags
7a	#8 Bentonite (Enviroplug)/4 bags
8- Type/quantity of filter material:	#3 Sand (Cemex Lapis Lustre)/45.5 bags
9- Screen type/slot size/details:	Schedule 80 PVC screen/0.020" slot size 10' screened intervals use single 10' slotted PVC section, 15' screened intervals use one 10' and one 5' slotted PVC section
10- End cap type/size:	PVC end cap/3" long
Centralizer type/depths:	Bow-spring, placed at bottom and top of screened intervals
Development:	
a) Method:	N/A
b) Duration:	N/A
c) Final field parameters:	N/A
b) Purged volume:	N/A

Comments:

1) Vapor piezometer cluster installed for Bedrock Vapor Extraction (BVE) Treatability Study (does not intersect the water table as of November 2014).

2) All material bags were 50 lbs, except Portland cement (47 lbs).

3) Probes placed on 8/20/14. Well vault constructed on 10/30/14.

ft bgs - feet below ground surface; N/A - not applicable; TBD - to be determined

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Appendix F
Rock Core Analytical Data

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Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	500	U	µg/kg	250	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	500	U	µg/kg	100	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	591-78-6	2-Hexanone	500	U	µg/kg	250	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	500	U	µg/kg	250	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	67-64-1	Acetone	500	U	µg/kg	250	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	74-83-9	Bromomethane	500	U	µg/kg	100	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	74-87-3	Chloromethane	10	U	µg/kg	5	10
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	100	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	5	U	µg/kg	2.5	5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-09-2	Methylene chloride	500	U	µg/kg	250	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	PAH	SW8260B	91-20-3	Naphthalene	500	U	µg/kg	100	500
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	1000	U	µg/kg	500	1000
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	50	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	100	250
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS004	267161.5	1789435.2	28-Jul-14	8:26	RC	47	47.3	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS005	267161.5	1789435.2	28-Jul-14	9:21	RC	55.1	55.3	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	79-01-6	Trichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS006	267161.5	1789435.2	28-Jul-14	10:49	RC	76.9	77.2	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	84		µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	100-41-4	Ethylbenzene	1.2	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	108-88-3	Toluene	1.4	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	11		µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	79-01-6	Trichloroethene	630		µg/kg	12	25
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS007	267161.5	1789435.2	28-Jul-14	11:18	RC	82.4	82.7	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	470	U	µg/kg	230	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	470	U	µg/kg	94	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	591-78-6	2-Hexanone	470	U	µg/kg	230	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	470	U	µg/kg	230	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	67-64-1	Acetone	470	U	µg/kg	230	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	108-86-1	Bromobenzene	230	U	µg/kg	47	230

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	74-97-5	Bromochloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-27-4	Bromodichloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-25-2	Bromoform	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	74-83-9	Bromomethane	470	U	µg/kg	94	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-15-0	Carbon Disulfide	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	108-90-7	Chlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-00-3	Chloroethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	74-87-3	Chloromethane	9.4	U	µg/kg	4.7	9.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	124-48-1	Dibromochloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	74-95-3	Dibromomethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	98-82-8	Isopropylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.7	U	µg/kg	2.4	4.7
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-09-2	Methylene chloride	470	U	µg/kg	230	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	PAH	SW8260B	91-20-3	Naphthalene	470	U	µg/kg	94	470
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	104-51-8	n-butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	103-65-1	n-Propylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	100-42-5	Styrene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	940	U	µg/kg	470	940
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	79-01-6	Trichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS008	267161.5	1789435.2	28-Jul-14	13:22	RC	93.5	93.8	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS009	267161.5	1789435.2	28-Jul-14	14:00	RC	104.9	105.2	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS010	267161.5	1789435.2	28-Jul-14	14:58	RC	110.8	111.1	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS011	267161.5	1789435.2	28-Jul-14	15:58	RC	118.6	118.9	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS012	267161.5	1789435.2	28-Jul-14	15:25	RC	123.6	123.8	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS013	267161.5	1789435.2	28-Jul-14	15:45	RC	128.1	128.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	79-01-6	Trichloroethene	4.1	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	79-01-6	Trichloroethene	8.2	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014FD	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	FD	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS014	267161.5	1789435.2	01-Aug-14	14:30	RC	144.9	145.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.8		µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	79-01-6	Trichloroethene	30		µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-202	PZ202RCS015	267161.5	1789435.2	01-Aug-14	15:00	RC	156.2	156.6	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS001	267177.7	1789377.6	17-Jul-14	13:55	RC	19.6	19.85	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS002	267177.7	1789377.6	17-Jul-14	14:20	RC	27.25	27.6	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	230	U	µg/kg	47	230

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	470	U	µg/kg	230	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	470	U	µg/kg	94	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	591-78-6	2-Hexanone	470	U	µg/kg	230	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	470	U	µg/kg	230	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	67-64-1	Acetone	470	U	µg/kg	230	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	108-86-1	Bromobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	74-97-5	Bromochloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-27-4	Bromodichloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-25-2	Bromoform	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	74-83-9	Bromomethane	470	U	µg/kg	94	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-15-0	Carbon Disulfide	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	108-90-7	Chlorobenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-00-3	Chloroethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	74-87-3	Chloromethane	9.4	U	µg/kg	4.7	9.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	124-48-1	Dibromochloromethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	74-95-3	Dibromomethane	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	98-82-8	Isopropylbenzene	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.7	U	µg/kg	2.4	4.7
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-09-2	Methylene chloride	470	U	µg/kg	230	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	PAH	SW8260B	91-20-3	Naphthalene	470	U	µg/kg	94	470
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	104-51-8	n-butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	103-65-1	n-Propylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	100-42-5	Styrene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	230	U	µg/kg	47	230

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	940	U	µg/kg	470	940
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	230	U	µg/kg	47	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	79-01-6	Trichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	230	U	µg/kg	94	230
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS003	267177.7	1789377.6	17-Jul-14	17:20	RC	34.1	34.5	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS004	267177.7	1789377.6	18-Jul-14	11:00	RC	46.9	47.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS005	267177.7	1789377.6	18-Jul-14	15:05	RC	58	58.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS006	267177.7	1789377.6	18-Jul-14	16:20	RC	68.7	69.1	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS007	267177.7	1789377.6	21-Jul-14	11:20	RC	79.55	79.85	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	UJ	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	79-01-6	Trichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS008	267177.7	1789377.6	22-Jul-14	11:15	RC	99	99.5	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	UJ	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	79-01-6	Trichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS009	267177.7	1789377.6	22-Jul-14	11:20	RC	99.5	99.7	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	79-01-6	Trichloroethene	3.3		µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS010	267177.7	1789377.6	22-Jul-14	13:00	RC	104.9	105.2	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	79-01-6	Trichloroethene	10		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS011	267177.7	1789377.6	22-Jul-14	15:45	RC	115.7	116.2	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.1	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	3.9		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	179601-23-1	m,p-Xylenes	3.2	J	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	95-47-6	o-Xylene	1.4	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	79-01-6	Trichloroethene	55	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	79-01-6	Trichloroethene	30	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCD012	267177.7	1789377.6	22-Jul-14	17:00	RC	126.4	126.9	FD	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	UJ	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	79-01-6	Trichloroethene	1.3	J	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS013	267177.7	1789377.6	22-Jul-14	9:00	RC	135.55	135.9	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	1.9	J	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	240	U	µg/kg	96	240

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	591-78-6	2-Hexanone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	67-64-1	Acetone	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	71-43-2	Benzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	108-86-1	Bromobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	74-97-5	Bromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-27-4	Bromodichloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-25-2	Bromoform	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	74-83-9	Bromomethane	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-15-0	Carbon Disulfide	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.4	UJ	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	108-90-7	Chlorobenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-00-3	Chloroethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	74-87-3	Chloromethane	9.6	U	µg/kg	4.8	9.6
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	1.9	J	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	124-48-1	Dibromochloromethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	74-95-3	Dibromomethane	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	98-82-8	Isopropylbenzene	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.8	U	µg/kg	2.4	4.8
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-09-2	Methylene chloride	480	U	µg/kg	240	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	PAH	SW8260B	91-20-3	Naphthalene	480	U	µg/kg	96	480
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	104-51-8	n-butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	103-65-1	n-Propylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	95-47-6	o-Xylene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	100-42-5	Styrene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	960	U	µg/kg	480	960
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	240	U	µg/kg	48	240

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	108-88-3	Toluene	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	7.3		µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	240	U	µg/kg	48	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	79-01-6	Trichloroethene	5.4		µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	240	U	µg/kg	96	240
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS014	267177.7	1789377.6	23-Jul-14	9:45	RC	139.9	140.3	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.4	U	µg/kg	1.2	2.4
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	79-01-6	Trichloroethene	2.3	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS015	267177.7	1789377.6	23-Jul-14	10:55	RC	155.4	155.7	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	UJ	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	4.6		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	8.2		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	79-01-6	Trichloroethene	25		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS016	267177.7	1789377.6	23-Jul-14	12:45	RC	163	163.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	UJ	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	108-88-3	Toluene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	1.7	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	79-01-6	Trichloroethene	3.8		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS017	267177.7	1789377.6	23-Jul-14	17:30	RC	175	175.4	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	630-20-6	1,1,1,2-Tetrachloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	71-55-6	1,1,1-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	79-34-5	1,1,2,2-Tetrachloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	79-00-5	1,1,2-Trichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-34-3	1,1-Dichloroethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-35-4	1,1-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	563-58-6	1,1-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	87-61-6	1,2,3-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	96-18-4	1,2,3-Trichloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	120-82-1	1,2,4-Trichlorobenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	95-63-6	1,2,4-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	96-12-8	1,2-Dibromo-3-chloropropane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	106-93-4	1,2-Dibromoethane (EDB)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	95-50-1	1,2-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	107-06-2	1,2-Dichloroethane	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	78-87-5	1,2-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	108-67-8	1,3,5-Trimethylbenzene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	541-73-1	1,3-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	142-28-9	1,3-Dichloropropane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	106-46-7	1,4-Dichlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	594-20-7	2,2-Dichloropropane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	78-93-3	2-Butanone (MEK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-88-7	2-Chloro-1,1,1-trifluoroethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	95-49-8	2-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	591-78-6	2-Hexanone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	106-43-4	4-Chlorotoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	108-10-1	4-Methyl-2-pentanone (MIBK)	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	67-64-1	Acetone	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	71-43-2	Benzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	108-86-1	Bromobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	74-97-5	Bromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-27-4	Bromodichloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-25-2	Bromoform	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	74-83-9	Bromomethane	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-15-0	Carbon Disulfide	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	56-23-5	Carbon tetrachloride	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	108-90-7	Chlorobenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-00-3	Chloroethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	74-87-3	Chloromethane	9.8	U	µg/kg	4.9	9.8
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	156-59-2	cis-1,2-Dichloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	10061-01-5	cis-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	124-48-1	Dibromochloromethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	74-95-3	Dibromomethane	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-71-8	Dichlorodifluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	SVOC	SW8260B	108-20-3	Diisopropyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	100-41-4	Ethylbenzene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	87-68-3	Hexachlorobutadiene	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	98-82-8	Isopropylbenzene	250	U	µg/kg	98	250

Table F-1. Rock Core Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	179601-23-1	m,p-Xylenes	4.9	U	µg/kg	2.5	4.9
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-09-2	Methylene chloride	490	U	µg/kg	250	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	1634-04-4	Methyl-tert-butyl Ether (MTBE)	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	PAH	SW8260B	91-20-3	Naphthalene	490	U	µg/kg	98	490
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	104-51-8	n-butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	103-65-1	n-Propylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	95-47-6	o-Xylene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	99-87-6	p-Isopropyltoluene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	135-98-8	sec-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	100-42-5	Styrene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	SVOC	SW8260B	TAME	tert-Amyl methyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	SVOC	SW8260B	75-65-0	tert-Butyl alcohol	980	U	µg/kg	490	980
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	SVOC	SW8260B	637-92-3	tert-Butyl ethyl ether	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	98-06-6	tert-Butylbenzene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	127-18-4	Tetrachloroethene	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	108-88-3	Toluene	1.4	J	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	156-60-5	trans-1,2-Dichloroethene	3.9		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	10061-02-6	trans-1,3-Dichloropropene	250	U	µg/kg	49	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	79-01-6	Trichloroethene	3.2		µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-69-4	Trichlorofluoromethane	250	U	µg/kg	98	250
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	67-66-3	Trichloromethane (Chloroform)	2.5	U	µg/kg	1.2	2.5
GRP3 - BRV	PZ-203	PZ203RCS018	267177.7	1789377.6	24-Jul-14	14:28	RC	186.5	186.9	N	VOC	SW8260B	75-01-4	Vinyl chloride	2.5	U	µg/kg	1.2	2.5

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (estimated).

R = Data are unusable. The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.

S = Result is considered screening-level

U = Analyte was analyzed for but not detected above the reported sample quantitation limit, or this analyte was considered not detected due to laboratory or field blank contamination.

UJ = Analyte was analyzed for but not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

µg/kg = microgram per kilogram

bgs = below ground surface

CAS = Chemical Abstracts Service

FD = field duplicate sample

GRP3 - BRV = Group 3 Bravo Area site

ID = identification number

N = normal sample

NAD27 = North American 1927 datum (State Plane California Zone 5)

PAH = polycyclic aromatic hydrocarbons

RC = rock core

SVOC = semivolatile organic compound

VOC = volatile organic compound

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Appendix G
BVE Operational Data

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TABLE G-1

Summary of BVE Operations - HAR-19

Bravo Bedrock Vapor Extraction Treatability Study Summary

Date	Time	Wellhead Vacuum (inches of mercury)	Wellhead Vacuum (inches of water)	Differential Pressure (inches of water)	Calculated Flow Rate (SCFM)	Pre-Dilution Influent (ppm as Isobutylene)	Post-Dilution Influent (ppm as Isobutylene)	Lead Vessel Effluent (ppm as Isobutylene)	Lag Vessel Effluent (ppm as Isobutylene)	Radius of Influence (inches of water vacuum)					Action Taken
										HAR-20	PZ-061	PZ-070	PZ-156	RD-104	
8/26/2014	12:48	6.00	81.57	0.12	73										Start Up
8/27/2014	08:00	6.05	82.25	0.09	63		86.0	0.0	0.0	0.3	0.0	0.0	0.7	0.0	
8/27/2014	10:00	5.84	79.40	0.10	65										
8/27/2014	12:00	5.80	78.85	0.10	65										
8/27/2014	14:00	5.83	79.26	0.10	65										
8/27/2014	16:00	5.84	79.40	0.10	65		89.5	0.0	0.0						
8/28/2014	07:00	6.05	82.25	0.10	66		95.3	0.0	0.0						
8/28/2014	08:30									0.1	0.0	0.0	2.2	0.0	
8/28/2014	11:00	5.82	79.12	0.10	67										
8/28/2014	13:00	5.85	79.53	0.10	66										
8/28/2014	15:00	5.84	79.40	0.10	65		101	0.0	0.0						
8/29/2014	07:30	6.08	82.66	0.10	66		102	0.0	0.0	0.2	0.0	0.1	2.2	0.0	
8/29/2014	09:00	5.97	81.16	0.10	66										
8/29/2014	12:30	6.00	81.57	0.10	66										
8/29/2014	13:48	5.93	80.6	0.10	66										Shut Off
9/2/2014	11:38	6.30	85.6	0.12	72	270	102	0.0	0.0						Start Up
9/2/2014	13:50	4.00	54.4	0.03	34										
9/3/2014	07:45	6.63	90.1	0.11	65	312	102	0.0	0.0	0.2	0.0	0.0	2.2	0.0	
9/3/2014	10:00	5.94	80.8	0.10	65										
9/3/2014	12:00	5.89	80.1	0.10	65										
9/3/2014	14:00	5.87	79.8	0.10	65										
9/3/2014	15:30	5.90	80.2	0.10	65		92.3	0.0	0.0						
9/4/2014	07:00	6.12	83.2	0.10	65	370	81.2	0.0	0.0	0.2	0.0	0.0	2.4	0.0	
9/4/2014	09:00	6.09	82.8	0.10	65										
9/4/2014	11:00	5.92	80.5	0.10	65										
9/4/2014	13:00	5.80	78.9	0.10	65										
9/4/2014	14:30	5.86	79.7	0.10	65	365	86.3	0.0	0.0						
9/5/2014	07:15	6.08	82.7	0.10	65	368	100	0.0	0.0	0.2	0.0	0.0	2.9	0.0	
9/5/2014	09:00	6.93	94.2	0.10	65										
9/5/2014	11:00	5.88	79.9	0.10	65										
9/5/2014	14:25	5.84	79.4	0.10	65	365	100	0.0	0.0						
9/8/2014	11:48	6.05	82.3	0.28	111										
9/8/2014	11:55	5.99	81.4	0.22	98	172	63.3	0.0	0.0						
9/8/2014	12:00	6.01	81.7	0.15	81										
9/8/2014	12:05	6.05	82.3	0.14	78										
9/8/2014	12:10	6.02	81.8	0.13	74										
9/8/2014	12:15	6.01	81.7	0.12	73										
9/8/2014	12:20	6.00	81.6	0.12	73										
9/8/2014	12:55	6.06	82.4	0.11	69										
9/8/2014	13:40	6.00	81.6	0.10	66										
9/8/2014	15:00	5.94	80.8	0.10	66	281	123	0.0	0.0						
9/9/2014	07:20	6.24	84.8	0.18	88	361	120	0.0	0.0	0.3	0.0	0.0	2.7	0.0	
9/9/2014	09:00	6.10	82.9	0.10	66										
9/9/2014	11:00	6.04	82.1	0.10	66										
9/9/2014	13:00	6.00	81.6	0.10	66										
9/9/2014	14:30	6.00	81.6	0.10	66	345	98.4	0.0	0.0						
9/10/2014	07:15	6.32	85.9	0.23	100	441	100	0.0	0.0	0.1	0.0	0.0	2.6	0.0	
9/10/2014	09:00	6.08	82.7	0.10	66										
9/10/2014	11:00	6.03	82.0	0.10	66										
9/10/2014	13:00	6.05	82.3	0.10	66										
9/10/2014	15:00	6.04	82.1	0.10	66	354	99.5	0.0	0.0						
9/11/2014	07:10	6.27	85.2	0.18	88	396	93.7	0.0	0.0	0.2	0.0	0.0	2.5	0.0	
9/11/2014	09:00	6.07	82.5	0.10	66										
9/11/2014	11:00	6.02	81.8	0.10	66										
9/11/2014	12:30	5.97	81.2	0.10	66										
9/11/2014	14:30	6.04	82.1	0.10	66	321	76.7	0.0	0.0						
9/12/2014	07:30	6.25	85.0	0.16	83	375	100	0.0	0.0	0.2	0.0	0.0	2.5	0.0	
9/12/2014	09:00	6.12	83.2	0.10	66										
9/12/2014	15:30	6.05	82.3	0.10	66										Shut Off

TABLE G-1

Summary of BVE Operations - HAR-19

Bravo Bedrock Vapor Extraction Treatability Study Summary

Date	Time	Wellhead Vacuum (inches of mercury)	Wellhead Vacuum (inches of water)	Differential Pressure (inches of water)	Calculated Flow Rate (SCFM)	Pre-Dilution Influent (ppm as Isobutylene)	Post-Dilution Influent (ppm as Isobutylene)	Lead Vessel Effluent (ppm as Isobutylene)	Lag Vessel Effluent (ppm as Isobutylene)	Radius of Influence (inches of water vacuum)					Action Taken
										HAR-20	PZ-061	PZ-070	PZ-156	RD-104	
Rebound Test															
10/22/2014	13:05	4.00	54.4	0.20	98	55.0									Start Up
10/22/2014	13:10	4.00	54.4	0.12	76	125									
10/22/2014	13:15	4.06	55.2	0.11	72	142									
10/22/2014	13:20	4.02	54.6	0.10	69	165									
10/22/2014	13:25	4.09	55.6	0.09	65	181									
10/22/2014	13:30	4.15	56.4	0.09	65	196									
10/22/2014	13:40	4.16	56.5	0.08	62	216									
10/22/2014	13:50	4.18	56.8	0.07	58	223									
10/22/2014	14:00	4.19	56.9	0.06	53	217									
10/22/2014	14:30	4.20	57.1	0.06	53	208									
10/22/2014	15:00	4.24	57.6	0.06	53	212									
10/22/2014	16:00	4.28	58.2	0.06	53	250									
10/23/2014	07:10	4.13	56.1	0.06	53	320									
10/23/2014	08:00	4.07	55.3	0.06	53	323									
10/23/2014	09:00	4.05	55.0	0.06	53	329									
10/23/2014	10:00	4.02	54.6	0.06	53	332									Shut Off (10:05)

Calculation for flow was not mathematical, but from a manufacturer-supplied chart.
Grayed out cells indicate no measurement was made for that parameter at that time.
SCFM = standard cubic feet per minute, calculated from calibrated Pitot Tube
ppm = parts per million

Appendix H
Pneulog Report

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PRAXIS
ENVIRONMENTAL TECHNOLOGIES, INC.

PneuLog® PROFILING
Well HAR-19
Santa Susana Field Laboratory
Brandeis, California

Draft Final Report
November 2014

Prepared for:

CH2M Hill

Prepared by:

PRAXIS Environmental Technologies, Inc.
1440 Rollins Road
Burlingame, California 94010

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FINAL REPORT
PneuLog® Profiling of Well HAR-19
Santa Susana Field Laboratory, Brandeis, CA

1. INTRODUCTION

This effort supported the performance of a soil vapor extraction (SVE) pilot test in a single corehole drilled in bedrock at the Santa Susana Field Laboratory (SSFL), Brandeis, CA. The purposes of the field effort were (1) to locate the depth and to quantify the flow from major fractures, and (2) to estimate soil gas contaminant concentrations in vapors extracted from such fractures along the corehole HAR-19 at different times during the pilot test. The corehole is cased from the surface to a depth of 30 feet below ground surface (ft bgs) and the roughly 8-inch diameter corehole is uncased from 30 ft bgs down to 200 ft bgs. Under ambient conditions, groundwater is encountered at approximately 179 ft bgs. The primary contaminant of concern is trichloroethene (TCE). To collect the fracture data and data for assessing the long-term viability of SVE, PneuLog testing was performed at five different times during the SVE pilot test. The PneuLog profiling coincided with the startup or shutdown of SVE preceding or following a period of dormancy. The first log was performed shortly after the startup of the SVE pilot test on 26-Aug-14. The timing of subsequent logs is provided in Table 1-1. This memorandum summarizes the logging data collected in the field and provides an interpretation of the data as it applies to the profiles generated.

Table 1-1. Summary of Field Activities for PneuLog Profiling

Date	Time	Task
26-Aug	13:35	Start of Initial SVE period
26-Aug	15:00-17:30	1stPneuLog Profile of HAR-19
29-Aug	11:45-13:50	2ndPneuLog Profile of HAR-19
29-Aug	13:50	End of Initial SVE period
2-Sep	11:39	Start of Second SVE period
2-Sep	12:00-14:50	3rdPneuLog Profile of HAR-19
5-Sep	PM	End of Second SVE period
8-Sep	AM	Start of Third SVE period
12-Sep	13:30-15:30	4thPneuLog Profile of HAR-19
12-Sep	15:35	End of Third and Final SVE period
22-Oct	13:00-16:15	5th PneuLog Profile after 6 weeks of Rebound

2. PNEULOG PROFILES

PneuLog was performed at five different times during the SVE pilot test and followed the Standard Operating Procedure (SOP) provided in Appendix A. For the three logs following a period of dormancy (8/26/14, 9/2/14 and 10/22/14), the PneuLog equipment was placed in the well before initiating extraction. For the two logs at the end of extraction periods, a brief interruption in extraction (less than 10 minutes) was necessary to place the equipment. During each log, approximately 25 vapor samples were collected at varying depths from 30 ft bgs (the top of the open corehole) down to just above the water table. Under ambient conditions the water table was located at approximately 179 ft bgs but rose when a vacuum was applied (~172 ft bgs for a vacuum of 6 inHg; ~174 ft bgs for a vacuum of 4 inHg). Vapor samples were collected in Tedlar bags. After logging, the PneuLog equipment was removed from the well.

The corehole diameter was not precisely eight inches and variability with depth was observed in a video log. The PneuLog flow sensor measures vapor velocity such that small variations in diameter yield small variations in velocity for a constant flow rate. This variability is evident in all of the PneuLog flow profiles. In addition to the irregular diameter, protrusions exist along the wall. The protrusions provided obstacles for the sensor and centralizers contributing to variability in velocity. To reduce variability, the flow sensor for the first two logs was replaced by a more sensitive, smaller diameter sensor yielding lesser variability from the protrusions.

The vapor samples collected in Tedlar bags were transported to Praxis' laboratory and analyzed within 24 hours of collection with a calibrated gas chromatograph (GC) using a modified EPA Method 18 for GC analyses of volatile organic compounds. The GC is a Hewlett Packard 6890 with flame ionization detector (FID). Throughout the logging of each screen, chemical concentrations were also monitored by a photoionization detector (PID) although the presence of water at the bottom of the log impacted the deep PID response. The continuous vapor concentration profiles from the PID were converted from the isobutylene calibration to TCE concentrations by multiplying with the TCE relative response factor of 0.55 (as specified by the PID manufacturer). This profile was sometimes altered slightly to match more closely the results of the GC analyses of the vapors collected in the Tedlar bags. Matching the PID reading to the GC data required a correction factor of less than 5% in all five logs.

HAR-19 (26-Aug-14)

The initial PneuLog testing was performed in HAR-19 on 26-Aug-14 at the start of the SVE pilot test. During the test, a vacuum of approximately 6 inches of mercury (inHg) was applied yielding a total extraction rate of nearly 100 standard cubic feet per minute (scfm). The extraction rate decayed with time after startup and the applied vacuum was adjusted as reported elsewhere. Before extraction was initiated, the PneuLog sensor was lowered to a depth of 36.5 ft bgs below the transition from a 10-inch diameter casing to the 8-inch diameter uncased corehole. The PneuLog flow response and the PID response (corrected to TCE) at this depth are plotted in Figure 2-1. As shown in Figure 2-1, the vacuum applied to the wellhead was adjusted after startup. The PID response yielded a stable concentration after about 75 minutes of extraction and the initial PneuLog was then initiated. Figure 2-1 also indicates the PID calibration performed with isobutylene just before the extraction was initiated.

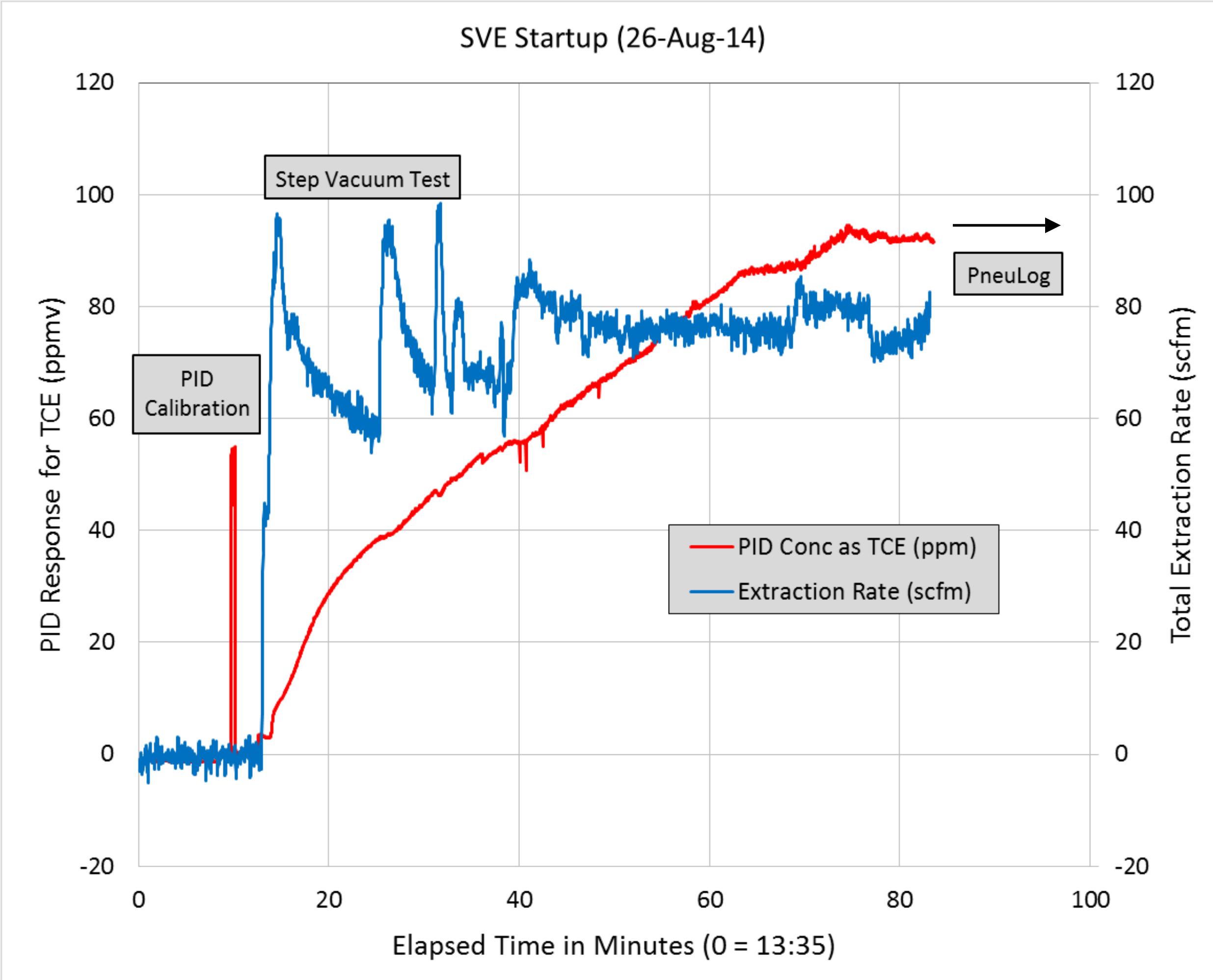


Figure 2-1. Initial Flow Response and PID Concentration Response (8/26/14)

The cumulative airflow profile measured in this initial log is presented on the left side of Figure 2-2. This raw flow profile is from the first downward log. At the bottom of this log, the flow sensor was submerged into the vacuum-elevated water table. Excessive water invalidated the subsequent flow response in the upward direction. As illustrated, the flow at the very bottom of the well dropped precipitously to zero below 158 ft bgs. The flow at 158 ft bgs was estimated to be 71 scfm; however, the PneuLog sensor measures velocity in the central portion of the corehole. The total flow is a function of the velocity and the cross-sectional area of the corehole (assumed to have a uniform diameter of 8 inches). Hence, variability in the corehole diameter imparts an uncertainty in the flow calculated from the velocity. As a result, small increases in flow above 158 ft bgs may or may not be real as the actual corehole diameter is unknown and irregular. However, the measured velocity near the top of the borehole was consistently higher than the measure at 158 ft bgs indicating fractures producing small flows exist above 158 ft bgs. Yet, the overwhelming majority of the flow extracted from the corehole (greater than 80%) emerged from depths exceeding 158 ft bgs. No discernable flow was measured below 166 ft bgs indicating one or two major fractures existed in this interval from 158 to 166 ft bgs at the start of the SVE pilot test.

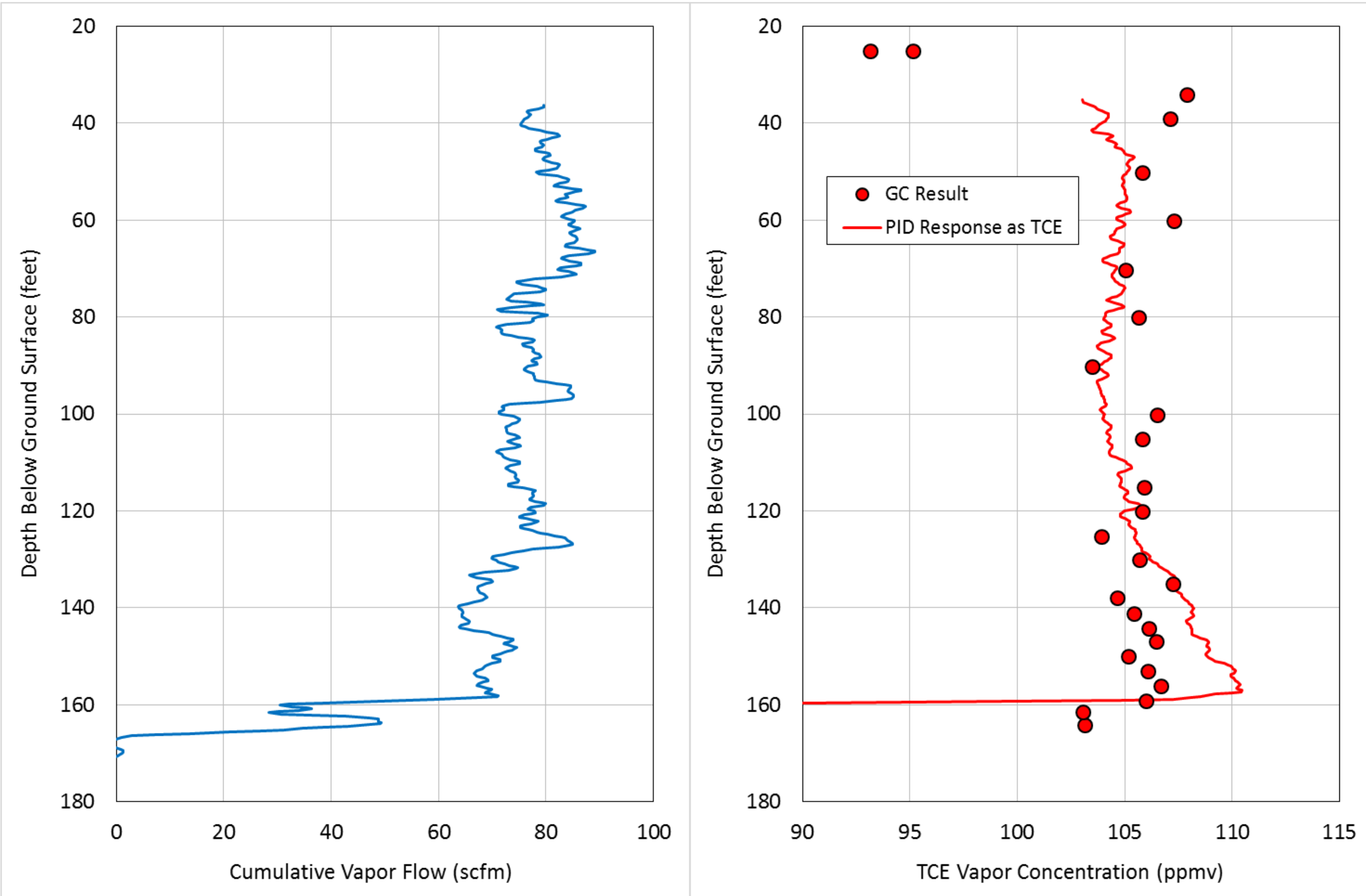


Figure 2-2. PneuLog Measured Profiles (8/26/14)

Vapor samples were collected in Tedlar bags to determine compound-specific vapor concentration profiles. The samples in Tedlar bags were analyzed by Praxis within 24 hours of collection using a calibrated gas chromatograph (Model HP 6890). The quality of the data is commensurate with field screening. The depth and TCE result for each sample is illustrated on the right hand side of Figure 2-2 where the PID response (as TCE) is also plotted versus depth. Table 2-1 summarizes the results for TCE and cis-1,2-DCE from these analyses. The sample from a depth of 110 ft bgs was noted in the laboratory to have a questionable seal upon receipt. The PID response at the bottom of the log dropped to near zero because water entered the sampling line and blocked all flow and therefore, is not indicative of the actual concentration at the bottom.

Table 2-1. Results of Vapor Sample Analyses from 8/26/14

DEPTH	**cis-1,2-DCE** (ppmv)	**TCE** (ppmv)	**NOTES**
25.2	13.5	95.1	
25.2	13.4	93.1	Field Duplicate
34.1	15.3	107.9	
39.1	15.6	107.1	
50.3	15.4	105.8	
60.1	15.2	107.3	
70.3	15.1	105.0	
80.1	15.1	105.6	
90.2	14.7	103.5	
100.1	15.3	106.5	
105.2	15.3	105.8	
110.0	13.0	95.9	Septum loose
115.1	15.5	105.9	
120.1	15.2	105.8	
125.2	14.8	103.9	
130.0	15.1	105.7	
135.1	15.5	107.3	
137.9	14.9	104.7	
141.2	15.0	105.4	
144.2	15.1	106.1	
147.0	15.4	106.5	
150.0	14.7	105.2	
153.1	14.8	106.1	
156.1	15.0	106.7	
159.1	14.9	106.0	
161.4	14.6	103.1	
164.2	14.9	103.1	
QA/QC	0.0	0.1	Field Ambient

The TCE vapor concentrations across the open corehole were relatively consistent around 105 ppmv as illustrated in Figure 2-2. Any concentration change resulting from the small addition of flow from small fractures is not identifiable as a result of the irregular diameter of the corehole. The TCE concentrations just above the water table were slightly lower at 103 ppmv and a slight increase was observed near the top of the corehole. A drop of concentration was measured above the transition from 8-inch corehole to 10-inch casing suggesting the entry of dilution air; however, the change in diameter negated the possibility to measure such a change in flow.

The TCE vapor concentration of 103 ppmv is equivalent to a water concentration of about 1.5 mg/L if equilibrium between the vapor and underlying groundwater is assumed. If measured groundwater concentrations in the vicinity of this borehole are significantly lower, then results suggest the extracted TCE is emerging from fractures in the overlying vadose zone. Hence, soil vapor extraction was removing TCE mass through fractures that intersect HAR-19 just above the water table at rate of approximately 4 pounds per day (ppd) at the start of the pilot test.

HAR-19 (29-Aug-14)

The second PneuLog profile was performed in HAR-19 on 29-Aug-14 at the end of the initial extraction period of 72 hours. The extraction was interrupted briefly to insert the logging device and allowed to re-equilibrate before starting the log. During the log, a vacuum of approximately 6 inches of mercury (inHg) was applied yielding a total extraction rate of about 65 scfm. The PneuLog sensor was initially located at a depth of 36.5 ft bgs below the transition to the 8-inch diameter corehole.

The cumulative airflow profiles measured in this second log are presented on the left side of Figure 2-3. These raw flow profiles are from both the downward and upward logs. The PneuLog device was modified in an attempt to measure more fully the total flow along the corehole but the result yielded a significant amount of scraping along the corehole wall that yielded unrealistic measures in flow. The portions of the logs considered unacceptable are dashed and the acceptable portions are solid. A number of obstructions are known to exist in the interval from about 50 to 70 ft bgs based on a video log of the well and their impact is evident in the flow log. Toward the bottom of this log, the flow response approached zero at depths below 150 ft bgs suggesting nearly all of the flow emerged from deeper depths. Again, the overwhelming majority of the flow extracted from the corehole (greater than 80%) emerged from depths exceeding 150 ft bgs. Repeatable responses by the flow sensor at depths of 160 ft bgs and 167 ft bgs suggest the location of fractures as lateral flow impinged on the sensor sufficiently to generate a response.

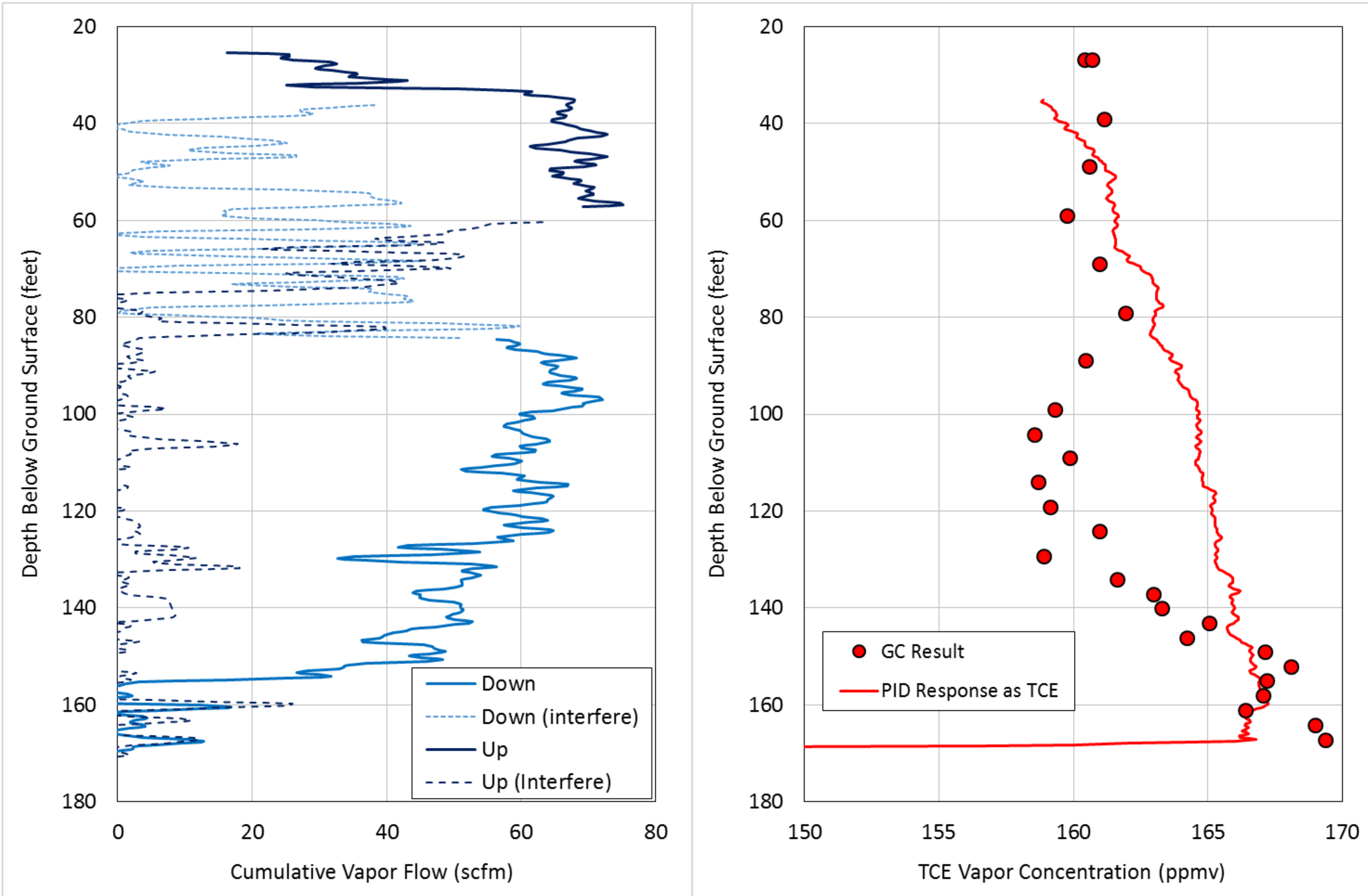


Figure 2-3. PneuLog Measured Profiles (8/29/14)

Vapor samples were collected in Tedlar bags and analyzed as illustrated on the right hand side of Figure 2-3 where the PID response (as TCE) is also plotted versus depth. Table 2-2 summarizes the results for TCE and cis-1,2-DCE from these analyses. The PID response at the bottom of the log dropped to near zero because water entered the sampling line and blocked all flow and is not indicative of the actual concentration at the water table interface.

Table 2-2. Results of Vapor Sample Analyses from 8/29/14

DEPTH	cis-1,2-DCE (ppmv)	TCE (ppmv)	NOTES
27.89	17.6	160.4	
27.89	17.7	160.7	Field Duplicate
40.05	17.8	161.1	
49.92	17.7	160.6	
60.05	17.7	159.8	
69.93	17.8	161.0	
80.05	17.9	161.9	
89.93	17.6	160.4	
100.06	17.7	159.3	
105.12	17.7	158.5	
109.93	17.7	159.9	
115.00	17.5	158.7	
120.06	17.8	159.1	
125.12	17.8	161.0	
130.19	17.5	158.9	
135.00	18.0	161.6	
138.04	18.3	163.0	
141.07	18.0	163.3	
144.11	18.3	165.0	
147.15	18.3	164.2	
149.94	18.5	167.1	
152.98	18.6	168.1	
156.01	18.5	167.2	
159.05	18.6	167.1	
162.09	18.4	166.4	
165.13	18.8	169.0	
168.17	19.2	169.4	
QA/QC	0.0	0.2	Field Ambient

The TCE vapor concentrations across the open corehole were highest at the bottom, just above the water table and decreased with decreasing depth with the exception of an apparent increase around a depth of 80 ft bgs. However, without a reliable measure of flow, the concentration change resulting from the small addition of flow from fractures is not quantifiable. In general the TCE concentration was increased over the concentration measured at the start of the pilot test. The TCE concentrations just above the water table were 169 ppmv compared to the startup concentration of 103 ppmv. The drop in concentration above the transition from 8-inch corehole to 10-inch casing at 30 ft bgs was not repeated from the initial log suggesting the entry of dilution air had terminated. SVE was removing TCE mass through fractures that intersect HAR-19 just above the water table at a rate of ~5.2 ppd at the end of the first extraction period.

HAR-19 (2-Sep-14)

PneuLog testing was performed in HAR-19 on 2-Sep-14 after a 96-hour rebound period using a smaller, more sensitive flow sensor. During the re-start, a vacuum of 6 inHg was applied yielding an initial total extraction rate over 100 scfm. The extraction rate decayed with time after startup to less than 60 scfm. The PneuLog sensor was located at a depth of 36.5 ft bgs below the transition to the 8-inch diameter uncased corehole. The PneuLog flow response and the PID response (corrected to TCE) at this depth during the re-start are plotted in Figure 2-4. The PID response was not quite stable and the TCE concentration was increasing above 110 ppmv when the PneuLog was initiated.

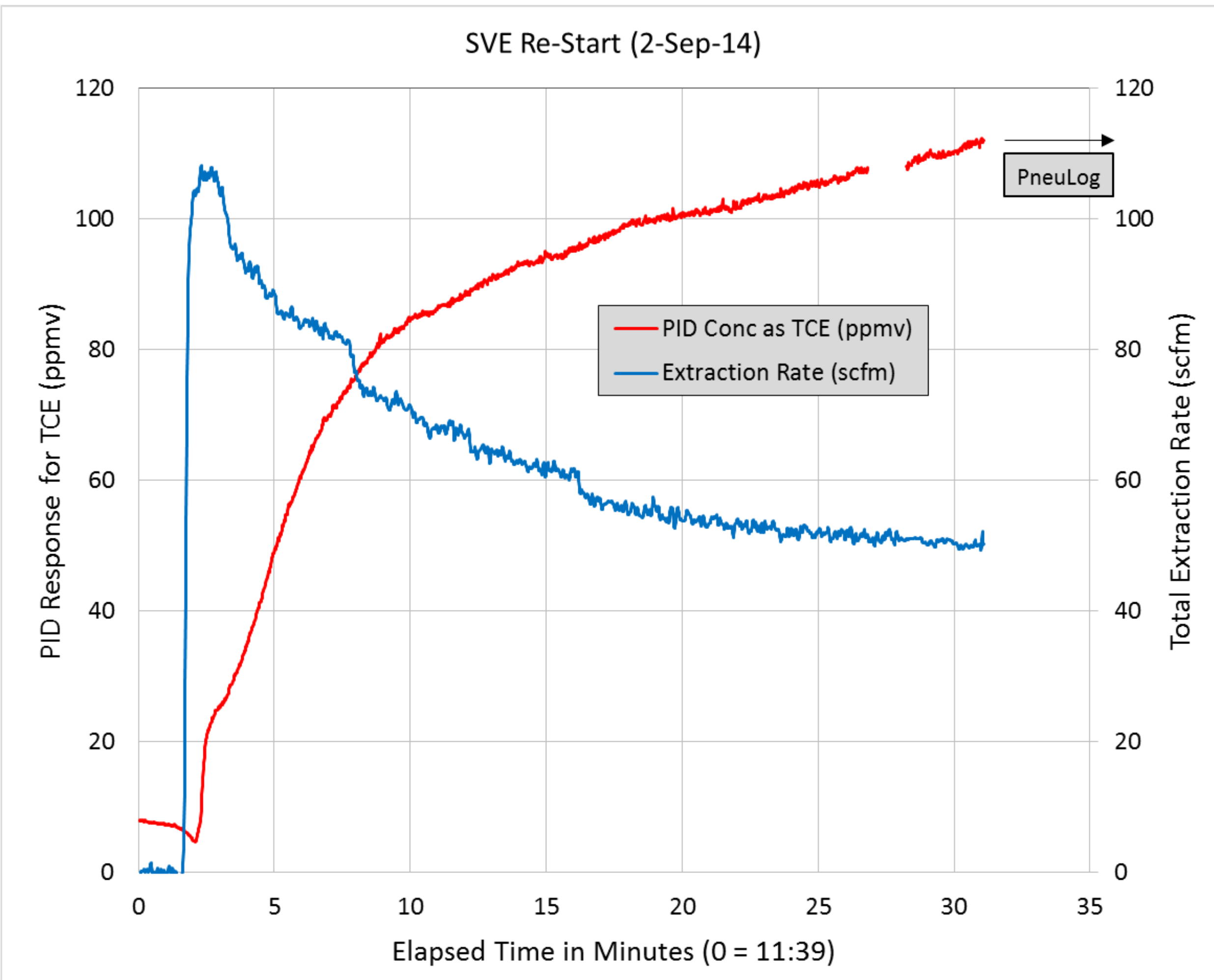


Figure 2-4. Flow Response and PID Concentration Response during Re-Start (9/2/14)

The cumulative airflow profiles measured in this third logging event are presented on the left side of Figure 2-5. These raw flow profiles are from both the downward and upward logs. Compared to the log of 29-Aug-14, a different flow sensor was employed with more sensitivity but a smaller diameter in an attempt to get a "cleaner" flow log. As illustrated in Figure 2-5, this modification was successful as the flow logs were much improved. After logging the well from top to bottom and then back up to a depth of 140 ft bgs, including vapor sampling during this first up log, the vacuum applied to the well was reduced from 6 inHg to 4 inHg. The purpose of lowering the vacuum was to lower the water table and expose another two feet of the corehole to logging. The reduced vacuum yielded a lower flow but the modified probe also had a more sensitive flow sensor as described above. The flow logs at the reduced vacuum and flow are provided in Figure 2-5 and are very similar in shape to the higher flow logs.

As observed previously, toward the bottom of this log, the flow response approached zero at depths below 158 ft bgs suggesting nearly all of the flow (greater than 80%) emerged from deeper depths. Repeatable responses by the flow sensor at depths of 160 ft bgs and 167 ft bgs suggest the location of fractures as lateral flow impinged on the sensor sufficiently to generate a response.

Vapor samples were collected in Tedlar bags and analyzed as illustrated on the right hand side of Figure 2-5 where the PID response (as TCE) is also plotted versus depth. Table 2-3 summarizes the results for TCE and cis-1,2-DCE from these analyses. Vapor samples were collected during the higher vacuum operation and then repeated in the deeper interval after the vacuum was reduced. The PID response at the bottom of the log dropped to near zero because water entered the sampling line and blocked all flow and is not indicative of the actual concentration above the water table.

The TCE vapor concentrations across the open corehole were consistent over the length of the corehole around 140 ppmv of TCE; however, just above the water table, the TCE vapor concentration was decreased. The decrease was observed during sampling for both applied vacuums substantiating this finding. This behavior indicates the productive fractures in the interval from 158 to 166 ft bgs are the primary sources for the extracted TCE mass.

A vapor sample was collected above the transition (136.5 ft bgs) before the start of the logging as the extracted concentration had not yet stabilized. As indicated, during the logging, the wellhead TCE vapor concentration increased from 113 ppmv to 138 ppmv during the profiling. SVE was removing TCE mass through fractures that intersect HAR-19 just above the water table at a rate of ~3.9 ppd at the start of the second extraction period. This mass extraction rate is similar to that at the start of the pilot test although the total flow was lower and the extracted TCE concentration was higher.

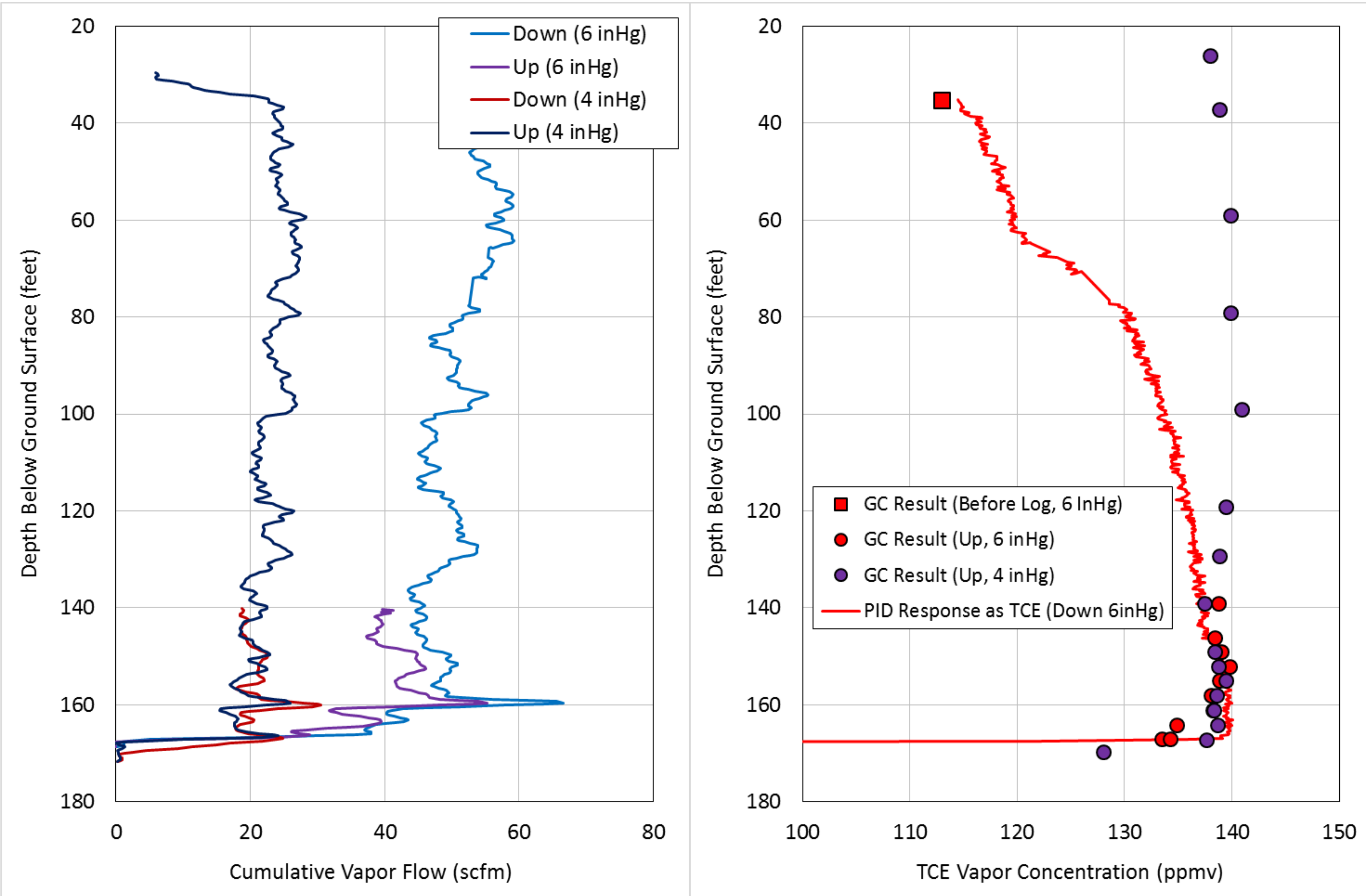


Figure 2-5. PneuLog Measured Profiles (9/2/14)

Table 2-3. Results of Vapor Sample Analyses from 9/2/14

DEPTH	cis-1,2-DCE (ppmv)	TCE (ppmv)	NOTES
35.25	13.9	113.0	Before Logging
139.06	16.4	138.7	Vacuum of 6 inHg
146.15	16.3	138.4	Vacuum of 6 inHg
148.94	16.4	139.0	Vacuum of 6 inHg
151.98	16.6	139.8	Vacuum of 6 inHg
155.01	16.3	138.8	Vacuum of 6 inHg
158.05	15.7	138.1	Vacuum of 6 inHg
161.09	16.4	138.2	Vacuum of 6 inHg
164.13	15.5	134.9	Vacuum of 6 inHg
166.91	15.3	133.5	Vacuum of 6 inHg
166.91	15.4	134.3	Field Duplicate
26.13	16.0	138.0	Vacuum of 4 inHg
37.28	16.0	138.8	Vacuum of 4 inHg
59.05	16.2	139.9	Vacuum of 4 inHg
79.05	16.2	139.8	Vacuum of 4 inHg
99.06	16.2	140.9	Vacuum of 4 inHg
119.06	16.1	139.4	Vacuum of 4 inHg
129.19	16.0	138.8	Vacuum of 4 inHg
139.06	15.9	137.5	Vacuum of 4 inHg
148.94	16.1	138.4	Vacuum of 4 inHg
151.98	16.0	138.8	Vacuum of 4 inHg
155.01	16.2	139.4	Vacuum of 4 inHg
158.05	16.1	138.6	Vacuum of 4 inHg
161.09	16.1	138.3	Vacuum of 4 inHg
164.13	15.9	138.6	Vacuum of 4 inHg
167.17	15.9	137.6	Vacuum of 4 inHg
169.70	14.8	128.0	Vacuum of 4 inHg
QA/QC	0.0	0.3	Field Ambient

HAR-19 (12-Sep-14)

The fourth PneuLog profile was performed in HAR-19 on 12-Sep-14 at the end of the third extraction period and preceding a 6-week rebound period. The extraction was interrupted briefly to insert the logging device and allowed to re-equilibrate before starting the log. During the log, a vacuum of 6 inHg was applied yielding a total extraction rate of about 65 scfm. The PneuLog sensor was initially located at a depth of 36.5 ft bgs below the transition to the 8-inch diameter corehole.

The cumulative airflow profiles measured in the fourth logging event are presented on the left side of Figure 2-6. These raw flow profiles are from both the downward and upward logs. The more sensitive flow sensor employed on 2-Sep-14 was again used. After logging the well from top to bottom and then back up to a depth of 140 ft bgs including vapor sampling during this first up log, the vacuum applied to the well was reduced from 6 inHg to 4 inHg. The purpose of lowering the vacuum was to lower the water table and expose another two feet of the corehole to logging. The reduced vacuum yielded a lower flow but the modified probe also had a more sensitive flow sensor as described previously. The flow logs at the reduced vacuum and flow are proportional to the higher flow logs. However, as illustrated in Figure 2-6, an attempt to go deeper on the second down log at lowered vacuum resulted in submerging the sensor and the erroneous upward log (Up, 4 inHg) until the sensor was somewhat dried out.

Toward the bottom of this log, the flow response persisted compared to the previous logs, and did not approach zero until attaining a depth of almost 167 ft bgs. These observations again indicated nearly all of the flow (greater than 90%) emerged from deeper depths. Repeatable responses by the flow sensor at depths of 160 ft bgs and 167 ft bgs suggest the location of fractures as lateral flow impinged on the sensor sufficiently to generate a response.

Vapor samples were collected in Tedlar bags and analyzed as illustrated on the right hand side of Figure 2-6 where the PID response (as TCE) is also plotted versus depth. Table 2-4 summarizes the results for TCE and cis-1,2-DCE from these analyses. As indicated sampling was performed during the higher vacuum operation in the deeper interval and then repeated after the vacuum was reduced. The PID response at the bottom of the log did not drop to near zero as in previous logs because water did not enter the sampling line.

The TCE vapor concentrations across the open corehole were consistent over the length of the corehole from 135 to 137 ppmv of TCE; however, just above the water table, the TCE vapor concentration was decreased during sampling with the lesser applied vacuum. This behavior indicates the productive fractures in the interval from 158 to 166 ft bgs are the primary sources for the extracted TCE mass. SVE was removing TCE mass through fractures that intersect HAR-19 just above the water table at a rate of ~4.4 ppd at the end of the third extraction period.

Of note is the lower TCE vapor concentration measured after the vacuum was reduced from 6 in Hg to 4 inHg. This behavior was not observed during the re-start of SVE suggesting a higher applied vacuum may be beneficial to contaminant removal; however, this effect may also be a short-term response to the change in applied vacuum.

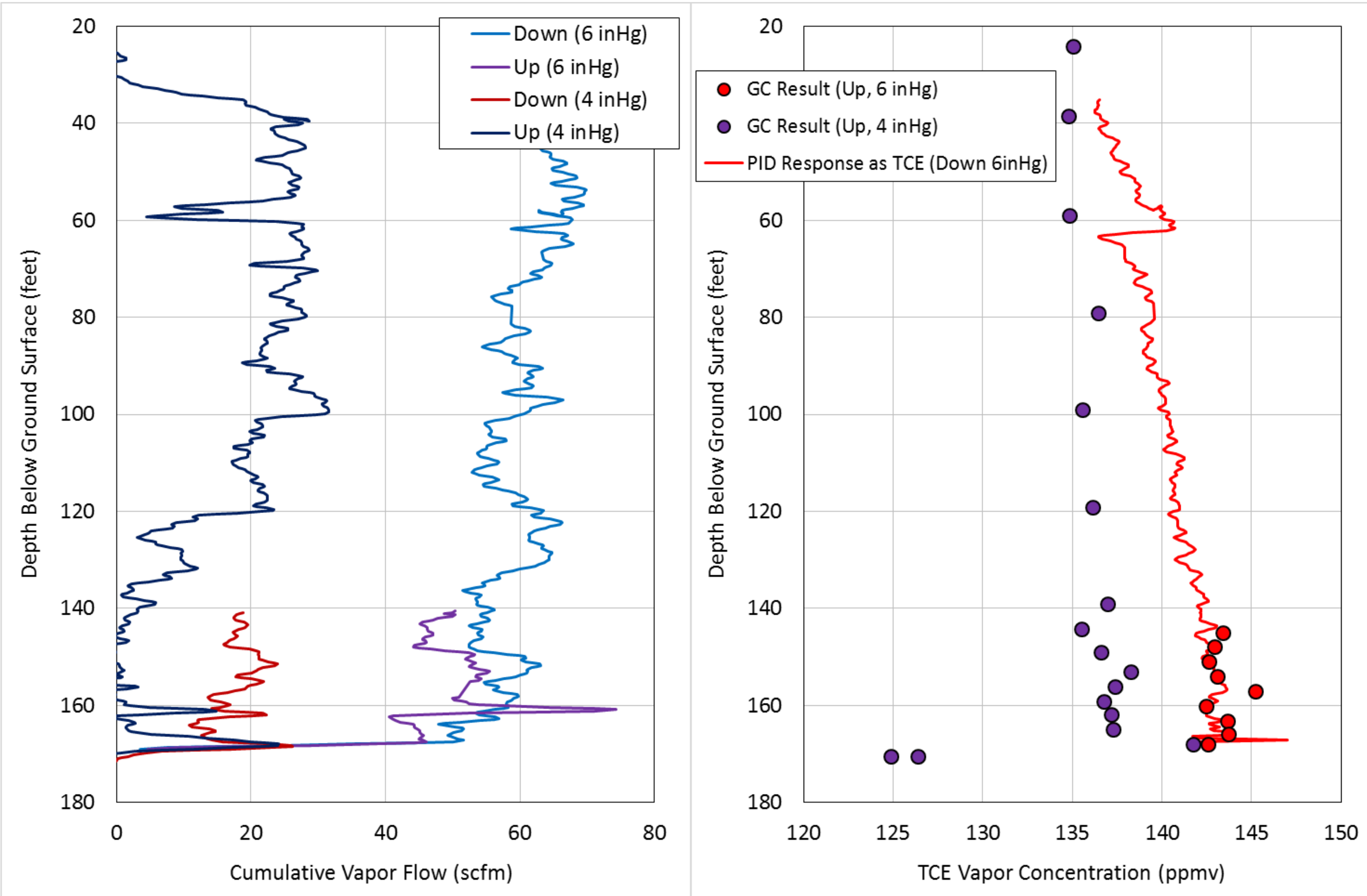


Figure 2-6. PneuLog Measured Profiles (9/12/14)

Table 2-4. Results of Vapor Sample Analyses from 9/12/14

DEPTH	cis-1,2-DCE (ppmv)	TCE (ppmv)	NOTES
139.06	14.0	142.0	Vacuum of 6 inHg
144.89	14.4	143.4	Vacuum of 6 inHg
147.92	14.3	142.9	Vacuum of 6 inHg
150.96	14.3	142.6	Vacuum of 6 inHg
154.00	14.4	143.1	Vacuum of 6 inHg
157.04	14.5	145.2	Vacuum of 6 inHg
160.08	14.4	142.5	Vacuum of 6 inHg
163.12	14.4	143.7	Vacuum of 6 inHg
165.90	14.5	143.7	Vacuum of 6 inHg
167.93	14.5	142.6	Vacuum of 6 inHg
24.11	13.3	135.0	Vacuum of 4 inHg
38.54	13.4	134.8	Vacuum of 4 inHg
59.05	13.5	134.8	Vacuum of 4 inHg
79.05	13.4	136.4	Vacuum of 4 inHg
99.06	13.4	135.6	Vacuum of 4 inHg
119.06	13.5	136.1	Vacuum of 4 inHg
139.06	13.7	137.0	Vacuum of 4 inHg
144.13	13.4	135.5	Vacuum of 4 inHg
148.94	13.6	136.6	Vacuum of 4 inHg
152.99	13.8	138.2	Vacuum of 4 inHg
156.03	13.7	137.4	Vacuum of 4 inHg
159.06	13.6	136.7	Vacuum of 4 inHg
161.85	13.8	137.2	Vacuum of 4 inHg
164.89	13.7	137.3	Vacuum of 4 inHg
167.93	13.7	141.8	Vacuum of 4 inHg
170.46	12.6	126.4	Vacuum of 4 inHg
170.46	12.4	124.9	Field Duplicate
QA/QC	0.0	0.1	Field Ambient

HAR-19 (22-Oct-14)

PneuLog testing was performed in HAR-19 on 22-Oct-14 after a 6-week rebound period. During the re-start, a vacuum of 4 inches of mercury (inHg) was applied yielding an initial total extraction rate over 100 standard cubic feet per minute (scfm). The extraction rate decayed with time after startup to less than 60 scfm. The PneuLog sensor was located at a depth of 36.5 ft bgs below the transition to the 8-inch diameter uncased corehole. The PneuLog flow response and the PID response (corrected to TCE) at this depth during the re-start are plotted in Figure 2-7. The PID response was relatively stable at a TCE concentration of about 105 ppmv (based on the PID reading) and the flow was stable at about 56 scfm after about 60 minutes of extraction.

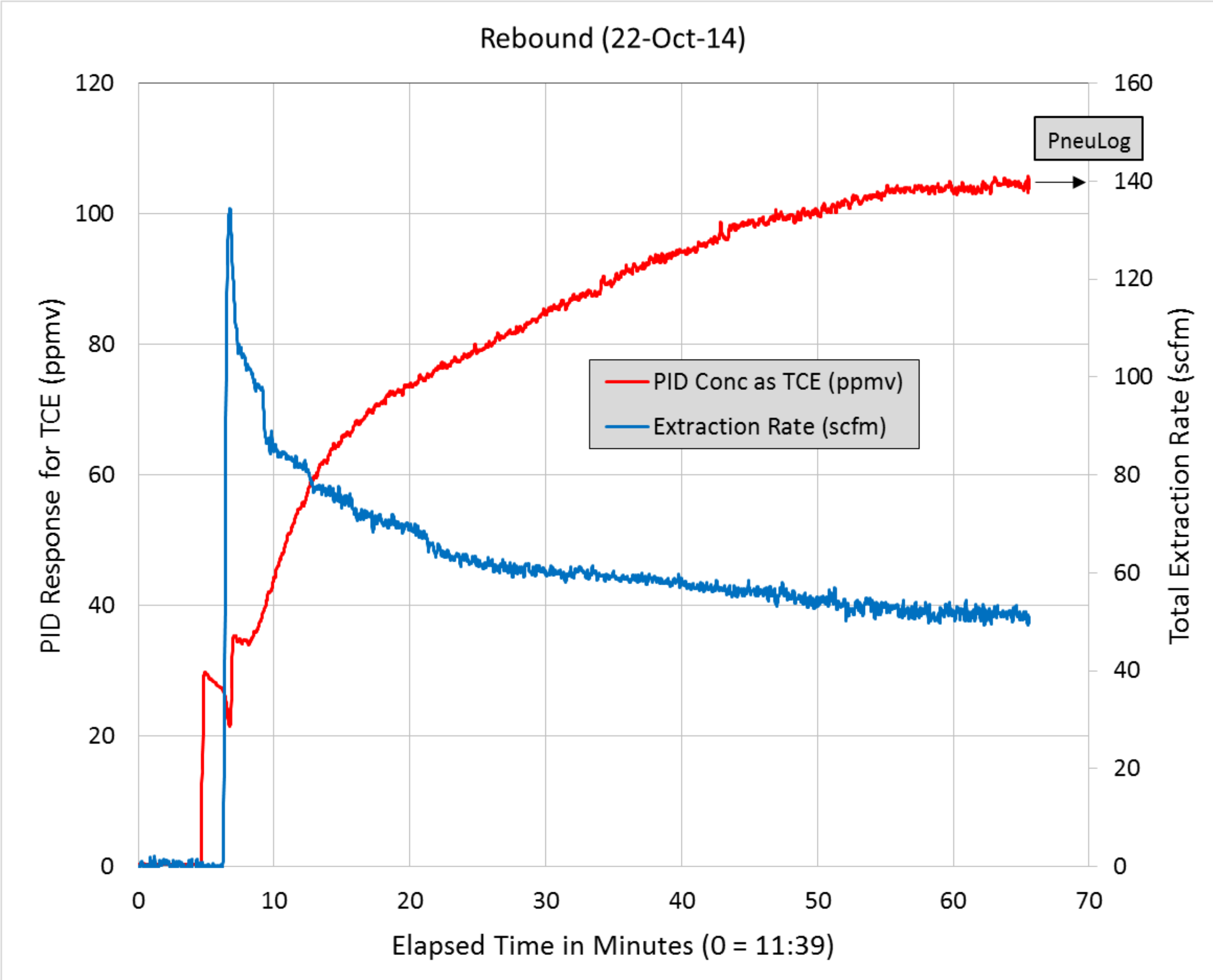


Figure 2-7. Flow Response and PID Concentration Response during Rebound (10/22/14)

The cumulative airflow profiles measured in the fifth logging event after extended dormancy are presented on the left side of Figure 2-8. These raw flow profiles are from both the downward and upward logs. The more sensitive flow sensor employed on 2-Sep-14 and 12-Sep-14 was again used without modification. After logging the well from top to bottom and then back up to a depth of 140 ft bgs including vapor sampling during the first up log, the down log and vapor sampling were repeated in the deep interval. The flow logs in the deep interval are very similar; however, the flow was slightly reduced after the first down log. This small apparent reduction in flow was likely the result of water on the sensor rather than an actual reduction in flow. The second down log encountered a number of obstructions that interfered with the flow reading; therefore, this log is shown with dashes. The second up log encountered much less interference until the probe reached about 65 feet where the sensor became low and erratic. This logging interval is shown as a dashed line labeled, “Up 2 (rock).” When the device was retrieved from the well a rock was lodged on the sensor and appeared to be broken off from the wall of the corehole.

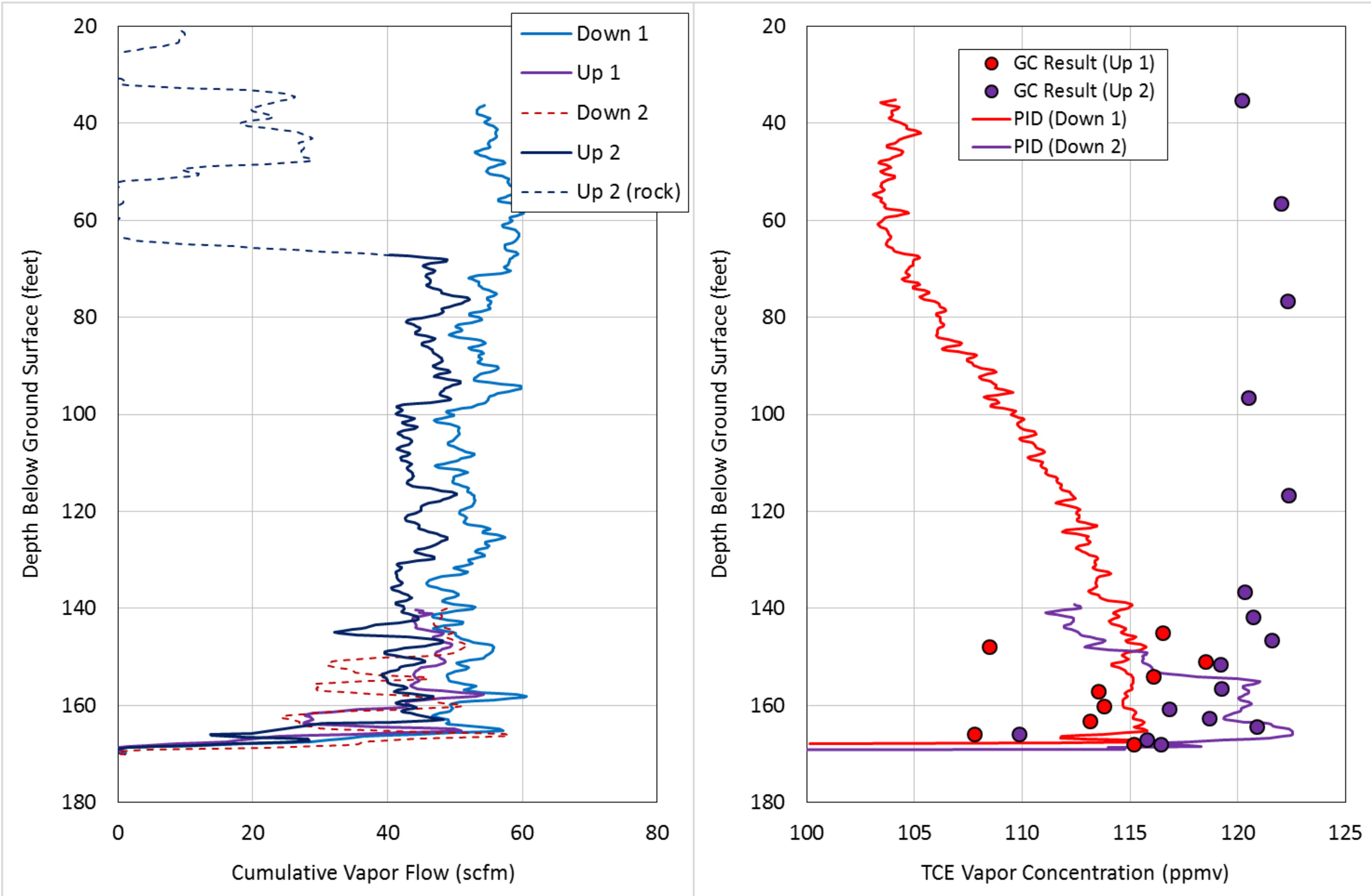


Figure 2-8. PneuLog Measured Profiles (10/22/14)

This flow log again indicates nearly all of the flow (greater than 90%) emerged from deeper depths. Repeatable responses by the flow sensor at depths of 160 ft bgs and 167 ft bgs suggest the location of fractures as lateral flow impinged on the sensor altering its response.

Vapor samples were collected in Tedlar bags and analyzed as illustrated on the right hand side of Figure 2-6 where the PID response (as TCE) is also plotted versus depth. Table 2-5 summarizes the results for TCE and cis-1,2-DCE from these analyses. Vapor samples were collected twice in the deep interval. The second sampling event yielded slightly higher TCE vapor concentrations but these concentrations may have not yet been stable (still slightly increasing). The PID response at the bottom of the log dropped to near zero because water entered the sampling line.

Table 2-5. Results of Vapor Sample Analyses from 10/22/14

DEPTH	**cis-1,2-DCE** (ppmv)	**TCE** (ppmv)	**NOTES**
139.06	12.9	116.5	Up Log 1
144.89	12.8	116.5	Up Log 1
147.92	12.0	108.4	Up Log 1
150.96	13.1	118.5	Up Log 1
154.00	12.8	116.1	Up Log 1
157.04	12.6	113.5	Up Log 1
160.08	12.6	113.8	Up Log 1
163.12	12.6	113.1	Up Log 1
165.90	12.3	107.8	Up Log 1
167.93	13.3	115.2	Up Log 1
12.49	13.0	120.8	Up Log 2
35.28	13.0	120.2	Up Log 2
56.55	13.2	122.0	Up Log 2
76.55	13.3	122.3	Up Log 2
96.56	13.1	120.5	Up Log 2
116.56	13.4	122.4	Up Log 2
136.56	13.2	120.3	Up Log 2
141.63	13.2	120.7	Up Log 2
146.44	13.2	121.6	Up Log 2
151.50	13.0	119.2	Up Log 2
156.56	13.0	119.2	Up Log 2
160.62	12.7	116.8	Up Log 2
162.64	12.9	118.7	Up Log 2
164.41	13.3	120.9	Up Log 2
165.93	12.0	109.9	Up Log 2
166.95	12.7	115.8	Up Log 2
166.95	12.7	116.6	Field Duplicate
167.96	12.9	116.4	Up Log 2
QA/QC	0.0	0.2	Field Ambient

The TCE vapor concentrations across the open corehole were consistent across the length of the corehole from 116 to 122 ppmv of TCE; however, just above the water table and up to a depth of about 155 ft bgs, the TCE vapor concentration was very slightly lower, in particular at a depth of 166 ft bgs. The local decrease at 166 ft bgs was observed during both sampling events. The stable TCE concentration and total flow above 155 ft bgs indicates the productive fractures in the interval from 158 to 166 ftbgs are the primary sources for the extracted TCE mass. SVE was removing TCE mass through fractures that intersect HAR-19 just above the water table at a rate of ~3.5 ppd after six weeks of rebound.

The TCE concentration in the sample collected at the top of the corehole was 121 ppmv and was was higher than the similarly collected TCE concentration of 108 ppmv at the start of the SVE pilot test. This observation suggests sustained SVE in HAR-19 would yield a relatively stable extraction of TCE on a timescale of at least months.

3. COMPARISON OF PNEULOG PROFILES

A comparison of the flow and TCE vapor concentration logs in the interval from 140 to 175 ft bgs is provided in Figure 3-1.

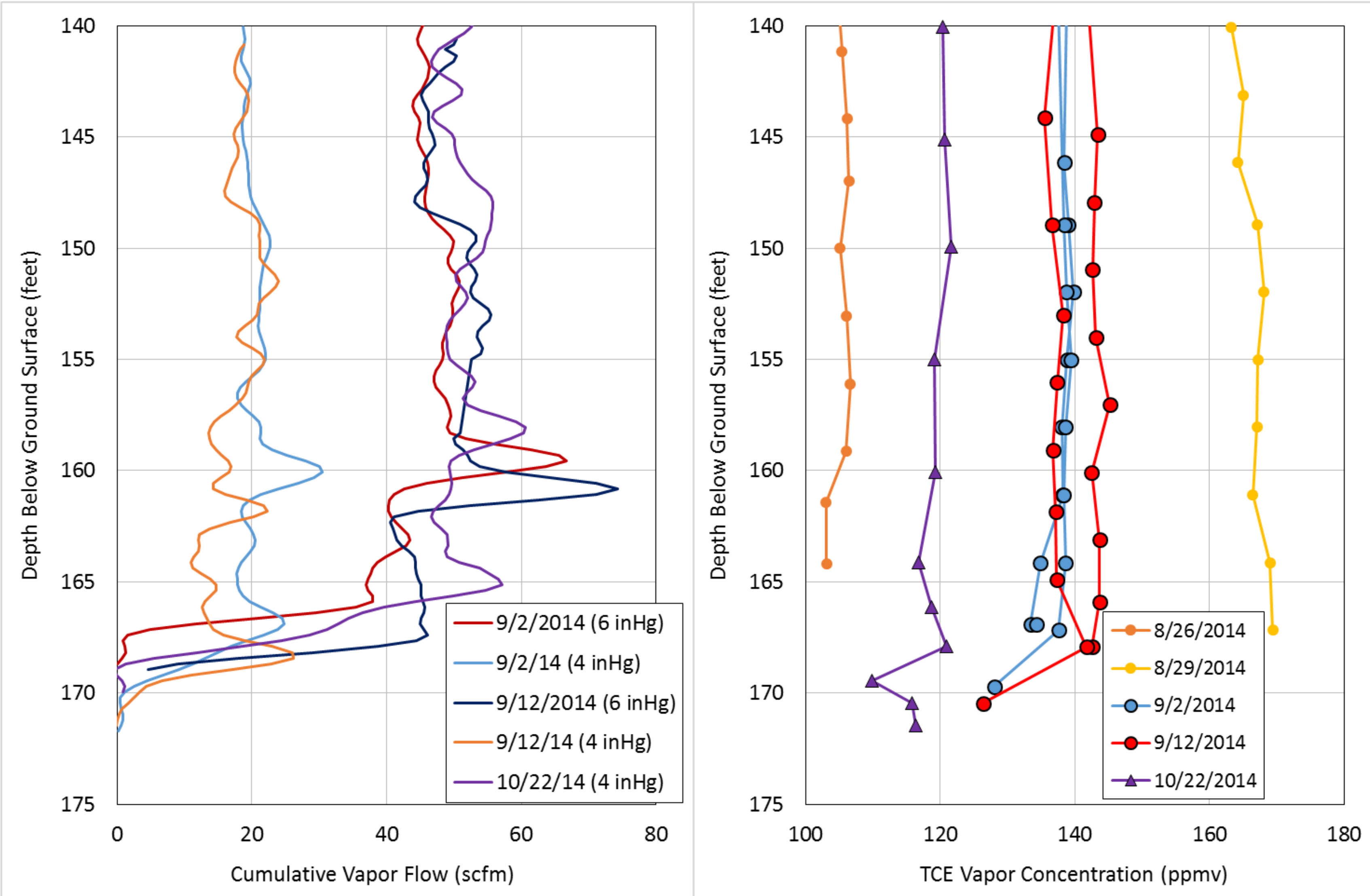


Figure 3-1. Comparison of PneuLog Measured Profiles

Appendix A
PneuLog Standard Operating Procedure

STANDARD OPERATING PROCEDURE - PneuLog®

1. INTRODUCTION

This project will utilize a procedure combining site characterization and the collection of soil vapor extraction (SVE) data in vadose zone soils containing volatile organic compounds (VOCs). The procedure developed by PRAXIS Environmental Technologies, Inc. uses pneumatic well logging, known as PneuLog®, to measure the vertical air permeability and chemical concentration profiles in wells screened for SVE. The field procedures associated with PneuLog® are described in this attachment. All field activities will adhere to the procedures and specifications contained in the project Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) prepared as separate documents.

Pneumatic well logging is used to develop a detailed conceptual site model to aid in the design, optimization, or closure of SVE systems. The following data are collected in addition to lithologic logging and conventional sample analyses to build the conceptual site model:

- Flow and vacuum data from extraction wells,
- Vertical vapor concentration data from extraction wells, and
- Vertical air production profiles from extraction wells.

This attachment describes the PneuLog® technology and the collection of the data listed above.

2. TECHNOLOGY DESCRIPTION

This project will employ an expedited approach to vadose zone characterization with simultaneous collection of data for optimized SVE design and operation. For both vadose zone characterization and remedial design, Praxis has developed, field-tested and commercialized a pneumatic well logging process. Known as PneuLog®, the well logging is performed by simultaneously measuring the cumulative air flow and chemical vapor concentrations along the depth of an extraction well screen during active SVE. To make these measurements, a flow sensor is moved through the well during vapor extraction and soil gas samples are collected and analyzed continuously. Performing these measurements at a representative number of wells can yield a three-dimensional picture of the extent of chemicals in soils at a site as well as the soil permeability distribution. These measurements, in conjunction with traditional measurements, yield a thorough site evaluation.

The equipment for the pneumatic logging is illustrated in Figure 1. The Pneulog® instrumentation is attached to a cable, which passes through alignment pulleys and a vacuum-tight fitting at the wellhead. The instrumentation is raised or lowered by a motorized reel around which the cable is wound. The logging proceeds at roughly eight feet per minute along the screen in the SVE well. Sensors in the pulley assembly indicate the depth of the measurement. Electrical leads connect the flow sensor to a data acquisition system located on the motorized reel. A vapor sampling tube connects the sample port on the instrument to a vacuum pump, also on the reel. The sampling pump draws a continuous stream of air through the sampling tube to the surface where it is analyzed for VOCs and other compounds of interest (e.g., oxygen and carbon dioxide). A photoionization detector (PID) is used to provide a continuous reading of total VOC concentration. Canister samples can be collected for off-site gas chromatographic and mass spectrometer analyses to determine compound-specific concentrations at discrete depths and to calibrate the PID readings. Supplemental vapor samples can be collected and analyzed on-site with a field gas chromatograph.

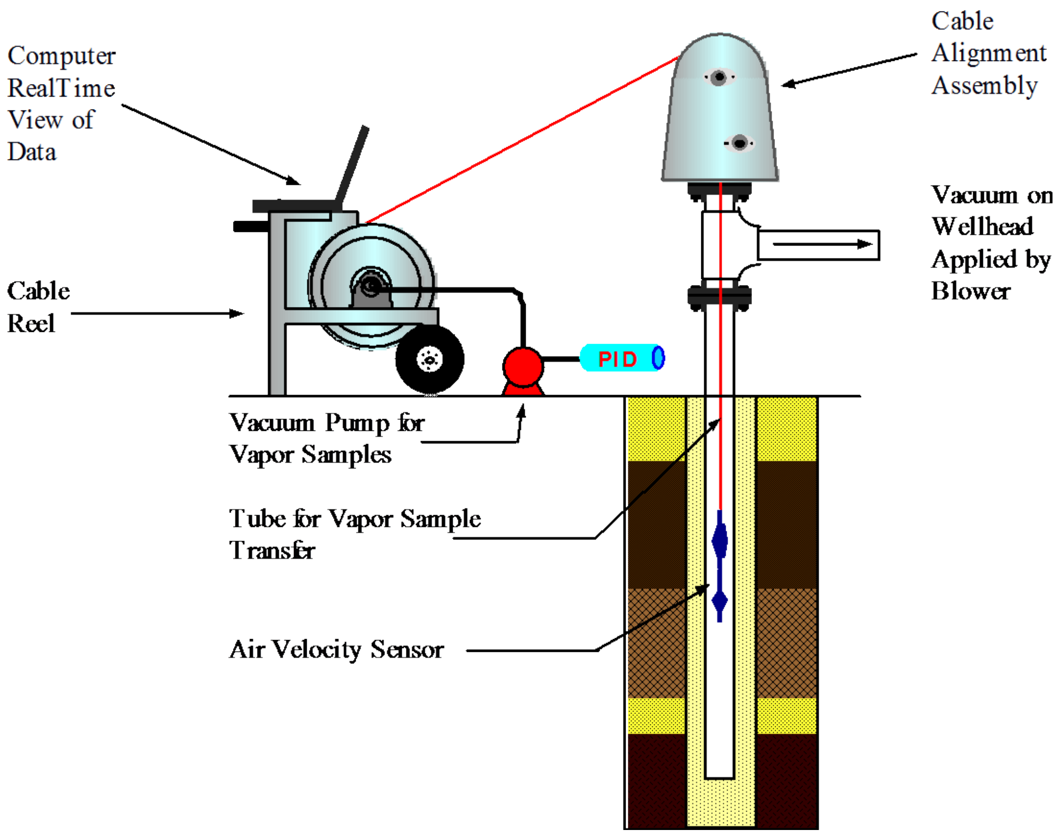


Figure 1. Schematic of Pneumatic Well Logging Equipment

The airflow from each soil layer is related to the cumulative airflow by a simple mass balance. To determine the airflow from a given soil layer, the cumulative airflow measured below the soil layer is subtracted from the cumulative airflow measured above the soil layer. The soil permeability of the interval is then determined from Darcy's law. The data and the analyses appear similar to output from borehole flowmeter testing in water wells (Molz et al., 1989). A typical cumulative airflow measurement from PneuLog® is provided in Figure 2a. In this example, the well is screened from 12 to 32 feet below the ground surface (bgs). The screen interval is indicated by the green (dark) and yellow (light) blocks together. As shown, the airflow from the bottom half of the well is practically zero. The airflow increases steadily from 0 to 28 standard cubic feet per minute (scfm) between 23 and 16.5 feet bgs as the instrument is raised through the screen. The steady flow increase indicates this soil interval has a relatively uniform permeability to air. From 16.5 to 15 feet, only 2.5 scfm of soil gas are added. 15 scfm are then added in the next 1.5-foot interval up to 13.5 feet. The top 1.5 feet of the screen adds only one scfm to the total.

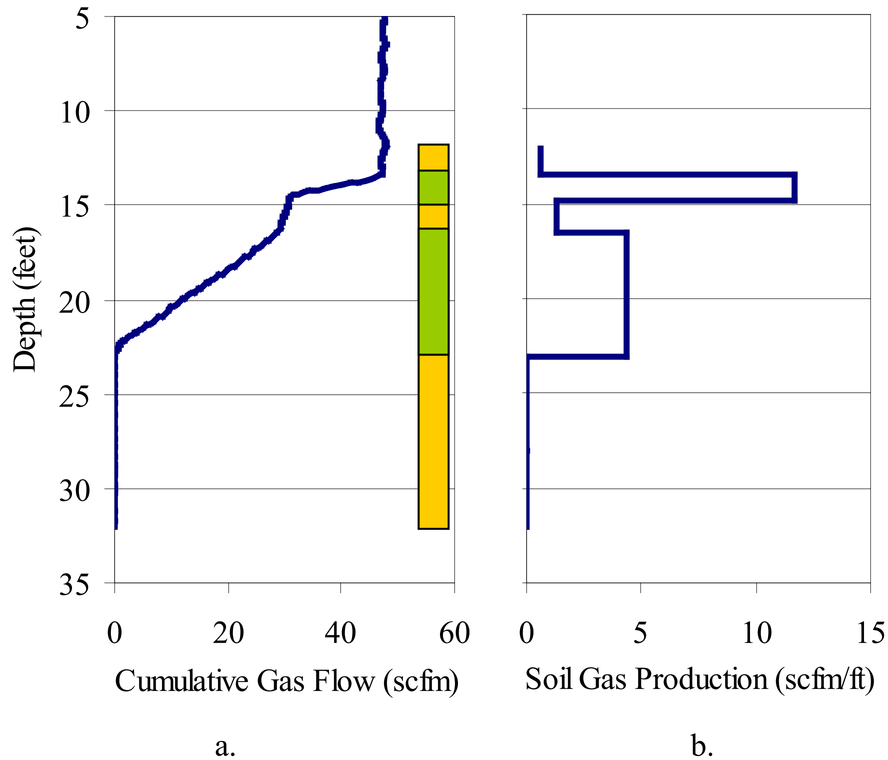
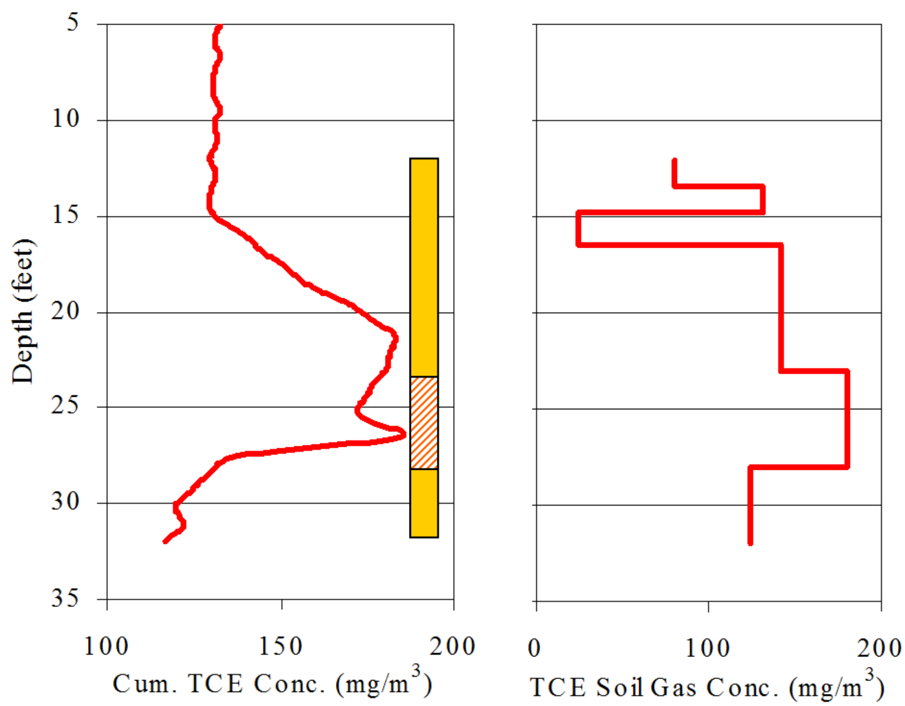


Figure 2. Example Pneumatic Well Logging Results for Soil Permeability to Air

Figure 2b presents an interpretation of the cumulative flow measurements as soil gas production. An effective air permeability profile can be generated using the soil gas production profile with multi-dimensional analytical or numerical airflow models. The permeability of an interval is proportional to the change in flow across the interval, its thickness, its depth below the surface and the well vacuum according to Darcy's law. Figure 2b reveals roughly five soil strata along the screen. The stratum intersected by the bottom half of the screen has a relatively low permeability since no measurable soil gas was produced. The geologist characterized the soils of this interval as silts. The soil intervals from 16.5 to 23 feet and 13.5 to 15 feet have air productions indicative of coarse sands. These two sand intervals are separated by a 1.5-foot-thick silt interval. The soil at the top of the screen would also be characterized as silt. This characterization of the physical properties is superior to a geological log and a typical air permeability test. The PneuLog® results were qualitatively consistent with the geological log; however, the geological log provided little indication of air permeability. Without the pneumatic logging data, the permeability determined by typical testing would be averaged over the screen interval and dominant features of the subsurface flow during SVE would not be quantified.

The characterizations of zones containing chemicals and soil gas concentrations result from the measurement of VOC concentrations along the well screen. An example concentration log, which was collected simultaneously with the previously discussed air flow log, is presented in Figure 3a. This concentration profile was obtained from a continuous PID reading which was calibrated to trichloroethylene (TCE) concentrations with on-site and off-site gas chromatographic analyses of vapor samples from discrete depths and the wellhead. The measured vapor concentration is lowest near the bottom of the screen and increases slightly up to a depth of about 28 feet. As the instrumentation is raised higher in the well, the concentration increases sharply to a maximum and remains relatively steady into the soil gas production interval starting at 23 feet. The concentration then decreases steadily from 22 to 15 feet bgs. Between 15 feet and the top of the screen, the concentration increases very slightly.



a. b.

Figure 3. Sample Pneumatic Well Logging Results

The observed increases and decreases in concentration can be combined with the depth-specific air production in a mass balance to estimate depth-specific soil gas concentrations. The PneuLog® device simultaneously measures the flow rate and concentration versus depth. The change in the product of these two variables over a specified depth interval divided by the flow change is equal to the chemical vapor concentration in the soils of that depth interval.

Application of this relationship to the data shown in Figures 2a and 3a yields the chemical vapor concentration profile presented in Figure 3b. The highest concentration occurs in the low permeability material underlying the deep sand interval. This high concentration indicates the low permeability interval creates a mass transfer constraint to SVE. Compounds must migrate slowly out of this interval into the flow interval above. The silt interval at 15 feet does not appear to be a barrier to chemical migration between the sands.

As illustrated by this example, pneumatic logging provides a more thorough and appropriate site characterization than traditional methods alone. Repeating the process in a representative number of wells can generate a three-dimensional description of the physical and chemical subsurface by correlating between locations. The technique also provides data to more effectively design and optimize an SVE system. Soil strata near or below cleanup goals are quickly identified and the extraction flow rate can be lowered or terminated from these layers. The operation can then be focused on strata remaining above cleanup goals. This optimization could lead to cost savings by accelerating cleanup and lowering operation & maintenance costs.

3. FIELD TASKS AND PROCEDURES

This section describes the field activities and procedures to collect data for site characterization and SVE design using PneuLog®. The activities adhere to the procedures and specifications contained in the project Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) prepared as separate documents. Site evaluation includes measurements of flow and vacuum in extraction and monitoring wells during pneumatic logging. Concentrations during the tests are monitored with a PID and two samples from each screen interval are collected and analyzed for VOCs. During the testing, vacuum responses are monitored in other available screens to aid in the calculation of permeabilities at the site. Vacuum responses depend on the soil properties and well spacing and may not be measurable in all monitored screen intervals.

The PneuLog® technique was described in detail in Section 2. During the pneumatic logging, a small flow of air is extracted through the Teflon® tubing attached to the flow instrument in the well. The total organic compound concentration in this air flow will be measured with a calibrated photoionization detector (PID) to yield the chemical concentration in soil gases extracted along the well screen depth. The pneumatic log will then be repeated and the instrument will be paused at a depth of major change in flow or concentration, generally at the maximum concentration. At this discrete depth, a sample of the soil gas may be collected in a canister or Tedlar® bag. A second canister or Tedlar® sample will be collected at the top of the well. Canisters will be packaged and shipped to a state-certified, off-site laboratory for analysis by GC/MS. The flow data from the pneumatic well log will immediately be analyzed to yield an air production profile along the well screen and the concentration log will be analyzed to indicate the intervals with the highest chemical concentrations. In wells with lower concentrations, a meaningful maximum concentration along the screen may not be identified. In these screens, a vapor sample will be collected from the bottom of the screen.

Any point or non-point discharge to air generally requires review and permission from the local air board. This includes any process that volatilizes materials from the ground (e.g., soil vapor extraction) or uses volatilization as a means of disposal for unwanted materials or constituents. The SVE aspect of this fieldwork will require the extraction of vaporous chemicals from the subsurface. The SVE discharge from each well will be treated with existing vapor abatement equipment on each site.

4. VAPOR SAMPLING AND ANALYSES

This section summarizes the procedures for collecting and analyzing vapor samples during the field tests. The equipment that will be used to collect vapor samples is also described. The sample locations, frequencies, and procedures presented are subject to change based on site-specific conditions.

Vapor concentrations will be monitored continuously during extraction periods with a calibrated PID as described in Section 3. Vapor samples will be collected in Summa® canisters for off-site analysis via method TO-14 (VOCs) or TO-15 (VOCs), and/or method TO-3 (total volatile petroleum hydrocarbons) at a state-certified laboratory or in Tedlar bags for on-site analyses of VOCs using a modified EPA Method 18. Approximately 2 samples will be collected during the pneumatic log of each screen in each well location. Samples will be collected through the pneumatic logging instrumentation and will provide depth-specific concentrations from inside the extraction wells. One sample will be collected from above the screen interval and one sample from the depth in the screen yielding the highest concentration or the bottom.

Depth-specific samples will be drawn by a small, oilless diaphragm pump through a Teflon® tube attached to the flow instrumentation for pneumatic logging. The vapor sample will be monitored by a PID on the surface and collected near the discharge of the Teflon® tube in a stainless steel SUMMA® canister or Tedlar® bag. The majority of samples collected in Tedlar bags will be analyzed on-site with a portable GC. Canisters will also be used to directly collect vapor samples at the wellhead to validate on-site analyses. The canisters will be submitted for offsite chemical analysis. Samples will be collected following the guidance offered in EPA's "*Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*," EPA 4-84-041-April 1984. The specific methods to be used are TO-14, "Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatography Analysis" or TO-15 and/or TO-3 for total volatile petroleum hydrocarbons. The canisters will be used and samples collected in the vacuum mode. The vacuum in the clean canister (near 30 inches Hg) will be sufficient to pull the sample out of the gas line. A slow flow rate into the canister will be controlled manually by slightly cracking open its valve. The rate is checked by monitoring the canister vacuum gauge and comparing the value to the elapsed time and the wellhead vacuum. The final canister vacuum will be approximately equal to the vacuum in the vapor extraction line. The final vacuum will be recorded on the chain-of-custody and then measured at the laboratory after shipment and before analysis. The two recorded vacuums will be approximately equal if the canister has not leaked. Each canister will be cleaned in the laboratory before delivery.

The purpose of a field quality control program is to provide a measure of data quality. QA samples to be collected include field duplicates, equipment blanks, trip blanks, ambient condition blanks, and material for matrix spike/matrix spike duplicate (MS/MSD) analyses. Collection of the QA samples during the project is described in the project Work Plan. A summary of the quality control sampling for vapor sampling during PneuLog® is provided in Table 1. The sample handling, preservation and shipment procedures are described in the Work Plan along with sample custody and decontamination procedures.

TABLE 1
QUALITY CONTROL SAMPLES

Sample Matrix Analysis	Analysis Level	Number of Samples						
		Primary	Duplicate	Ambient Blank	Trip Blank	Equipment Blank	Matrix Spike /MSD	Total
Soil Vapor								
VOCs (Offsite TO-14)	III	TBD[1]	1 per 10	0	0	0	0	TBD[1]
VOCs (Offsite TO-15)	III	TBD[1]	1 per 10	0	0	0	0	TBD[1]
VOCs (Onsite TO-18)	I	2 per well	1 per 10	1 per 10	0	1 per 10	0	13 per 5 wells
TVPH (Offsite TO-3)	III	TBD[1]	1 per 10	0	0	0	0	TBD[1]

[1] TBD = To Be Determined

5. DATA MANAGEMENT

The data to be collected during PneuLog® include:

- Soil vapor concentrations,
- Extraction air flowrates,
- Wellhead vacuums,
- Vertical air flow profiles, and
- Vertical concentration profiles.

These data can be used to define the vertical and horizontal extent of chemicals at the various sites if a sufficient number of representative wells are logged. The data will also yield the disposition of the chemicals (e.g., found primarily in low permeability soil, found near the groundwater, suspected non-aqueous phase liquid present, etc.). The pneumatic logging data, combined with historical data can provide information on optimal SVE system operation and possibly the optimal locations for new SVE wells.

A general chronicle of field activities and personnel on site will be recorded daily. The following information shall be recorded for all field activities: (1) location, (2) date and time, and (3) identity of people performing activity. The information shall be recorded in a field notebook or on data logging sheets. These records shall be archived in an easily accessible form and made available to the Air Force upon request.

The collection of soil vapor samples will be documented in a field notebook or on appropriate data logging sheets. These records shall be archived in an easily accessible form and made available to the Air Force or its contractors upon request. The following additional information shall be recorded for all sampling activities: (1) sample type and sampling method, (2) the identity of each sample including location and depth(s), where applicable, from which it was collected, (3) the date and time of collection, (4) the amount of each sample or sample container volume, (5) sample description (e.g., color, odor, clarity), and (6) identification of conditions that might affect the representativeness of a sample (e.g., refueling operations, damaged casing).

Field measurements will be recorded on data sheets specific to each measurement (e.g., air flow rates and wellhead vacuums). For each field instrument the following shall also be recorded: (1) the numerical value and units of each measurement, and (2) calibration results

6. HEALTH AND SAFETY

The health and safety plan for the fieldwork is prepared separately and is adhered to during all field activities.

7. MANAGEMENT AND STAFFING

Key staff from PRAXIS assigned to the project are shown in Table 2 with their responsibilities. Team members include:

Ms. Mary Scarpetti is the President of PRAXIS. She is responsible for the administrative, contractual and fiscal aspects of all PRAXIS projects. All significant changes in scope or cost must have her approval. Ms. Scarpetti received her law degree from the University of San Francisco in 1990 and is a member of the California Bar Association. Ms. Scarpetti has seven years of experience in the operations and financing of small firms and, in particular, government contracting and accounting. She worked in the securities industry prior to law school.

Dr. Lloyd "Bo" Stewart is the Principal Engineer for the pneumatic well logging and a Vice President of PRAXIS. Dr. Stewart has ten years of experience overseeing the development and implementation of innovative technologies for the remediation and characterization of hazardous waste sites. Dr. Stewart also develops and implements computer models for risk assessments and cleanup actions. Remedial technologies under development at Praxis include steam injection combined with vacuum extraction, dual-phase extraction, and hydraulic fracturing. Dr. Stewart received his Ph.D. in Mechanical Engineering from the University of California Berkeley in 1989.

Mr. Mike Chendorain in the Soil Hydrologist for the subsurface investigation, data analysis, and modeling. Mr. Chendorain received an MS in Soil and Environmental Sciences from the University of California at Riverside. He received a BS in Environmental Sciences from Virginia Institute of Technology. He has three years of experience in modeling the fate and transport of chemicals in the subsurface. While working on his MS, he also worked as a teaching assistant and as a research assistant.

Table 2
PRAXIS Project Team Members

Responsibility	Team Member
Program Manager / Contracts	Mary Scarpetti
Project Manager / Principal Engineer	Bo Stewart
Subsurface Modeling/Data Analysis	Mike Chendorain
Equipment Installation & Maintenance	Steven Scarpetti

8. REFERENCES

Molz, F.J., R. H. Morin, A. E. Hess, J. G. Melville, and O. Guven, 1989, "The Impeller Meter for Measuring Aquifer Permeability Variations: Evaluation and Comparison with Other Tests," *Water Resources Research*, Vol. 25, No. 7, pp. 1677-1683.

Appendix I
Soil Vapor Analytical Data

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Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	1000	U	$\mu g/m^3$	470	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	1500	U	$\mu g/m^3$	690	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	2800	U	$\mu g/m^3$	1300	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	2600	U	$\mu g/m^3$	1200	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	2700	U	$\mu g/m^3$	1200	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	550	U	$\mu g/m^3$	250	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	2500	U	$\mu g/m^3$	1100	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	1000	U	$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	1500	U	$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	2800	U	$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	270	U	$\mu g/m^3$	270	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	2600	U	$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	270	U	$\mu g/m^3$	270	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	2700	U	$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	550	U	$\mu g/m^3$	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	2500	U	$\mu g/m^3$	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	1000	U	$\mu g/m^3$	310	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	1500	U	$\mu g/m^3$	450	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	2800	U	$\mu g/m^3$	830	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	2600	U	$\mu g/m^3$	770	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	2700	U	$\mu g/m^3$	800	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	550	U	$\mu g/m^3$	170	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	2500	U	$\mu g/m^3$	740	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	64000		$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	92000		$\mu g/m^3$	240	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	150000		$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	130000		$\mu g/m^3$	240	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	150000		$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	15000		$\mu g/m^3$	590	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100000		$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240000		$\mu g/m^3$	590	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140000		$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	99000		$\mu g/m^3$	240	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	96000		µg/m^3	240	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120000		µg/m^3	940	2800
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120000		µg/m^3	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	1000	U	µg/m^3	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	µg/m^3	130	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	1500	U	µg/m^3	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	µg/m^3	130	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	2800	U	µg/m^3	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	310	U	µg/m^3	310	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	2600	U	µg/m^3	820	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	310	U	µg/m^3	310	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	2700	U	µg/m^3	860	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	µg/m^3	130	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	µg/m^3	130	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	550	U	µg/m^3	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	2500	U	µg/m^3	790	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	1000	U	µg/m^3	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	µg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	1500	U	µg/m^3	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	µg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	2800	U	µg/m^3	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	310	U	µg/m^3	310	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	2600	U	µg/m^3	820	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	310	U	µg/m^3	310	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	2700	U	µg/m^3	860	2700
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	µg/m^3	120	400
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	µg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	550	U	µg/m^3	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	2500	U	µg/m^3	790	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	1000	U	µg/m^3	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	µg/m^3	140	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	1500	U	µg/m^3	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	µg/m^3	140	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	2800	U	µg/m^3	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	360	U	µg/m^3	360	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	2600	U	µg/m^3	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	360	U	µg/m^3	360	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	2700	U	µg/m^3	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	µg/m^3	140	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	µg/m^3	140	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	1000		µg/m^3	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	2500	U	µg/m^3	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	1000	U	µg/m^3	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	µg/m^3	210	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	1500	U	µg/m^3	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	µg/m^3	210	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	2800	U	µg/m^3	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	530	U	µg/m^3	530	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	2600	U	µg/m^3	820	2600

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	530	U	$\mu g/m^3$	530	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	2700	U	$\mu g/m^3$	860	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	550	U	$\mu g/m^3$	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	2500	U	$\mu g/m^3$	790	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	1000	U	$\mu g/m^3$	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	1500	U	$\mu g/m^3$	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	2800	U	$\mu g/m^3$	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	200	U	$\mu g/m^3$	200	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	2600	U	$\mu g/m^3$	820	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	200	U	$\mu g/m^3$	200	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	2700	U	$\mu g/m^3$	860	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	550	U	$\mu g/m^3$	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	2500	U	$\mu g/m^3$	790	2500
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	GENCHEM	E3C	Mobile Lab	124-38-9	Carbon Dioxide	4.67		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	GENCHEM	E3C	Mobile Lab	124-38-9	Carbon Dioxide	4.68		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	GENCHEM	E3C	Mobile Lab	124-38-9	Carbon Dioxide	5.54		%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	GENCHEM	E3C	Mobile Lab	630-08-0	CARBON MONOXIDE	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	GENCHEM	E3C	Mobile Lab	630-08-0	CARBON MONOXIDE	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	GENCHEM	E3C	Mobile Lab	630-08-0	CARBON MONOXIDE	0.17	U	%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	1000	U	$\mu g/m^3$	310	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	1500	U	$\mu g/m^3$	450	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	2800	U	$\mu g/m^3$	830	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	580	U	$\mu g/m^3$	580	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	2600	U	$\mu g/m^3$	770	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	580	U	$\mu g/m^3$	580	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	2700	U	$\mu g/m^3$	800	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	550	U	$\mu g/m^3$	170	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	2500	U	$\mu g/m^3$	740	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	1000	U	$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	1500	U	$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	2800	U	$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	800	U	$\mu g/m^3$	800	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	2600	U	$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	800	U	$\mu g/m^3$	800	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	2700	U	$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	550	U	$\mu g/m^3$	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	2500	U	$\mu g/m^3$	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	33000		$\mu g/m^3$	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	11000		$\mu g/m^3$	190	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	27000		$\mu g/m^3$	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	16000		$\mu g/m^3$	190	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	35000		$\mu g/m^3$	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2200		$\mu g/m^3$	470	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	29000		$\mu g/m^3$	820	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	28000		$\mu g/m^3$	470	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	31000		$\mu g/m^3$	860	2700
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	15000		$\mu g/m^3$	190	400
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	16000		$\mu g/m^3$	190	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	38000		$\mu g/m^3$	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	36000		$\mu g/m^3$	790	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	36000		$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	39000		$\mu g/m^3$	220	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	19000		$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	39000		$\mu g/m^3$	220	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	28000		$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	5600		$\mu g/m^3$	550	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	23000		$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	80000		$\mu g/m^3$	550	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	13000		$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	51000		$\mu g/m^3$	220	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	51000		$\mu g/m^3$	220	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	31000		$\mu g/m^3$	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	31000		$\mu g/m^3$	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	1000	U	$\mu g/m^3$	330	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	1500	U	$\mu g/m^3$	480	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	2800	U	$\mu g/m^3$	890	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	150	U	$\mu g/m^3$	150	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	2600	U	$\mu g/m^3$	820	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	150	U	$\mu g/m^3$	150	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	2700	U	$\mu g/m^3$	860	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	550	U	$\mu g/m^3$	180	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	2500	U	$\mu g/m^3$	790	2500
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	GENCHEM	E3C	Mobile Lab	1333-74-0	Hydrogen	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	GENCHEM	E3C	Mobile Lab	1333-74-0	Hydrogen	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	GENCHEM	E3C	Mobile Lab	1333-74-0	Hydrogen	0.17	U	%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	2100	U	$\mu g/m^3$	620	2100
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	3000	U	$\mu g/m^3$	900	3000
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	5600	U	$\mu g/m^3$	1700	5600

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	400	U	$\mu g/m^3$	400	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	5100	U	$\mu g/m^3$	1500	5100
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	400	U	$\mu g/m^3$	400	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	5400	U	$\mu g/m^3$	1600	5400
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	1100	U	$\mu g/m^3$	330	1100
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	4900	U	$\mu g/m^3$	1500	4900
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	E3C	Mobile Lab	74-82-8	Methane	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	E3C	Mobile Lab	74-82-8	Methane	0.21	U	%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	E3C	Mobile Lab	74-82-8	Methane	0.17	U	%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	1000	U	$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	1500	U	$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	2800	U	$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	520	U	$\mu g/m^3$	520	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	2600	U	$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	520	U	$\mu g/m^3$	520	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	2700	U	$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	550	U	$\mu g/m^3$	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	2500	U	$\mu g/m^3$	840	2500
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	GENCHEM	E3C	Mobile Lab	7727-37-9	NITROGEN	83.6		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	GENCHEM	E3C	Mobile Lab	7727-37-9	NITROGEN	82.5		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	GENCHEM	E3C	Mobile Lab	7727-37-9	NITROGEN	86.2		%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	GENCHEM	E3C	Mobile Lab	Oxygen + Argon	Oxygen + Argon	11.7		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	GENCHEM	E3C	Mobile Lab	Oxygen + Argon	Oxygen + Argon	12.8		%v/v		0.21
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	GENCHEM	E3C	Mobile Lab	Oxygen + Argon	Oxygen + Argon	8.25		%v/v	0.17	0.17
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	1000	U	$\mu g/m^3$	310	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	1500	U	$\mu g/m^3$	450	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	2800	U	$\mu g/m^3$	830	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	440	U	$\mu g/m^3$	440	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	2600	U	$\mu g/m^3$	770	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	440	U	$\mu g/m^3$	440	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	2700	U	$\mu g/m^3$	800	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	550	U	$\mu g/m^3$	170	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	2500	U	$\mu g/m^3$	740	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	1000	U	$\mu g/m^3$	290	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	1500	U	$\mu g/m^3$	420	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	2800	U	$\mu g/m^3$	780	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	270	U	$\mu g/m^3$	270	1000

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	2600	U	$\mu g/m^3$	720	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	270	U	$\mu g/m^3$	270	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	2700	U	$\mu g/m^3$	750	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	550	U	$\mu g/m^3$	150	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	2500	U	$\mu g/m^3$	690	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	1000	U	$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	1500	U	$\mu g/m^3$	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	2800	U	$\mu g/m^3$	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	210	U	$\mu g/m^3$	210	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	2600	U	$\mu g/m^3$	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	210	U	$\mu g/m^3$	210	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	2700	U	$\mu g/m^3$	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	550	U	$\mu g/m^3$	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	2500	U	$\mu g/m^3$	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	6200		$\mu g/m^3$	390	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1400		$\mu g/m^3$	78	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	2700		$\mu g/m^3$	570	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	900		$\mu g/m^3$	78	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	2800	U	$\mu g/m^3$	1100	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	190	U	$\mu g/m^3$	190	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	2600	U	$\mu g/m^3$	970	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2000		$\mu g/m^3$	190	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	2700	U	$\mu g/m^3$	1000	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1600		$\mu g/m^3$	78	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1800		$\mu g/m^3$	78	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	4400		$\mu g/m^3$	210	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	3900		$\mu g/m^3$	940	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	240000		$\mu g/m^3$	580	2100
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	120000		$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	250000		$\mu g/m^3$	420	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	200000		$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	340000		$\mu g/m^3$	780	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	29000		$\mu g/m^3$	580	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	280000		$\mu g/m^3$	720	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	400000		$\mu g/m^3$	580	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	360000		$\mu g/m^3$	750	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	190000		$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	190000		$\mu g/m^3$	230	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	320000		$\mu g/m^3$	770	2800
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	370000		$\mu g/m^3$	690	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	1000	U	$\mu g/m^3$	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	1500	U	$\mu g/m^3$	510	1500

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	μg/m^3	110	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	2800	U	μg/m^3	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	270	U	μg/m^3	270	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	2600	U	μg/m^3	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	270	U	μg/m^3	270	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	2700	U	μg/m^3	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	μg/m^3	110	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	μg/m^3	110	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	550	U	μg/m^3	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	2500	U	μg/m^3	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	1000	U	μg/m^3	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	μg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	1500	U	μg/m^3	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	μg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	2800	U	μg/m^3	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	300	U	μg/m^3	300	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	2600	U	μg/m^3	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	300	U	μg/m^3	300	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	2700	U	μg/m^3	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	μg/m^3	120	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	μg/m^3	120	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	550	U	μg/m^3	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	2500	U	μg/m^3	840	2500
GRP3 - BRV	HAR-19	HAR19SVS001	267192.4	1789364.5	8/26/2014	15:45	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	9300		μg/m^3	350	1000
GRP3 - BRV	HAR-19	HAR-19-SV-S002	267192.4	1789364.5	9/2/2014	13:28	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	6400		μg/m^3	200	400
GRP3 - BRV	HAR-19	HAR19SVS003	267192.4	1789364.5	9/2/2014	13:39	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	4100		μg/m^3	510	1500
GRP3 - BRV	HAR-19	HAR-19-DISCHARGE	267192.4	1789364.5	9/5/2014	13:55	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	6400		μg/m^3	200	400
GRP3 - BRV	HAR-19	HAR19SVS005	267192.4	1789364.5	9/5/2014	14:10	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	4500		μg/m^3	950	2800
GRP3 - BRV	HAR-19	HAR-19-SV-S004	267192.4	1789364.5	9/8/2014	12:49	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	510	U	μg/m^3	510	1000
GRP3 - BRV	HAR-19	HAR19SVS006	267192.4	1789364.5	9/8/2014	13:08	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	4000		μg/m^3	870	2600
GRP3 - BRV	HAR-19	HAR-19-SV-S005	267192.4	1789364.5	9/12/2014	11:12	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	12000		μg/m^3	510	1000
GRP3 - BRV	HAR-19	HAR19SVS007	267192.4	1789364.5	9/12/2014	11:13	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	3800		μg/m^3	910	2700
GRP3 - BRV	HAR-19	HAR-19-2-SV-S006	267192.4	1789364.5	10/22/2014	15:36	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	5200		μg/m^3	200	400
GRP3 - BRV	HAR-19	HAR-19-1-SV-S006	267192.4	1789364.5	10/22/2014	15:05	BV	30	220	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	5400		μg/m^3	200	400
GRP3 - BRV	HAR-19	HAR19SV008	267192.4	1789364.5	10/22/2014	15:23	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	3900		μg/m^3	190	550
GRP3 - BRV	HAR-19	HAR19SV009	267192.4	1789364.5	10/22/2014	15:29	BV	30	220	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	4100		μg/m^3	840	2500
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	μg/m^3	9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	μg/m^3	9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	μg/m^3	5.4	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	μg/m^3	5.4	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	μg/m^3	8.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	μg/m^3	8.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	12	U	μg/m^3	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	12	U	μg/m^3	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	μg/m^3	6.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	μg/m^3	6.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	μg/m^3	6.2	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	μg/m^3	6.2	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	μg/m^3	7.2	20

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	9.4	U	$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	9.4	U	$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	270		$\mu g/m^3$	10	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	6	J	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	33		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	16	J	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-061	PZ-061-SV-S003	267329.7	1789461.4	9/5/2014	10:58	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-061	PZ-061-SV-S005	267329.7	1789461.4	9/12/2014	12:32	BV	38	48	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	$\mu g/m^3$	90	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	$\mu g/m^3$	54	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	270	U	$\mu g/m^3$	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	270	U	$\mu g/m^3$	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	450	U	$\mu g/m^3$	450	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	180000		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	180000		$\mu g/m^3$	590	1000

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	44000		$\mu g/m^3$	590	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100000		$\mu g/m^3$	240	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	310	U	$\mu g/m^3$	310	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	310	U	$\mu g/m^3$	310	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	310	U	$\mu g/m^3$	310	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	310	U	$\mu g/m^3$	310	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	360	U	$\mu g/m^3$	360	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	360	U	$\mu g/m^3$	360	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	530	U	$\mu g/m^3$	530	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	530	U	$\mu g/m^3$	530	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	200	U	$\mu g/m^3$	200	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	200	U	$\mu g/m^3$	200	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	580	U	$\mu g/m^3$	580	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	580	U	$\mu g/m^3$	580	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	800	U	$\mu g/m^3$	800	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	800	U	$\mu g/m^3$	800	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	94	U	$\mu g/m^3$	94	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	470	U	$\mu g/m^3$	470	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	470	U	$\mu g/m^3$	470	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	190	U	$\mu g/m^3$	190	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	94000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	98000		$\mu g/m^3$	550	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	26000		$\mu g/m^3$	550	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	58000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	150	U	$\mu g/m^3$	150	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	150	U	$\mu g/m^3$	150	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	400	U	$\mu g/m^3$	400	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	400	U	$\mu g/m^3$	400	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	520	U	$\mu g/m^3$	520	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	520	U	$\mu g/m^3$	520	1000

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	µg/m^3	210	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	µg/m^3	89	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	440	U	µg/m^3	440	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	440	U	µg/m^3	440	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	µg/m^3	180	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	µg/m^3	53	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	270	U	µg/m^3	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	270	U	µg/m^3	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	µg/m^3	110	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	µg/m^3	43	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	210	U	µg/m^3	210	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	400	J	µg/m^3	210	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	µg/m^3	85	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	µg/m^3	39	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	190	U	µg/m^3	190	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	190	U	µg/m^3	190	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	78	U	µg/m^3	78	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	650		µg/m^3	120	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	580	U	µg/m^3	580	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	580	U	µg/m^3	580	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	230	U	µg/m^3	230	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	µg/m^3	53	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	270	U	µg/m^3	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	270	U	µg/m^3	270	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	µg/m^3	110	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	µg/m^3	60	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	300	U	µg/m^3	300	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	300	U	µg/m^3	300	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	µg/m^3	120	400
GRP3 - BRV	PZ-156	PZ-156-SV-S002	267141.7	1788999.0	9/2/2014	12:07	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	µg/m^3	100	200
GRP3 - BRV	PZ-156	PZ-156-SV-S003	267141.7	1788999.0	9/5/2014	11:22	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	510	U	µg/m^3	510	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S005	267141.7	1788999.0	9/12/2014	10:25	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	510	U	µg/m^3	510	1000
GRP3 - BRV	PZ-156	PZ-156-SV-S006	267141.7	1788999.0	10/22/2014	12:47	BV	104	114	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	µg/m^3	200	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	µg/m^3	180	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	µg/m^3	90	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	µg/m^3	9	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	µg/m^3	110	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	µg/m^3	54	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	µg/m^3	5.4	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	µg/m^3	180	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	µg/m^3	89	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	µg/m^3	8.9	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6500		µg/m^3	59	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	550		µg/m^3	240	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6200		µg/m^3	120	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8400		µg/m^3	12	20

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	$\mu g/m^3$	6.3	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	$\mu g/m^3$	6.2	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	150		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1100		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	94	U	$\mu g/m^3$	94	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	150		$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	27000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	2000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	26000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	36000		$\mu g/m^3$	11	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	20000		$\mu g/m^3$	210	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	$\mu g/m^3$	43	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	7.4	J	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	19	U	$\mu g/m^3$	19	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	550		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	$\mu g/m^3$	39	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	63		$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2000		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3900		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2500		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3800		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	$\mu g/m^3$	60	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-201B	PZ-201B-SV-S002	267252.4	1789425.7	9/2/2014	8:45	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-201B	PZ-201B-SV-S003	267252.4	1789425.7	9/5/2014	10:26	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	$\mu g/m^3$	200	400
GRP3 - BRV	PZ-201B	PZ-201B-SV-S004	267252.4	1789425.7	9/8/2014	10:12	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-201B	PZ-201B-SV-S006	267252.4	1789425.7	10/22/2014	8:42	BV	100	115	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	98		$\mu g/m^3$	10	20
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	2500		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	410		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	17000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	140		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	6000		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-201C	PZ-201C-SV-S002	267252.4	1789425.7	9/2/2014	8:34	BV	124.9	139.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	$\mu g/m^3$	90	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	$\mu g/m^3$	9	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	$\mu g/m^3$	54	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	$\mu g/m^3$	5.4	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	690		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	370	J	$\mu g/m^3$	240	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1400		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	$\mu g/m^3$	6.3	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	$\mu g/m^3$	6.2	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1200		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1500		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1700		$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	10000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	7600		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	20000		$\mu g/m^3$	11	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	µg/m^3	160	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	µg/m^3	8	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	µg/m^3	100	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	µg/m^3	210	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	µg/m^3	10	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	µg/m^3	89	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	µg/m^3	180	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	µg/m^3	8.9	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	µg/m^3	53	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	µg/m^3	110	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	µg/m^3	5.3	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	µg/m^3	43	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	µg/m^3	85	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	µg/m^3	4.3	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	µg/m^3	39	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	78	U	µg/m^3	78	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	270		µg/m^3	3.9	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	13000		µg/m^3	120	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	8300		µg/m^3	230	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	15000		µg/m^3	12	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	µg/m^3	53	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	µg/m^3	110	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	µg/m^3	5.3	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	µg/m^3	60	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	µg/m^3	120	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	µg/m^3	6	20
GRP3 - BRV	PZ-201D	PZ-201D-SV-S004	267252.4	1789425.7	9/8/2014	10:09	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	µg/m^3	100	200
GRP3 - BRV	PZ-201D	PZ-201D-SV-S005	267252.4	1789425.7	9/12/2014	10:25	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	µg/m^3	200	400
GRP3 - BRV	PZ-201D	PZ-201D-SV-S006	267252.4	1789425.7	10/22/2014	8:38	BV	149.8	164.8	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	290		µg/m^3	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	µg/m^3	9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	µg/m^3	9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	µg/m^3	9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	µg/m^3	5.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	µg/m^3	5.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	µg/m^3	5.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	µg/m^3	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	µg/m^3	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	µg/m^3	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100		µg/m^3	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	320		µg/m^3	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	920		µg/m^3	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	µg/m^3	6.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	µg/m^3	6.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	µg/m^3	6.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	µg/m^3	6.2	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	µg/m^3	6.2	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	µg/m^3	6.2	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	µg/m^3	7.2	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	µg/m^3	7.2	20

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	9.4	U	$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	17	J	$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	230		$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	210		$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	520		$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	670		$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	11	J	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	10	J	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	6	J	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	5	J	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	13	J	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	52		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	5100		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202A	PZ-202A-SV-S002	267161.5	1789435.2	9/2/2014	7:43	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S003	267161.5	1789435.2	9/5/2014	8:40	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202A	PZ-202A-SV-S005	267161.5	1789435.2	9/12/2014	8:53	BV	50.9	60.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	38		$\mu g/m^3$	10	20
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	570		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	820		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1800		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2600		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	2300		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	3500		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	170		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	220		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	4700		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	7200		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202C	PZ-202C-SV-S002	267161.5	1789435.2	9/2/2014	11:25	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-202C	PZ-202C-SV-S004	267161.5	1789435.2	9/8/2014	8:40	BV	116	131	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	140		$\mu g/m^3$	51	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	$\mu g/m^3$	90	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	$\mu g/m^3$	9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	$\mu g/m^3$	9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	$\mu g/m^3$	54	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	$\mu g/m^3$	5.4	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	$\mu g/m^3$	5.4	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	980		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	900		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1400		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	$\mu g/m^3$	6.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	$\mu g/m^3$	6.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	$\mu g/m^3$	6.2	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	$\mu g/m^3$	6.2	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1600		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1900		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1700		$\mu g/m^3$	9.4	20

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1000		μg/m^3	9.4	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	4900		μg/m^3	110	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	6300		μg/m^3	55	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	4300		μg/m^3	11	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	4900		μg/m^3	11	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	μg/m^3	30	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	μg/m^3	15	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	μg/m^3	3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	μg/m^3	3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	μg/m^3	80	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	μg/m^3	40	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	μg/m^3	8	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	μg/m^3	8	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	μg/m^3	100	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	μg/m^3	52	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	μg/m^3	10	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	μg/m^3	10	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	μg/m^3	89	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	μg/m^3	44	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	μg/m^3	8.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	μg/m^3	8.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	μg/m^3	53	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	μg/m^3	27	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.6	J	μg/m^3	5.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	5.3	U	μg/m^3	5.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	μg/m^3	43	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	μg/m^3	21	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	μg/m^3	4.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	μg/m^3	4.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	170	J	μg/m^3	39	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	25000		μg/m^3	19	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	320		μg/m^3	3.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	310		μg/m^3	3.9	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3400		μg/m^3	120	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	5800		μg/m^3	58	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	4000		μg/m^3	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3300		μg/m^3	12	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	μg/m^3	53	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	μg/m^3	27	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	μg/m^3	5.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	μg/m^3	5.3	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	μg/m^3	60	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	μg/m^3	30	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	μg/m^3	6	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	μg/m^3	6	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S003	267161.5	1789435.2	9/5/2014	8:45	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	μg/m^3	100	200
GRP3 - BRV	PZ-202D	PZ-202D-SV-S004	267161.5	1789435.2	9/8/2014	8:44	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	μg/m^3	51	100
GRP3 - BRV	PZ-202D	PZ-202D-SV-S005	267161.5	1789435.2	9/12/2014	8:48	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	18	J	μg/m^3	10	20
GRP3 - BRV	PZ-202D	PZ-202D-SV-S006	267161.5	1789435.2	10/22/2014	7:54	BV	146.2	156.2	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	μg/m^3	10	20

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	$\mu g/m^3$	9	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	$\mu g/m^3$	90	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	5.4	U	$\mu g/m^3$	5.4	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	$\mu g/m^3$	54	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	870		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5600		$\mu g/m^3$	240	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1700		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	6.3	U	$\mu g/m^3$	6.3	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	6.2	U	$\mu g/m^3$	6.2	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	7.2	U	$\mu g/m^3$	7.2	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	4.1	U	$\mu g/m^3$	4.1	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	12	U	$\mu g/m^3$	12	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	16	U	$\mu g/m^3$	16	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1400		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	190	U	$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	9.4	U	$\mu g/m^3$	9.4	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1400		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	2800		$\mu g/m^3$	55	100

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	25000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	11	U	$\mu g/m^3$	11	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	2200		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	3	U	$\mu g/m^3$	3	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	8	U	$\mu g/m^3$	8	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	8.9	U	$\mu g/m^3$	8.9	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	6	J	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	4.3	U	$\mu g/m^3$	4.3	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	$\mu g/m^3$	43	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1500		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	78	U	$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3.9	U	$\mu g/m^3$	3.9	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2100		$\mu g/m^3$	39	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	5300		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2000		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	38		$\mu g/m^3$	12	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	7300		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	5.3	U	$\mu g/m^3$	5.3	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	6	U	$\mu g/m^3$	6	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	$\mu g/m^3$	60	200
GRP3 - BRV	PZ-203C	PZ-203C-SV-S002	267177.7	1789377.6	9/2/2014	10:06	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	300		$\mu g/m^3$	51	100
GRP3 - BRV	PZ-203C	PZ-203C-SV-S003	267177.7	1789377.6	9/5/2014	10:37	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203C	PZ-203C-SV-S005	267177.7	1789377.6	9/12/2014	8:04	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	10	U	$\mu g/m^3$	10	20
GRP3 - BRV	PZ-203C	PZ-203C-SV-S006	267177.7	1789377.6	10/22/2014	11:53	BV	131	146	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	9	U	μg/m^3	9	20
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	ug/m3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	μg/m^3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	μg/m^3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	μg/m^3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	μg/m^3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	μg/m^3	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	μg/m^3	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6600		μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5000		μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	400	J	μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	12000		μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	240	U	μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	27000		μg/m^3	240	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	μg/m^3	130	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	μg/m^3	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	μg/m^3	140	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	μg/m^3	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	μg/m^3	81	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	μg/m^3	81	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	μg/m^3	81	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	3100		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2100		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2200		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	5200		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2700		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	4700		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	19000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	5800		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	1900		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	5300		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	2000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	12000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	$\mu g/m^3$	85	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2700	J	$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1400		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	770		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2300		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	880		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	3600		$\mu g/m^3$	78	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	21000	J	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	10000		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	7000		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	25000		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	8600		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	25000		$\mu g/m^3$	230	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S001	267177.7	1789377.6	8/26/2014	15:56	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	1900		$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S002	267177.7	1789377.6	9/2/2014	7:13	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	430		$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S003	267177.7	1789377.6	9/5/2014	7:44	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	410		$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S004	267177.7	1789377.6	9/8/2014	7:53	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S005	267177.7	1789377.6	9/12/2014	8:01	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	540		$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203D	PZ-203D-SV-S006	267177.7	1789377.6	10/22/2014	11:49	BV	154.9	164.9	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	200	U	$\mu g/m^3$	200	400
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	820		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	47	U	$\mu g/m^3$	47	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	47	U	$\mu g/m^3$	47	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	8400		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	9500		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	19	U	$\mu g/m^3$	19	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	19	U	$\mu g/m^3$	19	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	140		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	250		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S002	267166.0	1789387.8	9/2/2014	10:47	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-203V	PZ-203V-SV-S004	267166.0	1789387.8	9/8/2014	8:00	BV	0	0	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	2300		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	µg/m^3	36	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	µg/m^3	53	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	µg/m^3	20	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	µg/m^3	58	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	µg/m^3	80	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	140		µg/m^3	47	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	9900		µg/m^3	55	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	µg/m^3	15	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	µg/m^3	40	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	µg/m^3	52	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	µg/m^3	44	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	µg/m^3	21	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	19	U	µg/m^3	19	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	1100		µg/m^3	58	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	µg/m^3	30	100
GRP3 - BRV	PZ-204A	PZ-204A-SV-S002	267244.7	1789347.7	9/2/2014	9:27	BV	50.2	60.2	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	µg/m^3	51	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	µg/m^3	90	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	630-20-6	1,1,1,2-Tetrachloroethane	31	U	µg/m^3	14	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	µg/m^3	90	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	µg/m^3	54	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	71-55-6	1,1,1-Trichloroethane	31	U	µg/m^3	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	µg/m^3	54	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	µg/m^3	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	µg/m^3	89	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	79-34-5	1,1,2,2-Tetrachloroethane	31	U	µg/m^3	9.4	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	µg/m^3	89	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	µg/m^3	45	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7800		µg/m^3	120	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5800		µg/m^3	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8400		µg/m^3	120	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9400		µg/m^3	59	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8800		µg/m^3	59	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	4200		µg/m^3	59	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	µg/m^3	63	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	79-00-5	1,1,2-Trichloroethane	31	U	µg/m^3	10	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	µg/m^3	63	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	µg/m^3	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	µg/m^3	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	µg/m^3	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	µg/m^3	62	200

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	10	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-35-4	1,1-Dichloroethene	31	U	$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	107-06-2	1,2-Dichloroethane	31	U	$\mu g/m^3$	10	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	71-43-2	Benzene	31	U	$\mu g/m^3$	10	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	56-23-5	Carbon tetrachloride	31	U	$\mu g/m^3$	9.4	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-00-3	Chloroethane	31	U	$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	250		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	156-59-2	cis-1,2-Dichloroethene	290		$\mu g/m^3$	10	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	430		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	740		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	880		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1600		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	30000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-71-8	Dichlorodifluoromethane	7800		$\mu g/m^3$	18	52
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	36000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	42000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	40000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	43000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	100-41-4	Ethylbenzene	31	U	$\mu g/m^3$	10	31

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	179601-23-1	m,p-Xylenes	62	U	$\mu g/m^3$	19	62
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-09-2	Methylene chloride	31	U	$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	95-47-6	o-Xylene	31	U	$\mu g/m^3$	9.4	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	127-18-4	Tetrachloroethene	31	U	$\mu g/m^3$	8.7	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	$\mu g/m^3$	43	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	108-88-3	Toluene	68		$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	$\mu g/m^3$	43	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	$\mu g/m^3$	21	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	$\mu g/m^3$	39	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	156-60-5	trans-1,2-Dichloroethene	35		$\mu g/m^3$	12	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	$\mu g/m^3$	39	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	65	J	$\mu g/m^3$	19	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	140		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2700		$\mu g/m^3$	19	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2000		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	79-01-6	Trichloroethene	1800		$\mu g/m^3$	8.7	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3500		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	5100		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	6300		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	3600		$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-69-4	Trichlorofluoromethane	31	U	$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	$\mu g/m^3$	53	200

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	$\mu g/m^3$	60	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	67-66-3	Trichloromethane (Chloroform)	34		$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	$\mu g/m^3$	60	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	$\mu g/m^3$	30	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S001	267244.7	1789347.7	8/26/2014	17:10	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-204C	PZ204CSVS001	267244.7	1789347.7	8/26/2014	17:13	BV	122.4	137.4	N	VOC	TO15	Fixed Lab	75-01-4	Vinyl chloride	31	U	$\mu g/m^3$	11	31
GRP3 - BRV	PZ-204C	PZ-204C-SV-S003	267244.7	1789347.7	9/5/2014	9:32	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-204C	PZ-204C-SV-S004	267244.7	1789347.7	9/8/2014	9:29	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	$\mu g/m^3$	51	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S005	267244.7	1789347.7	9/12/2014	9:39	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	280		$\mu g/m^3$	51	100
GRP3 - BRV	PZ-204C	PZ-204C-SV-S006	267244.7	1789347.7	10/22/2014	9:26	BV	122.4	137.4	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	1500		$\mu g/m^3$	51	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	$\mu g/m^3$	90	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	$\mu g/m^3$	54	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	110	U	$\mu g/m^3$	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	27	U	$\mu g/m^3$	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	45	U	$\mu g/m^3$	45	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	4700		$\mu g/m^3$	240	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6600		$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7400		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	3100		$\mu g/m^3$	240	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9900		$\mu g/m^3$	59	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	$\mu g/m^3$	63	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	130	U	$\mu g/m^3$	130	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	$\mu g/m^3$	62	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	120	U	$\mu g/m^3$	120	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	31	U	$\mu g/m^3$	31	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	$\mu g/m^3$	72	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	140	U	$\mu g/m^3$	140	400

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	36	U	$\mu g/m^3$	36	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	53	U	$\mu g/m^3$	53	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	$\mu g/m^3$	41	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	81	U	$\mu g/m^3$	81	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	20	U	$\mu g/m^3$	20	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	$\mu g/m^3$	120	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	230	U	$\mu g/m^3$	230	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	58	U	$\mu g/m^3$	58	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	$\mu g/m^3$	160	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	320	U	$\mu g/m^3$	320	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	80	U	$\mu g/m^3$	80	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	930		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1400		$\mu g/m^3$	94	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	2300		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	1100		$\mu g/m^3$	190	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	770		$\mu g/m^3$	47	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	39000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	45000		$\mu g/m^3$	110	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	50000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	19000		$\mu g/m^3$	220	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	45000		$\mu g/m^3$	55	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	60	U	$\mu g/m^3$	60	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	15	U	$\mu g/m^3$	15	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	160	U	$\mu g/m^3$	160	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	40	U	$\mu g/m^3$	40	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	210	U	$\mu g/m^3$	210	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	52	U	$\mu g/m^3$	52	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	$\mu g/m^3$	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	$\mu g/m^3$	44	100

Table I-1. Bedrock Vapor Analytical Data
Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	180	U	µg/m³	180	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	44	U	µg/m³	44	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	µg/m³	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	µg/m³	53	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	µg/m³	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	110	U	µg/m³	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	27	U	µg/m³	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	µg/m³	85	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	µg/m³	43	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	µg/m³	21	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	85	U	µg/m³	85	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	21	U	µg/m³	21	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	970		µg/m³	78	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	1600		µg/m³	39	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	2100		µg/m³	19	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	920		µg/m³	78	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	67	J	µg/m³	19	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	1900		µg/m³	230	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2900		µg/m³	120	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	6300		µg/m³	58	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	2800		µg/m³	230	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	5100		µg/m³	58	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	µg/m³	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	µg/m³	53	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	µg/m³	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	110	U	µg/m³	110	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	27	U	µg/m³	27	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	µg/m³	120	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	µg/m³	60	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	µg/m³	30	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	120	U	µg/m³	120	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	30	U	µg/m³	30	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S002	267244.7	1789347.7	9/2/2014	8:07	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	620		µg/m³	200	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S003	267244.7	1789347.7	9/5/2014	9:27	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	1300		µg/m³	100	200
GRP3 - BRV	PZ-204D	PZ-204D-SV-S004	267244.7	1789347.7	9/8/2014	9:26	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	1300		µg/m³	51	100
GRP3 - BRV	PZ-204D	PZ-204D-SV-S005	267244.7	1789347.7	9/12/2014	9:36	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	1500		µg/m³	200	400
GRP3 - BRV	PZ-204D	PZ-204D-SV-S006	267244.7	1789347.7	10/22/2014	9:24	BV	149	164	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	51	U	µg/m³	51	100
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	630-20-6	1,1,1,2-Tetrachloroethane	90	U	µg/m³	90	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	71-55-6	1,1,1-Trichloroethane	54	U	µg/m³	54	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	79-34-5	1,1,2,2-Tetrachloroethane	89	U	µg/m³	89	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	U	µg/m³	120	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	79-00-5	1,1,2-Trichloroethane	63	U	µg/m³	63	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-34-3	1,1-Dichloroethane	62	U	µg/m³	62	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-35-4	1,1-Dichloroethene	72	U	µg/m³	72	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	107-06-2	1,2-Dichloroethane	110	U	µg/m³	110	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	71-43-2	Benzene	41	U	µg/m³	41	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	56-23-5	Carbon tetrachloride	120	U	µg/m³	120	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-00-3	Chloroethane	160	U	µg/m³	160	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	156-59-2	cis-1,2-Dichloroethene	150	J	µg/m³	94	200

Table I-1. Bedrock Vapor Analytical Data

Bravo Bedrock Vapor Extraction Treatability Study Summary

Site	Location Name	Sample ID	Northing (feet NAD27)	Easting (feet NAD27)	Sample Date	Sample Time	Sample Matrix	Upper Depth (feet bgs)	Lower Depth (feet bgs)	Sample Type Code	Analytical Group	Analytical Method	Laboratory Type	CAS Number	Analyte Name	Result Value	Result Flag	Result Units	Method Detection Limit	Reporting Limit
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-71-8	Dichlorodifluoromethane	110	U	$\mu g/m^3$	110	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	100-41-4	Ethylbenzene	30	U	$\mu g/m^3$	30	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	179601-23-1	m,p-Xylenes	80	U	$\mu g/m^3$	80	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-09-2	Methylene chloride	100	U	$\mu g/m^3$	100	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	95-47-6	o-Xylene	89	U	$\mu g/m^3$	89	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	127-18-4	Tetrachloroethene	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	108-88-3	Toluene	43	U	$\mu g/m^3$	43	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	156-60-5	trans-1,2-Dichloroethene	39	U	$\mu g/m^3$	39	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	79-01-6	Trichloroethene	930		$\mu g/m^3$	120	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-69-4	Trichlorofluoromethane	53	U	$\mu g/m^3$	53	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	67-66-3	Trichloromethane (Chloroform)	60	U	$\mu g/m^3$	60	200
GRP3 - BRV	RD-104	RD-104-SV-S004	267304.9	1789160.7	9/8/2014	11:27	BV	30	60.5	N	VOC	SW8260B	Mobile Lab	75-01-4	Vinyl chloride	100	U	$\mu g/m^3$	100	200

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (estimated).

R = Data are unusable. The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.

S = Result is considered screening-level

U = Analyte was analyzed for but not detected above the reported sample quantitation limit, or this analyte was considered not detected due to laboratory or field blank contamination.

UJ = Analyte was analyzed for but not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

$\mu g/m^3$ = microgram per cubic meter

bgs = below ground surface

BV = bedrock vapor

CAS = Chemical Abstracts Service

FD = field duplicate sample

GRP3 - BRV = Group 3 Bravo Area site

ID = identification number

N = normal sample

NAD27 = North American 1927 datum (State Plane California Zone 5)

VOC = volatile organic compound

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Appendix J
Description of Soil Vapor Sample Collection

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APPENDIX J

Vapor Sample Collection

Soil vapor sampling during the BVE TS was performed in accordance with the Collection of Vapor Samples from Existing Piezometers and Wells, and from an Operating Vapor Extraction Well SOP (see Appendix A of the BVE IP), and involved the collection of approximately ten 0.5-liter glass bulb samples and up to two 1-liter summa canisters per sampling event. Glass bulb samples were analyzed via EPA method 8260B on the same day of collection at an on-site mobile laboratory operated by Environmental Support Technologies (EST). Summa canisters were shipped to ALS Environmental (under subcontract to EMAX Laboratories, Inc.) for analysis via methods TO-15 and 3C at the fixed laboratory in Simi Valley, CA.

Sampling Methodology

The procedure for the collection of glass bulb samples was as follows:

1. At lead two borehole volumes were purged from BVE vapor probes and modified piezometers/wells
   a. Purging was conducted with either a 5 liter-per-minute (L/min) pump, or a 100 L/min pump, depending on the borehole volume
   b. Pump flow, vacuum, and calibrated PID readings at the pump outlet were monitored throughout the purging process and recorded on purge logs (Appendix I)
   c. Leak checks were performed during the first two sampling events, by shutting off the pump for a period of 1 to 2 minutes and verifying that vacuum was maintained
2. The vapor probe with the highest final PID reading in each of the four newly installed vapor monitoring well clusters (that is, either the “a”, “b”, “c”, or “d” vapor probe at each piezometer) was selected for glass bulb sampling. The remaining six glass bulb samples were reserved for HAR-19 and discretionary sampling (which was generally focused on the vapor probes with the second highest PID readings, or modified wells with elevated PID or pressure readings).
3. At selected vapor probes/wells, a glass bulb was installed between the closed wellhead sampling port and the pump intake
   d. First, the bulb outlet valve was opened, and the bulb was evacuated
   e. Next, the bulb inlet valve and the well sampling port were opened, and soil vapor was allowed to pass through the bulb until the PID reading reached a value comparable to the last PID reading taken during purging
   f. Finally, the bulb inlet and outlet valves were closed simultaneously, followed by closure of the well sampling port
4. Glass bulbs were labeled with well ID, date, time, and final PID reading, and delivered to the mobile laboratory within 15 minutes of collection

Summa canister samples were collected at HAR-19 during each sampling event. Samples were collected from a sampling valve located between the wellhead and the BVE blower (therefore, samples did not undergo any dilution). TO-15 analyses were performed on the summa canister samples as a quality control measure, to verify the reliability of the 8260B data from the mobile laboratory. Analytical method 3C provided oxygen, carbon dioxide, methane, and nitrogen concentration data, and was performed on summa canister samples collected on the last 2 days of the 3-week TS operation as well as during the rebound test.

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Appendix K
Soil Vapor Monitoring Logs

CH2MHILL

WELL VACUUM MEASUREMENT LOG

Project Name: NASA SSFL BVE Study   Sampler/Team: K. Remmen/LAC

Project #: 474867.BV.02   J. Lindquist/THO

Location	Date: 8/26/14		Date: 8/27/14		Date: 8/29/14		Date: 9/2/14		Date: 9/4/14		Date: 9/5/14		Date: 9/8/14		Date: 9/12/14			Date: 10/22/14		Date: 10/22/14		Date: 10/23/14	
	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. Hg)	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)	Time	Vacuum (in. H_2O)
PZ-203v	~17:00	0.37	16:23	1.8	7:33	13.5	13:44	0.8	12:21	2.0	14:34	3.7	13:28	0.9	7:04	0.14	1.9	14:01	0.4	17:10	1.1	7:01	1.7
PZ-203a	~17:00	0.16	16:24	1.8	7:33	1.9	13:45	0.6	12:20	1.9	14:34	3.2	13:29	0.6	7:02	0.13	1.8	14:00	0.2	17:09	0.0	6:59	1.6
PZ-203b	~17:00	0.25	16:24	1.85	7:34	1.5	13:45	1.6	12:20	2.7	14:35	2.7	13:29	1.6	7:02	0.17	2.3	14:00	1.1	17:09	2.1	6:59	2.8
PZ-203c	~17:00	37.0	16:24	39.5	7:34	40.3	13:46	39.8	12:20	40.2	14:35	6.6	13:29	39.7	7:03	3.03	41.2	14:00	30.3	17:10	29.7	7:00	31.1
PZ-203d	~17:00	37.0	16:25	39.5	7:35	38.9	13:47	39.8	12:21	40.3	14:36	6.1	13:30	39.8	7:03	3.03	41.2	14:00	31.0	17:10	30.4	7:00	32.0
PZ-202a	~17:00	0.04	16:25	1.0	7:36	0.9	13:48	0.0	12:17	1.3	14:38	1.3	13:31	0.4	7:00	0.08	1.1	13:41	0.0	17:04	0.1	7:08	0.8
PZ-202b	~17:00	0.32	16:26	1.7	7:36	2.0	13:49	1.0	12:17	1.7	14:38	1.6	13:31	1.1	7:00	0.14	1.9	13:42	0.5	17:04	1.1	7:08	1.7
PZ-202c	~17:00	0.2	16:26	17.0	7:36	5.8	13:49	17.2	12:17	8.4	14:38	8.0	13:32	3.0	7:01	0.44	6.0	13:42	7.8	17:04	8.8	7:09	9.5
PZ-202d	~17:00	21.0	16:26	25.0	7:37	26.0	13:49	24.7	12:18	25.7	14:39	10.1	13:32	24.7	7:01	1.94	26.4	13:43	18.2	17:05	18.7	7:09	19.6
PZ-201a	~17:00	0.1	16:27	1.0	7:37	1.4	13:51	0.4	12:12	1.3	14:30	1.2	13:33	0.4	6:58	0.10	1.4	13:48	0.2	17:05	0.6	7:10	1.2
PZ-201b	~17:00	0.33	16:27	1.3	7:38	1.7	13:52	0.6	12:12	1.6	14:31	1.4	13:33	0.7	6:58	0.12	1.6	13:48	0.3	17:05	0.8	7:10	1.5
PZ-201c	~17:00	0.43	16:27	1.7	7:38	1.8	13:52	0.8	12:13	1.6	14:31	1.5	13:33	0.8	6:58	0.12	1.6	13:48	0.4	17:06	1.0	7:11	1.6
PZ-201d	~17:00	0.04	16:27	1.65	7:38	1.7	13:52	3.2	12:13	4.2	14:31	3.0	13:34	3.4	6:59	0.33	4.5	14:02	2.5	17:06	3.1	7:11	3.8
PZ-204a	~17:00	0.15	16:28	1.6	7:39	1.8	13:53	0.6	12:22	1.6	14:26	1.6	13:35	0.6	7:06	0.12	1.6	13:57	0.0	17:11	0.7	7:02	1.3
PZ-204b	~17:00	0.64	16:28	2.05	7:39	2.6	13:54	1.2	12:22	2.4	14:27	2.3	13:35	1.1	7:06	0.18	2.4	13:57	0.4	17:11	1.4	7:03	2.1
PZ-204c	~17:00	0.59	16:29	1.95	7:40	2.3	13:54	0.9	12:23	2.1	14:27	2.0	13:35	1.0	7:06	0.16	2.2	13:57	0.4	17:11	1.2	7:03	1.9
PZ-204d	~17:00	0.69	16:29	1.95	7:40	2.0	13:54	0.9	12:23	2.1	14:28	2.0	13:36	1.1	7:07	0.11	1.5	13:57	0.4	17:11	1.2	7:04	1.8
PZ-070	--	--	--	--	7:41	0.1	13:56	0.0	12:19	0.0	14:33	0.0	13:37	0.0	7:05	0.00	0.0	14:02	0.0	17:08	0.0	7:15	0.0
PZ-061	--	--	--	--	7:42	0.0	13:57	0.0	12:14	0.0	14:41	0.0	13:38	0.0	6:56	0.00	0.0	13:52	0.0	17:07	0.0	7:12	0.0
HAR-20	--	--	--	--	7:43	0.2	13:58	0.0	12:15	0.0	14:41	0.1	13:39	0.0	6:54	0.01	0.1	13:52	0.0	17:07	0.1	7:13	0.2
RD-104	--	--	--	--	7:45	0.0	14:01	0.0	12:24	0.0	14:44	0.0	13:41	0.0	7:08	0.00	0.0	13:59	0.0	17:13	0.0	7:05	0.0
PZ-156	--	--	--	--	~7:50	2.2	14:07	0.2	12:29	2.4	14:48	2.3	13:46	0.3	9:59	0.21	2.9	14:13	0.1	17:20	0.8	6:55	1.9
HAR-19	17:45	81.6	16:00	79.4	7:30	82.7	14:03	54.4	13:00	78.9	14:26	0.0	13:27	86.7	7:30	6.25	85.0	~15:00	57.1	16:00	58.2	7:06	106.1

Notes:
in. H_2O = inches of water

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VAPOR SAMPLING PURGE LOG

CH2MHILL

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, R. Lucich
Date: 8/26/2014, 8/27/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	14:35	0	0.0	0.0	-18	Pump on, valve closed
			14:35	0	5.0	0.3	0	Valve open
			14:36	1	5+	0.7	0	
			14:37	2	5.0	1.0	0	
			14:38	3	5+	1.4	0	
			14:39	4	5.0	2.6	0	
			14:40	5	4.8	6.1	0	
			14:41	6	5.0	7.0	0	Pump off
PZ-203a	4.0	0.2	14:55	0	0.0	0.3	-19	Pump on
			14:56	1	5.0	0.3	0	
			14:57	2	4.5	0.1	0	
			14:58	3	5.0	0.0	0	
			14:59	4	5+	0.0	0	
			15:00	5	5.0	1.2	0	
			15:01	6	5.0	1.4	0	Pump off
PZ-203b	6.4	0.32	15:02	0	0.0	0.0	-19	Pump on
			15:03	1	5.0	0.2	1	
			15:05	3	4.8	0.5	0	
			15:06	4	5+	0.3	0	
			15:07	5	5+	0.7	0	
			15:08	6	5.0	0.3	0	
			15:09	7	5.0	0.6	0	Pump off
PZ-203c	9.4	0.47	15:10	0	0.0	0.0	-18	Pump on
			15:11	1	5.0	0.0	0	
			15:14	4	4.8	0.1	1	
			15:16	6	5+	0.0	1	
			15:18	8	5+	1.1	1	
			15:19	9	5+	2.7	1	
			15:20	10	5+	3.5	1	
			15:22	12	5+	5.1	1	Pump off at 15:25
PZ-203d	10.6	0.53	15:26	0	0.0	0.0	-19	Pump on
			15:28	2	5.0	0.0	1	
			15:30	4	5.0	0.9	1	
			15:32	6	5.0	0.8	1	
			15:36	10	5.0	0.8	1	
			15:41	15	5.0	19.7	1	
			15:47	21	5.0	18.1	1	
			15:56	30	5.0	16.0	1	Collect glass bulb sample at 15:56, pump off
PZ-202a	3.9	0.195	11:30	0	0.0	0.0	-19	Pump on
			11:31	1	5.0	0.4	1	
			11:32	2	5.0	0.9	1	
			11:34	4	5.0	1.1	0	
			11:36	6	5.0	0.4	-1	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, R. Lucich
Date: 8/26/2014, 8/27/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
PZ-202b	5.8	0.29	11:37	0	0.0	0.0	-19	Pump on
			11:38	1	5.0	0.0	1	
			11:39	2	5.0	0.0	1	
			11:40	3	5.0	0.0	0.5	
			11:41	4	5.0	0.0	0.5	
			11:43	6	5.0	0.0	0.5	Pump off
PZ-202c	8.4	0.42	11:46	0	0.0	0.0	-19	Pump on
			11:48	2	5.0	0.0	0	
			11:50	4	5.0	0.0	-1	
			11:52	6	5.0	0.0	-2	
			11:54	8	5.0	0.0	-2	
			11:56	10	5.0	0.6	-2	
			11:58	12	5.0	1.2	-3	
			12:00	14	5.0	1.4	-2	Pump off
PZ-202d	10.1	0.505	12:02	0	0.0	0.0	-19	Pump on
			12:04	2	5.0	0.0	0	
			12:06	4	5.0	0.0	-1.5	
			12:08	6	5.0	0.0	-2.5	
			12:10	8	5.0	0.0	-3	
			12:12	10	5.0	0.0	-3	Pump off
PZ-204a	3.9	0.195	14:17	0	0.0	0.0	-19	Pump on
			14:17	0.2	5.0	0.0	1	Valve open
			14:19	2	5.0	0.1	0.8	
			14:21	4	5.0	0.0	0.7	
			14:28	11	4.5	0.8	0.7	Pump off
PZ-204b	5.8	0.29	16:37	0	0.0	0.0	-19	Pump on
			16:38	1	5.0	0.0	0	
			16:39	2	5.0	0.0	0	
			16:40	3	5.0	0.0	0	
			16:41	4	5.0	0.0	0	
			16:42	5	5.0	0.5	0	
			16:43	6	5.0	0.7	0	Pump off
PZ-204c	8.8	0.44	16:44	0	0.0	0.3	-19	Pump on
			16:46	2	5.0	0.2	0	
			16:48	4	5.0	0.1	0	
			16:50	6	5.0	0.2	0	
			16:52	8	5.0	0.8	0	
			16:54	10	5.0	0.8	1	Pump off
			17:10	26	--	2.8	--	Collect glass bulb sample at 17:10

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, R. Lucich
Date: 8/26/2014, 8/27/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
PZ-204d	10.6	0.53	16:55	0	0.0	0.1	-19	Pump on
			16:57	2	5.0	0.0	1	
			16:59	4	5.0	0.0	1	
			17:01	6	5.0	0.0	1	
			17:03	8	5.0	0.0	1	
			17:05	10	5.0	0.0	1	Pump off at 17:06
PZ-201a	4.2	0.21	10:45	0	0.0	0.0	-19	Pump on
			10:46	1	5.0	0.0	1	
			10:47	2	5.0	0.0	1	
			10:49	4	5.0	0.0	1	
			10:51	6	5.0	0.0	1	Pump off
PZ-201b	7.4	0.37	10:52	0	0.0	0.0	-19	Pump on
			10:53	1	5.0	0.0	1	
			10:54	2	5.0	0.0	1	
			10:56	4	5.0	0.0	1	
			10:58	6	5.0	0.1	1	
			11:00	8	5.0	0.1	1	Pump off
PZ-201c	9.0	0.45	11:02	0	0.0	0.0	-19	Pump on
			11:03	1	5.0	0.0	1	
			11:04	2	5.0	0.0	1	
			11:06	4	5.0	0.0	1	
			11:08	6	5.0	0.0	1	
			11:10	8	5.0	0.0	1	
			11:12	10	5.0	0.0	1	Pump off
PZ-201d	10.6	0.53	11:13	0	0.0	0.0	-19	Pump on
			11:14	1	5.0	0.0	1	
			11:15	2	5.0	0.0	1	
			11:17	4	5.0	0.0	1	
			11:19	6	5.0	0.0	1	
			11:21	8	5.0	0.0	1	
			11:23	10	5.0	0.0	1	
			11:24	11	5.0	0.0	1	Pump off
PZ-070	5.9	0.295	12:16	0	0.0	0.0	-19	Pump on
			12:17	1	5.0	147.0	0	
			12:18	2	5.0	92.4	1	
			12:20	4	5.0	76.0	1	
			12:22	6	5.0	64.6	1	
			12:24	8	5.0	61.1	1	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, R. Lucich
Date: 8/26/2014, 8/27/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
RD-104	97.4	4.87	13:00	0	0.0	0.0	-19	Pump on
			13:05	5	5.0	313.0	1	PID = 550 ppm at 13:01
			13:30	30	5.0	105.0	1	
			13:45	45	5.0	89.6	1	
			14:00	60	5.0	67.3	1	
			14:15	75	5.0	42.4	1	
			14:30	90	5.0	37.6	1	
			14:45	105	5.0	28.2	1	Pump off
PZ-061	5.7	0.285	12:33	0	0.0	0.0	-19	Pump on
			12:34	1	5.0	1032.0	1	
			12:35	2	5.0	683.0	1	Chemical odor observed during purge from
			12:37	4	5.0	395.0	1	pump discharge tube
			12:39	6	5.0	314.0	1	
			12:41	8	5.0	303.0	1	
			12:43	10	5.0	302.0	1	Pump off
HAR-20	717.3	35.865	10:40	0	--	0.4	0	Pump on (using Northstar equipment)
			10:41	1	low	0.5	37.5	Low RPM, not much flow
			10:42	2	--	--	--	Open dilution valve, increase RPM
			10:43	3	95.0	0.2	75	
			10:45	5	94.0	0.3	78	Pump off at 10:46
PZ-156	29.4	1.47	15:15	0	0.0	0.0	-19	Pump on
			15:20	5	5.0	150.0	1	PID = 620 ppm at 15:16
			15:30	15	5.0	31.6	1	
			15:40	25	5.0	32.2	1	
			15:50	35	5.0	39.6	1	
			15:55	40	5.0	37.3	1	
			16:00	45	5.0	52.4	1	
			16:05	50	5.0	63.3	1	Pump off

cfm = cubic feet per minute
in. Hg = inches of mercury
L/min = liters per minute
min = minute
PID = photoionization detector
ppm = parts per million
Q = flow
RPM = revolutions per minute

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 8/29/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	7:22	0	0.0	0.0	-19	Pump on
			7:23	1	5.0	0.0	0	
			7:25	3	4.9	0.1	0	
			7:27	5	5+	0.3	0	
			7:29	7	5.0	0.7	0	Pump off
PZ-203a	4.0	0.2	7:48	0	0.0	0.0	-19	Pump on
			7:49	1	5+	0.1	1	
			7:51	3	5+	0.4	0	
			7:52	4	5+	1.0	0	
			7:53	5	5+	1.3	0	Pump off
PZ-203b	6.4	0.32	7:56	0	0.0	0.0	-19	Pump on
			7:57	1	5+	0.1	0	
			7:59	3	5+	1.4	-1	
			8:01	5	5+	2.9	-5	
			8:03	7	5+	3.4	-6	Pump off
PZ-203c	9.4	0.47	8:05	0	0.0	0.0	-18	Pump on
			8:06	1	5+	1.5	0	
			8:08	3	5+	1.6	-2	
			8:10	5	5+	5.1	-3	
			8:13	8	5+	5.8	-4	
			8:15	10	5+	5.9	-4	Pump off
PZ-203d	10.6	0.53	8:16	0	0.0	0.0	-18	Pump on
			8:17	1	5+	3.2	-3	
			8:20	4	5+	22.1	-3	
			8:23	7	5+	34.1	-3	
			8:26	10	5+	37.2	-3	
			8:28	12	5+	39.1	-3	Pump off
PZ-202a	3.9	0.195	8:32	0	0.0	0.0	-18	Pump on
			8:33	1	5+	9.7	0	
			8:34	2	5+	8.4	-2	
			8:35	3	5+	6.6	-5	
			8:36	4	5+	5.3	-6	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 8/29/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-202b	5.8	0.29	8:38	0	0.0	0.0	-18	Pump on
			8:40	2	5+	4.2	1	
			8:42	4	5+	3.8	1	
			8:44	6	5+	4.0	0	Pump off
PZ-202c	8.4	0.42	8:45	0	0.4	0.0	-18	Pump on
			8:46	1	5.0	2.9	1	
			8:48	3	4.9	3.1	0	
			8:50	5	5+	3.8	0	
			8:52	7	4.9	3.6	-2	
			8:54	9	5+	3.4	-3	Pump off
PZ-202d	10.1	0.505	8:55	0	0.0	0.0	-18	Pump on
			8:57	2	5+	2.1	0	
			8:59	4	5+	2.1	-1	
			9:01	6	5+	2.2	-2	
			9:03	8	5.0	2.2	-3	
			9:05	10	5.0	2.1	-4	Pump off
PZ-204a	3.9	0.195	9:08	0	0.0	0.0	-18	Pump on
			9:09	1	5+	1.5	1	
			9:10	2	5+	1.8	1	
			9:11	3	5+	2.0	1	
			9:12	4	5+	2.2	0	Pump off
PZ-204b	5.8	0.29	9:13	0	0.0	0.0	-18	Pump on
			9:15	2	5.0	1.7	1	
			9:17	4	5+	1.7	1	
			9:19	6	5.0	1.6	1	Pump off
PZ-204c	8.8	0.44	9:21	0	0.0	0.0	-18	Pump on
			9:24	3	4.8	1.6	1	
			9:27	6	5+	2.1	0	
			9:30	9	5.0	2.2	0	Pump off

CH2MHILL

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 8/29/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-204d	10.6	0.53	9:31	0	0.0	0.0	-19	Pump on
			9:33	2	5.0	2.5	1	
			9:36	5	5.0	2.8	1	
			9:39	8	5.0	2.8	0	
			9:42	11	5.0	3.3	0	Pump off
PZ-201a	4.2	0.21	9:47	0	0.0	0.0	-18	Pump on
			9:48	1	5+	1.2	1	
			9:49	2	5+	1.3	1	
			9:50	3	5+	1.4	0	
			9:51	4	5+	1.5	0	Pump off
PZ-201b	7.4	0.37	9:52	0	0.0	0.0	-19	Pump on
			9:54	2	5+	2.3	0	
			9:56	4	5+	2.5	0	
			9:58	6	5+	2.9	0	
			10:00	8	5+	3.0	0	Pump off
PZ-201c	9.0	0.45	10:01	0	0.0	0.0	-19	Pump on
			10:04	3	5+	2.5	0	
			10:07	6	5+	2.4	0	
			10:10	9	5+	3.0	1	Pump off
PZ-201d	10.6	0.53	10:11	0	0.0	0.0	-19	Pump on
			10:13	2	5+	0.9	0	
			10:16	5	5+	1.0	0	
			10:19	8	5+	2.8	0	
			10:22	11	5+	2.9	0	Pump off
PZ-070	5.9	0.295	10:23	0	0.0	0.0	-19	Pump on
			10:25	2	5+	8.1	1	
			10:27	4	5+	5.4	1	
			10:29	6	5+	5.3	1	Pump off

CH2MHILL

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 8/29/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
RD-104	97.4	4.87	10:53	0	0.0	0.0	--	Pump on
			10:54	1	~100	224.0	--	Using 5 cfm pump; no vacuum readings
			10:56	3	~70	96.0	--	
			10:58	5	~70	102.3	--	
			11:00	7	~70	73.2	--	Pump off
								Hissing sound of air entering base of well
								casing when pump turned off
PZ-061	5.7	0.285	11:20	0	0.0	0.0	-19	Pump on
			11:21	1	5+	563.0	1	
			11:22	2	5+	193.1	1	
			11:24	4	5+	97.4	1	
			11:26	6	5+	87.8	1	Pump off
HAR-20	717.3	35.865	12:09	0	0.0	0.0	--	Pump on
			12:10	1	~70	1.0	--	Using 5 cfm pump; no vacuum readings
			12:11	2	~70	0.3	--	
			12:18	9	~123	0.0	--	Shortened discharge hose to increase Q
			12:23	14	~123	0.0	--	
			12:29	20	~123	0.0	--	
			12:34	25	~123	0.0	--	
			12:39	30	~123	0.0	--	Pump off
PZ-156	29.4	1.47	12:49	0	0.0	0 -> 352	-19	Pump on
			12:54	5	5.0	176.2	0	
			12:59	10	5+	94.8	0	
			13:04	15	5+	103.7	0	
			13:09	20	5+	101.3	0	
			13:14	25	5+	108.7	0	
			13:19	30	5+	120.2	0	Pump off

CH2MHILL

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/2/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	10:40	0	0.0	0.0	-19	Pump on
			10:42	2	5+	2.6	0	
			10:43	3	5.0	6.7	0	
			10:44	4	5+	9.3	0	
			10:45	5	5+	13.0	0	
			10:47	7	5+	8.0	0	Glass bulb (#8) collected at 10:47; pump off
PZ-203a	4.0	0.2	10:30	0	0.0	0.0	-19	Pump on
			10:31	1	5+	1.4	1	
			10:32	2	5+	1.7	0	
			10:33	3	5+	2.1	0	
			10:34	4	5+	1.9	0	Pump off at 10:35
PZ-203b	6.4	0.32	10:22	0	0.0	0.0	-19	Pump on
			10:24	2	5+	0.9	0	
			10:26	4	5+	2.0	0	
			10:28	6	5+	0.7	0	
			10:29	7	5+	1.0	-1	Pump off
								At ~10:32, vac. = 13.7" water (during purging
								of PZ-203a)
PZ-203c	9.4	0.47	9:55	0	0.0	0.0	-19	Pump on
			9:58	3	5+	11.1	1	
			10:01	6	5+	9.5	1	
			10:04	9	5+	8.8	0.5	
			10:05	10	5+	6.8	0.5	
			10:06	11	5+	8.9	0.5	Glass bulb (#7) collected at 10:06
								Pump off at 10:07
PZ-203d	10.6	0.53	7:01	0	0.0	0.0	-18	Pump on
			7:02	1	5+	0.1	1	
			7:04	3	4.8	3.7	1	
			7:06	5	5+	19.5	1	
			7:09	8	5+	25.5	1	
			7:12	11	5+	33.8	1	
			7:13	12	5+	41.2	1	Glass bulb (#9) collected at 7:13
								Pump off at 7:14
PZ-202a	3.9	0.195	7:36	0	0.0	0.0	-18	Pump on
			7:37	1	5+	2.4	1	
			7:38	2	5+	2.2	0.5	
			7:39	3	5+	5.3	0	
			7:40	4	5+	3.8	0	
			7:43	7	5+	3.6	0	Glass bulb (#2) collected at 7:43
								Pump off at 7:44

VAPOR SAMPLING PURGE LOG

CH2MHILL

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/2/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-202b	5.8	0.29	11:15	0	0.0	0.0	-18	Pump on
			11:17	2	5+	2.9	0	
			11:19	4	5+	2.4	-1	
			11:21	6	5+	1.9	0	Pump off
PZ-202c	8.4	0.42	11:05	0	0.4	0.0	-19	Pump on
			11:06	1	5.0	5.6	1	
			11:09	4	5+	8.3	-3	
			11:12	7	5+	9.0	-5	
			11:14	9	5+	8.7	-7	Pump off
			11:25	20	5+	9.6	--	Glass bulb (#11) collected at 11:25
PZ-202d	10.1	0.505	10:53	0	0.0	0.0	-19	Pump on
			10:54	1	5.0	5.4	1	
			10:56	3	5.0	7.4	0	
			10:58	5	5+	7.4	0	
			11:00	7	5.0	6.7	-1.5	
			11:02	9	5+	7.3	-2	
			11:03	10	5.0	7.3	-2	Pump off
PZ-204a	3.9	0.195	9:21	0	0.0	0.0	-19	Pump on
			9:22	1	5+	1.2	0	
			9:23	2	5+	2.7	0	
			9:24	3	5+	2.2	0	
			9:25	4	5+	3.5	0	
			9:27	6	5+	4.4	0	Glass bulb (#10) collected at 9:27; pump off
PZ-204b	5.8	0.29	9:33	0	0.0	0.0	-19	Pump on
			9:35	2	5+	1.6	1	
			9:37	4	5+	1.8	1	
			9:39	6	5+	2.1	1	Pump off
PZ-204c	8.8	0.44	9:41	0	0.0	0.0	-19	Pump on
			9:42	1	4.8	4.9	1	
			9:44	3	5+	4.1	0	
			9:47	6	5+	8.3	0	
			9:50	9	5+	4.2	0	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/2/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-204d	10.6	0.53	7:54	0	0.0	0.0	-18	Pump on
			7:55	1	5+	6.2	1	
			7:57	3	5+	7.8	0	
			7:59	5	5+	7.9	0	
			8:02	8	5+	29.8	0	PID increased when discharge tube secured
			8:05	11	5+	29.6	0	more firmly.
			8:07	13	5+	31.6	0	Glass bulb (#1) collected at 8:07; pump off
PZ-201a	4.2	0.21	8:47	0	0.0	0.0	-18	Pump on
			8:48	1	5+	3.6	1	
			8:49	2	5+	3.4	1	
			8:51	4	5+	3.7	1	
			8:52	5	5+	3.9	1	Pump off
PZ-201b	7.4	0.37	8:36	0	0.0	0.0	-18	Pump on
			8:37	1	5+	8.9	1	
			8:39	3	5+	13.7	0	
			8:41	5	5+	11.8	0	
			8:44	8	5+	12.6	0	
			8:45	9	5+	12.9	0	Glass bulb (#5) collected at 8:45; pump off
PZ-201c	9.0	0.45	8:22	0	0.0	0.0	-18	Pump on
			8:23	1	5+	3.2	1	
			8:25	3	5+	8.1	1	
			8:27	5	5+	12.4	1	
			8:29	7	5+	14.0	1	
			8:31	9	5+	14.8	1	
			8:34	12	5+	15.0	1	Glass bulb (#3) collected at 8:34; pump off
PZ-201d	10.6	0.53	9:01	0	0.0	0.0	-18	Pump on
			9:03	2	5+	3.5	1	
			9:06	5	5+	5.7	0	
			9:09	8	5+	11.4	0	
			9:12	11	5+	10.6	0	Pump off
PZ-070	5.9	0.295	11:25	0	0.0	0.0	-18	Pump on
			11:26	1	5+	97.3	1	
			11:27	2	5+	47.1	1	
			11:29	4	5+	18.2	1	
			11:31	6	5+	20.1	1	Pump off

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VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/2/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
RD-104	97.4	4.87	9:07	0	0.0	0.0	--	Pump on
			9:08	1	--	176.2	--	
			9:09	2	--	277.5	--	
			9:10	3	--	263.8	--	
			9:11	4	105.0	255.2	--	
			9:12	5	--	247.0	--	
			9:13	6	--	221.8	--	Pump off
PZ-061	5.7	0.285	11:35	0	0.0	0.0	-18	Pump on
			11:37	2	5+	823.0	1	
			11:39	4	5+	237.0	1	
			11:41	6	5+	208.8	1	Pump off
HAR-20	717.3	35.865	9:44	0	0.0	0.0	--	Pump on
			9:45	1	--	0.4	--	
			9:49	5	--	0.2	--	
			9:54	10	117.0	0.2	--	140 liters/72 seconds
			9:59	15	--	0.2	--	
			10:09	25	--	0.2	--	
			10:14	30	--	0.2	--	
			10:15	31	--	0.2	--	Pump off
PZ-156	29.4	1.47	11:52	0	0.0	0.0	--	Pump on (5 cfm)
			11:53	1	~100	354.0	--	Pump off - generator out of gas
			11:56	4	5+	114.0	-3	Pump on (5 L/min)
			11:59	7	5+	199.7	-1.5	
			12:02	10	5+	162.6	-1	
			12:04	12	5+	210.5	-1	
			12:07	15	5+	215.9	-1	Glass bulb (#12) collected at 12:07; pump off
								1``

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/5/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	7:48	--	--	--	--	Initial vacuum, in. water
			7:49	0	5+	4.6	1	Pump on
			7:51	2	5.0	4.2	-1	
			7:53	4	5+	4.1	-2	
			7:54	5	5+	4.2	-2	Pump off
PZ-203a	4.0	0.2	7:00	--	--	--	2.1	Initial vacuum, in. water
			7:01	0	5+	0.0	1	Pump on
			7:02	1	5+	0.1	0.5	
			7:03	2	5+	0.8	-1	
			7:04	3	5+	3.6	-1	
			7:05	4	5+	5.0	-1.5	Pump off
PZ-203b	6.4	0.32	7:05	--	--	--	2.5	Initial vacuum, in. water
			7:06	0	5+	0.2	1	Pump on
			7:09	3	5+	0.0	-1	
			7:11	5	5+	4.8	-2	
			7:13	7	5+	7.8	-2	
			7:15	9	5+	10.3	-3.5	Pump off
PZ-203c	9.4	0.47	7:05	--	--	--	40.8	Initial vacuum, in. water
			7:16	0	5+	0.0	-1	Pump on
			7:19	3	5+	1.0	-2	
			7:22	6	5+	7.8	-2	
			7:25	9	5+	8.8	-2	
			7:26	10	5+	11.8	-2	Pump off
			10:37	201	5+	8.1	--	Glass bulb (#12) collected at 10:37
PZ-203d	10.6	0.53	7:05	--	--	--	40.1	Initial vacuum, in. water
			7:26	0	5+	2.1	-1	
			7:30	4	5+	7.8	-1.5	
			7:34	8	5+	33.5	-1.5	
			7:37	11	5+	43.0	-1.5	
			7:44	18	5+	40.5	-1.5	Glass bulb (#13) collected at 7:44; pump off
PZ-202a	3.9	0.195	7:59	--	--	--	0.11	Initial vacuum
			8:01	0	5+	4.9	1	Pump on
			8:02	1	5+	3.5	0	
			8:03	2	5+	3.5	-1	
			8:05	4	5+	3.0	-2	Pump off
			8:40	39	5+	2.6	--	Glass bulb (#14) collected at 8:40

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/5/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-202b	5.8	0.29	7:59	--	--	--	0.19	Initial vacuum
			8:06	0	5+	2.2	1	Pump on
			8:08	2	5+	2.0	0	
			8:11	5	5+	2.0	-0.5	
			8:12	6	5+	2.0	-0.5	Pump off
PZ-202c	8.4	0.42	7:59	--	--	--	0.45	Initial vacuum
			8:13	0	5+	1.6	1	Pump on
			8:16	3	5+	1.4	-2	
			8:19	6	5+	2.6	-3	
			8:22	9	5+	2.9	-5	Pump off
PZ-202d	10.1	0.505	7:59	--	--	--	1.96	Initial vacuum
			8:23	0	5+	1.2	0	Pump on
			8:27	4	5+	1.2	-3	
			8:30	7	5+	2.1	-4	
			8:34	11	5+	2.9	-5	Pump off
			8:45	22	5+	3.5	--	Glass bulb (#1) collected at 8:45
PZ-204a	3.9	0.195	8:50	--	--	--	0.14	Initial vacuum
			8:52	0	5+	1.3	1	Pump on
			8:54	2	5+	0.8	0	
			8:56	4	5+	1.2	0	Pump off
PZ-204b	5.8	0.29	8:50	--	--	--	0.21	Initial vacuum
			8:57	0	5+	0.8	1	Pump on
			8:59	2	5+	0.8	1	
			9:01	4	5+	2.3	1	
			9:03	6	5+	2.2	1	Pump off
PZ-204c	8.8	0.44	8:50	--	--	--	0.18	Initial vacuum
			9:04	0	5+	0.7	1	Pump on
			9:07	3	5+	0.9	0	
			9:10	6	5+	2.7	0	
			9:13	9	5+	4.0	0	Pump off
			9:32	28	5+	4.0	--	Glass bulb (#3) collected at 9:32

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VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study — Sampler/Team: J. Lindquist, K. Remmen
Project #: 474867.BV.02 — Date: 9/5/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-204d	10.6	0.53	8:50	--	--	--	0.18	Initial vacuum
			9:14	0	5+	0.9	1	Pump on
			9:18	4	5+	5.6	0.5	
			9:22	8	5+	5.6	0.5	
			9:25	11	5+	5.5	0.5	
			9:27	13	5+	5.5	0.5	Glass bulb (#5) collected at 9:27; pump off
PZ-201a	4.2	0.21	9:43	--	--	--	0.12	Initial vacuum
			9:46	0	5+	0.8	1	Pump on
			9:48	2	5+	0.7	1	
			9:50	4	5+	0.6	1	
			9:51	5	5+	0.8	1	Pump off
PZ-201b	7.4	0.37	9:43	--	--	--	0.14	Initial vacuum
			9:51	0	5+	0.8	1	Pump on
			9:54	3	5+	10.3	1	
			9:57	6	5+	9.9	0	
			9:59	8	5+	7.6	0	Pump off
			10:26	35	5+	6.0	--	Glass bulb (#11) collected at 10:26
PZ-201c	9.0	0.45	9:45	--	--	--	0.14	Initial vacuum
			10:00	0	5+	0.9	1	Pump on
			10:03	3	5+	3.0	1	
			10:06	6	5+	3.0	1	
			10:09	9	5+	2.6	1	Pump off
PZ-201d	10.6	0.53	9:45	--	--	--	0.33	Initial vacuum
			10:10	0	5+	0.7	1	Pump on
			10:14	4	5+	0.5	0.5	
			10:18	8	5+	0.6	0	
			10:21	11	5+	4.1	0.5	Pump off
PZ-070	5.9	0.295	10:39	0	--	--	--	Pump on
			10:40	1	5+	11.3	1	
			10:41	2	5+	3.3	1	
			10:43	4	5+	2.0	1	
			10:45	6	5+	1.8	1	Pump off
			11:29	50	--	--	0	Vacuum only

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/5/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
RD-104	97.4	4.87	8:26	0	--	137.4	--	Pump on
			8:30	4	56.0	156.7	--	140 Liters/150 seconds
			8:35	9	--	117.0	--	
			8:37	11	--	114.9	--	Pump off
PZ-061	5.7	0.285	10:50	--	--	--	0.0	Initial vacuum
			10:51	0	5+	215.8	1	Pump on
			10:53	2	5+	154.5	1	
			10:55	4	5+	67.6	1	
			10:57	6	5+	50.9	1	
			10:58	7	5+	47.7	--	Glass bulb (#2) collected at 10:58; pump off
HAR-20	717.3	35.865	8:56	0	--	--	--	Pump on
			8:57	1	112.0	0.7	--	140 Liters/75 seconds
			9:01	5	--	0.3	--	
			9:06	10	--	0.2	--	
			9:12	16	--	0.1	--	
			9:18	22	--	0.0	--	
			9:22	26	--	0.0	--	
			9:26	30	--	0.1	--	
			9:34	38		0.1		Pump off
PZ-156	29.4	1.47	11:05	--	--	--	0.21	Initial vacuum
			11:07	0	110.0	193.2	--	Pump on (5 cfm)
			11:08	1	110.0	--	--	Pump off (5 cfm) - generator out of gas
			11:12	5	5+	12.6	-3.5	Pump on at 11:11 (5 L/min)
			11:15	8	5+	38.1	-1.5	
			11:18	11	5+	43.0	-1	
			11:22	15	5+	41.7	--	Glass bulb (#7) collected at 11:22; pump off

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VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/8/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	7:13	--	--	--	0.01	Initial vacuum
			7:54	0	5+	1.6	1	Pump on
			7:56	2	5+	3.5	0	
			7:59	5	5+	4.4	-1	
			8:00	6	5+	3.9	--	Glass bulb (#5) collected at 8:00; pump off
PZ-203a	4.0	0.2	7:08	--	--	--	0.0	Initial vacuum
			7:16	0	5+	0.6	1	Pump on
			7:18	2	5+	0.4	0	
			7:20	4	5+	1.0	-1	Pump off
PZ-203b	6.4	0.32	7:09	--	--	--	0.0	Initial vacuum
			7:21	0	5+	0.4	1	Pump on
			7:24	3	5+	0.3	0	
			7:26	5	5+	0.3	-1	
			7:28	7	5+	2.2	-1	Pump off
PZ-203c	9.4	0.47	7:09	--	--	--	0.0	Initial vacuum
			7:29	0	5+	1.3	1	Pump on
			7:33	4	5+	5.2	1	
			7:37	8	5+	5.1	0.5	
			7:39	10	5+	4.6	0.5	Pump off
PZ-203d	10.6	0.53	7:09	--	--	--	0.0	Initial vacuum, in. water
			7:40	0	5+	1.9	1	
			7:44	4	5+	11.8	1	
			7:48	8	5+	20.0	1	
			7:51	11	5+	16.0	1	
			7:53	13	5+	13.5	--	Glass bulb (#12) collected at 7:53; pump off
PZ-202a	3.9	0.195	7:10	--	--	--	0.02	Initial vacuum
			8:03	0	5+	2.6	1	Pump on
			8:04	1	5+	2.3	0	
			8:05	2	5+	2.0	0	
			8:06	3	5+	2.2	0	
			8:07	4	5+	2.2	-1	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/8/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
PZ-202b	5.8	0.29	7:10	--	--	--	0.19	Initial vacuum
			8:08	0	5+	2.2	1	Pump on
			8:10	2	5+	2.0	0	
			8:12	4	5+	2.0	-0.5	
			8:14	6	5+	2.0	-0.5	Pump off
PZ-202c	8.4	0.42	7:10	--	--	--	0.0	Initial vacuum
			8:15	0	5+	1.3	1	Pump on
			8:16	1	5+	1.3	0	
			8:18	3	5+	1.4	-1	
			8:20	5	5+	2.1	-1.5	
			8:22	7	5+	2.8	-2	
			8:24	9	5+	2.9	-3.5	Pump off
			8:40	25	5+	2.8	--	Glass bulb (#11) collected at 8:40
PZ-202d	10.1	0.505	7:10	--	--	--	0.0	Initial vacuum
			8:25	0	5+	2.3	1	Pump on
			8:28	3	5+	2.7	0	
			8:32	7	5+	2.6	-1	
			8:36	11	5+	2.7	-2	Pump off
			8:44	19	5+	3.1	--	Glass bulb (#2) collected at 8:44
PZ-204a	3.9	0.195	7:12	--	--	--	0.01	Initial vacuum
			8:54	0	5+	1.0	1	Pump on
			8:56	2	5+	1.2	0	
			8:58	4	5+	1.5	0	Pump off
PZ-204b	5.8	0.29	7:12	--	--	--	0.01	Initial vacuum
			8:58	0	5+	1.4	1	Pump on
			9:00	2	5+	2.1	1	
			9:02	4	5+	2.5	1	
			9:04	6	5+	2.5	1	Pump off
PZ-204c	8.8	0.44	7:12	--	--	--	0.01	Initial vacuum
			9:05	0	5+	1.1	1	Pump on
			9:08	3	5+	4.4	0	
			9:11	6	5+	4.6	0	
			9:14	9	5+	4.4	-0.5	Pump off
			9:29	24	5+	4.7	--	Glass bulb (#9) collected at 9:29

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/8/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-204d	10.6	0.53	7:12	--	--	--	0.01	Initial vacuum
			9:14	0	5+	2.1	1	Pump on
			9:18	4	5+	6.9	0	
			9:22	8	5+	6.0	0	
			9:25	11	5+	6.3	0	
			9:26	12	5+	6.1	--	Glass bulb (#3) collected at 9:26; pump off
PZ-201a	4.2	0.21	7:11	--	--	--	0.01	Initial vacuum
			9:33	0	5+	0.9	1	Pump on
			9:36	3	5+	1.0	1	
			9:38	5	5+	1.0	1	Pump off
PZ-201b	7.4	0.37	7:11	--	--	--	0.01	Initial vacuum
			9:38	0	5+	1.7	1	Pump on
			9:41	3	5+	3.6	0	
			9:44	6	5+	3.4	0	
			9:46	8	5+	3.3	0	Pump off
			10:12	34	5+	3.2	--	Glass bulb (#4) collected at 10:12
PZ-201c	9.0	0.45	7:11	--	--	--	0.01	Initial vacuum
			9:47	0	5+	2.8	1	Pump on
			9:50	3	5+	3.1	1	
			9:53	6	5+	3.0	1	
			9:56	9	5+	3.0	1	Pump off
PZ-201d	10.6	0.53	7:11	--	--	--	0.01	Initial vacuum
			9:56	0	5+	0.9	1	Pump on
			10:00	4	5+	4.2	0.5	
			10:04	8	5+	4.9	0.5	
			10:07	11	5+	5.2	--	
			10:09	13	5+	5.1		Glass bulb (#7) collected at 10:09; pump off
PZ-070	5.9	0.295	7:13	--	--	--	0.0	Initial vacuum
			11:06	0	5+	16.1	1	Pump on
			11:08	2	5+	6.6	1	
			11:10	4	5+	3.8	1	
			11:12	6	5+	2.6	1	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/8/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
RD-104	97.4	4.87	7:17	--	--	--	0.0	Initial vacuum
			8:40	0	110.0	147.7	--	Pump on (5 cfm)
			8:42	2	--	115.3	--	
			8:44	4	--	84.5	--	
			8:46	6	--	76.2	--	Pump off
			11:27	167	5+	13.0	--	Glass bulb (#8) collected at 11:27
								5 L/min pump on for 10+ minutes, but PID wouldn't rise
PZ-061	5.7	0.285	7:15	--	--	--	0.0	Initial vacuum
			11:40	0	5+	310.4	1	Pump on
			11:42	2	5+	283.9	1	
			11:44	4	5+	86.6	1	
			11:46	6	5+	51.0	1	Pump off
HAR-20	717.3	35.865	7:16	--	--	--	0.0	Initial vacuum
			8:57	0	--	0.0	--	Pump on
			9:00	3	127.6	0.0	--	149 Liters/70 seconds
			9:11	14	--	0.0	--	
			9:20	23	--	0.0	--	
			9:33	36	--	0.0	--	Pump off
PZ-156	29.4	1.47	9:44	--	--	--	0.0	Initial vacuum
			9:45	0	110.0	48.4	--	Pump on (5 cfm)
			9:46	1	--	147.5	--	
			9:47	2	--	140.6	--	
			9:48	3	--	157.2	--	
			9:49	4	--	162.5	--	Pump off

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VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/12/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	7:04	--	--	--	0.14	Initial vacuum
			8:05	0	5+	3.4	1	Pump on
			8:06	1	5+	2.4	0	
			8:08	3	5+	2.5	-0.5	
			8:09	4	5+	2.3	-0.5	
			8:10	5	5+	2.4	-1	Pump off
PZ-203a	4.0	0.2	7:02	--	--	--	0.13	Initial vacuum
			7:17	0	5.0	0.0	1	Pump on
			7:20	3	4.9	0.0	0	
			7:22	5	5+	0.0	0	Pump off
PZ-203b	6.4	0.32	7:02	--	--	--	0.17	Initial vacuum
			7:28	0	5+	0.0	1	Pump on
			7:31	3	5+	0.0	-0.5	
			7:33	5	5+	0.2	-2	
			7:35	7	5+	1.1	-3	Pump off
PZ-203c	9.4	0.47	7:03	--	--	--	3.03	Initial vacuum
			7:36	0	5+	0.4	-1	Pump on
			7:40	4	5+	0.1	-2	
			7:43	7	5+	4.7	-2	
			7:46	10	5+	4.9	-2	Pump off
			8:04	28	5+	4.8	--	Glass bulb (#11) collected at 8:04
PZ-203d	10.6	0.53	7:03	--	--	--	3.03	Initial vacuum, in. water
			7:47	0	5+	1.7	-1.5	
			7:51	4	5+	6.5	-1.5	
			7:55	8	5+	12.4	-1.5	
			7:58	11	5+	21.7	-1.5	
			8:01	14	5+	21.7	-1.5	Glass bulb (#8) collected at 8:01; pump off
PZ-202a	3.9	0.195	7:00	--	--	--	0.08	Initial vacuum
			8:13	0	5+	1.8	1	Pump on
			8:14	1	5.0	2.1	0	
			8:15	2	5+	2.2	0	
			8:16	3	5+	--	-0.5	
			8:17	4	5+	1.7	-1	Pump off
			8:52	39	--	1.4	--	Glass bulb (#1) collected at 8:52
								Initial PID on glass bulb = 20 ppm

VAPOR SAMPLING PURGE LOG

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Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/12/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
PZ-202b	5.8	0.29	7:00	--	--	--	0.14	Initial vacuum
			8:18	0	5.0	1.4	1	Pump on
			8:20	2	5.0	1.1	1	
			8:22	4	5.0	1.2	-0.5	
			8:24	6	5.0	1.1	0	Pump off
PZ-202c	8.4	0.42	7:01	--	--	--	0.44	Initial vacuum
			8:25	0	5.0	1.1	1	Pump on
			8:28	3	4.8	0.9	0	
			8:31	6	5+	0.8	-2	
			8:34	9	5.0	0.7	-3	Pump off
PZ-202d	10.1	0.505	7:01	--	--	--	1.94	Initial vacuum
			8:35	0	5+	0.7	0	Pump on
			8:39	4	5+	1.4	-3	
			8:43	8	5+	1.8	-4	
			8:46	11	5+	2.2	-4	
			8:48	13	5+	2.3	--	Glass bulb (#2) collected at 8:48
			8:49	14				Pump off
PZ-204a	3.9	0.195	7:06	--	--	--	0.12	Initial vacuum
			9:03	0	5+	0.7	1	Pump on
			9:05	2	5+	0.4	0	
			9:07	4	5+	0.7	0	Pump off
PZ-204b	5.8	0.29	7:06	--	--	--	0.18	Initial vacuum
			9:08	0	5+	0.3	1	Pump on
			9:10	2	5+	0.4	1	
			9:12	4	5+	1.6	1	
			9:14	6	5+	1.6	1	Pump off
PZ-204c	8.8	0.44	7:06	--	--	--	0.16	Initial vacuum
			9:14	0	5+	0.4	1	Pump on
			9:17	3	5+	0.6	0	
			9:20	6	5+	3.5	-1	
			9:23	9	5+	3.6	-1	Pump off
			9:39	25	5+	3.6	--	Glass bulb (#5) collected at 9:39

VAPOR SAMPLING PURGE LOG

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Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 9/12/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
PZ-204d	10.6	0.53	7:07	--	--	--	0.11	Initial vacuum
			9:23	0	5+	0.7	1	Pump on
			9:27	4	5+	6.7	0	
			9:31	8	5+	6.1	0	
			9:34	11	5+	7.1	0	
			9:36	13	--	6.7	--	Glass bulb (#7) collected at 9:36; pump off
PZ-201a	4.2	0.21	6:58	--	--	--	0.10	Initial vacuum
			9:49	0	5+	0.6	0.5	Pump on
			9:52	3	5+	0.6	0	
			9:54	5	5+	0.7	0	Pump off
PZ-201b	7.4	0.37	6:58	--	--	--	0.12	Initial vacuum
			9:54	0	5+	1.2	1	Pump on
			9:57	3	5+	3.6	-0.5	
			10:00	6	5+	3.8	-1	
			10:02	8	5+	4.0	-1	Pump off
PZ-201c	9.0	0.45	6:58	--	--	--	0.12	Initial vacuum
			10:02	0	5+	0.7	1	Pump on
			10:05	3	5+	3.6	0	
			10:08	6	5+	3.6	0	
			10:11	9	5+	3.7	0	Pump off
PZ-201d	10.6	0.53	6:59	--	--	--	0.33	Initial vacuum
			10:12	0	5+	0.4	1	Pump on
			10:16	4	5+	0.6	-1	
			10:20	8	5+	5.1	-1	
			10:23	11	5+	5.0	-1	
			10:25	13	5+	5.0	-1	Glass bulb (#12) collected at 10:25; pump off
PZ-070	5.9	0.295	7:05	--	--	--	0.0	Initial vacuum
			10:42	0	5+	8.8	1	Pump on
			10:44	2	5+	2.1	1	
			10:46	4	5+	1.5	1	
			10:48	6	5+	1.3	1	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02

Sampler/Team: J. Lindquist, K. Remmen
Date: 9/12/2014

Location	Purge Time (min) 5 L/min	Purge Time (min) 100 L/min	Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
RD-104	97.4	4.87	7:08	--	--	--	0.0	Initial vacuum
			8:35	0	--	27.4	--	Pump on (5 cfm)
			8:36	1	129.0	18.3	--	140 Liters/65 seconds
			8:38	3	--	9.6	--	
			8:39	4	--	13.7	--	
			8:40	5	--	13.1	--	Pump off
PZ-061	5.7	0.285	6:56	--	--	--	0.0	Initial vacuum
			12:24	0	5+	367.3	1	Pump on
			12:26	2	5+	57.3	1	
			12:28	4	5+	53.1	1	
			12:30	6	5+	41.3	1	
			12:32	8	5+	41.6	1	Glass bulb (#3) collected at 12:32; pump off
HAR-20	717.3	35.865	6:54	--	--	--	0.01	Initial vacuum
			7:54	0	--	0.2	--	Pump on
			7:55	1	120.0	--	--	140 Liters/70 seconds
			7:58	4	--	0.0	--	
			8:21	27	--	0.2	--	
			8:25	31	120.0	0.1	--	140 Liters/70 seconds
			8:30	36	--	0.2	--	Pump off
PZ-156	29.4	1.47	9:59	--	--	--	0.21	Initial vacuum
			10:00	0	--	300.8	--	Pump on (5 cfm)
			10:01	1	--	83.6	--	
			10:02	2	--	97.0	--	
			10:03	3	--	96.7	--	
			10:04	4	--	92.4	--	Pump off
			10:25	25		65.9		Glass bulb (#2) collected at 10:25

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study   Sampler/Team: J. Lindquist, K. Remmen

Project #: 474867.BV.02   Date: 10/22/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-203v	4.8	0.24	11:07	0	5	1.1	1	Pump on
			11:10	3	5+	4.3	0	
			11:12	5	5+	2.0	-1	Pump off
PZ-203a	4.0	0.2	11:13	0	5+	1.5	1	Pump on
			11:15	2	5+	1.2	0	
			11:17	4	5+	1.0	0	Pump off
PZ-203b	6.4	0.32	11:17	0	5+	0.9	1	Pump on
			11:21	4	5+	1.2	0	
			11:24	7	5+	1.3	-1	Pump off
PZ-203c	9.4	0.47	11:24	0	5+	0.9	1	Pump on
			11:28	4	5+	2.3	0	
			11:32	8	5+	3.8	0	
			11:34	10	5+	4.0	0	Pump off
			11:53	29	5+	4.3	--	Collect glass bulb (#13) at 11:53
PZ-203d	10.6	0.53	11:34	0	5+	2.0	1	Pump on
			11:39	5	5+	14.3	1	
			11:44	10	5+	11.2	1	
			11:45	11	5+	11.0	1	
			11:49	15	5+	11.1	--	Collect glass bulb (#9) at 11:49. Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 10/22/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-202a	3.9	0.195	7:17	--	--	--	-19	Pump on (valve closed)
			7:18	0	5+	0.1	1	Valve open
			7:20	2	5+	0.6	1	
			7:22	4	5+	0.5	0	
			7:23	5	5+	0.7	0	Pump off
PZ-202b	5.8	0.29	7:23	--	--	--	-18	Pump on (valve closed)
			7:24	0	5+	0.2	1	Valve open
			7:27	3	5+	0.6	1	
			7:30	6	5+	0.9	1	
			7:31	7	5+	1.1	1	Pump off
PZ-202c	8.4	0.42	7:31	0	5+	0.7	1	Pump on
			7:34	3	4.9	0.9	0	
			7:37	6	5.0	1.1	-0.5	
			7:40	9	5.0	1.5	-1	Pump off
PZ-202d	10.1	0.505	7:40	0	5.0	0.6	1	Pump on
			7:44	4	5+	1.8	0	
			7:48	8	5+	1.9	0	
			7:51	11	5+	2.3	-1	
			7:54	14	5+	2.0	--	Collect glass bulb (#3) at 7:54. Pump off
PZ-204a	3.9	0.195	8:47	0	5+	0.3	1	Pump on
			8:49	2	5+	0.4	0.5	
			8:51	4	5+	1.1	0	Pump off

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Sampler/Team: J. Lindquist, K. Remmen
Project #: 474867.BV.02
Date: 10/22/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-204b	5.8	0.29	8:52	0	4.8	0.6	1	Pump on
			8:55	3	5.0	0.8	1	
			8:58	6	5.0	1.8	1	
			8:59	7	5+	2.3	1	Pump off
PZ-204c	8.8	0.44	9:00	0	5+	0.8	1	Pump on
			9:03	3	5+	2.2	0.5	
			9:06	6	5+	2.6	0	
			9:09	9	5+	3.7	0	
			9:10	10	5+	4.0	0	Pump off
			9:26	26	5+	3.9	1	Collect glass bulb (#11) at 9:26
PZ-204d	10.6	0.53	9:11	0	5.0	3.7	1	Pump on
			9:15	4	5+	5.1	1	
			9:19	8	5+	7.0	1	
			9:22	11	5+	4.9	1	
			9:24	13	5+	4.7	1	Collect glass bulb (#1) at 9:24
PZ-201a	4.2	0.21	8:00	0	5+	0.4	1	Pump on
			8:03	3	5+	1.0	1	
			8:05	5	5+	1.1	1	Pump off
PZ-201b	7.4	0.37	8:06	0	5+	1.1	1	Pump on
			8:10	4	5+	3.1	0.5	
			8:14	8	5+	2.9	0.5	Pump off
			8:42	--	--	2.6	--	Collect glass bulb (#12) at 8:42

VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study
Project #: 474867.BV.02
Sampler/Team: J. Lindquist, K. Remmen
Date: 10/22/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
PZ-201c	9.0	0.45	8:15	0	5+	1.3	1	Pump on
			8:18	3	5+	2.6	1	
			8:21	6	5+	2.9	1	
			8:24	9	5+	2.9	1.0	Pump off
PZ-201d	10.6	0.53	8:25	0	5+	0.5	1	Pump on
			8:29	4	5+	1.8	1	
			8:33	8	5+	2.5	1	
			8:36	11	5+	3.6	1	
			8:38	13	--	3.8	--	Collect glass bulb (#7) at 8:38. Pump off
PZ-070	5.9	0.295	10:50	0	5+	2.1	1	Pump on
			10:53	3	5+	0.7	1	
			10:56	6	5+	0.5	1	Pump off
RD-104	97.4	4.87	9:34	0	--	5.0	--	Pump on
			9:37	3	110	6.7	--	
			9:38	4	--	6.6	--	
			9:39	5	110	7.4	--	
			9:41	7	--	9.4	--	
			9:43	9	--	10.3	--	Pump off
								Checked for leaks, none apparent
PZ-061	5.7	0.285	10:36	0	5+	4.1	1	Pump on
			10:39	3	5.0	4.6	1	
			10:42	6	5+	3.1	1	Pump off

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VAPOR SAMPLING PURGE LOG

Project Name: NASA SSFL BVE Study | Sampler/Team: J. Lindquist, K. Remmen

Project #: 474867.BV.02 | Date: 10/22/2014

Location	Purge Time (min)		Time	Elapsed Time (min)	Q (L/min)	PID (ppm)	Vacuum (in. Hg)	Remarks
	5 L/min	100 L/min						
HAR-20	717.3	35.865	9:54	0	110	1.5	--	Pump on
			9:59	5	110	0.6	--	
			10:04	10	110	0.2	--	
			10:09	15	110	0.2	--	
			10:14	20	110	0.1	--	
			10.19	25	110	0.1	--	
			10:24	30	110	0.0	--	
			10:30	36	110	0.1	--	Pump off
PZ-156	29.4	1.47	12:36	0	110	52.3	--	Pump on
			12:37	1	110	60.8	--	
			12:38	2	110	66.0	--	Pump off. -226 inches of water
			12:47	11	5+	15.7	--	Collect glass bulb (#10) at 12:47

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Appendix L
Signal Processing of Vacuum Time-Series Data

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APPENDIX L

Signal Processing of Vacuum Time-Series Data

This appendix documents the methods used for the signal processing analysis performed on the bedrock vapor extraction (BVE) Treatability Study pressure transducer data collected between August 26 and September 15, 2014. Examination of the raw data indicated it was likely that pressures measured in the monitoring wells were influenced by barometric fluctuations. Before vacuum responses to BVE could be assessed, it was necessary that these barometric influences be removed from the measured time series data. The barometric variations were removed from the measured vacuum signals using the publicly available signal-processing software SeriesSee, published by the United States Geological Survey (USGS, 2012). This software is designed to identify and correct for a known signal from another pressure source, in this case removing barometric fluctuations from pressure data recorded via transducer.

L.1 Signal Processing Theory

When multiple time-variable pressure sources simultaneously act on a surface, the pressures are additive and the resulting pressure time-series will exhibit the combined effects of all pressures. In the case of subsurface pressure fluctuations, pressure changes are conveyed through the compression and displacement of air within the soil or rock matrix. If pressure propagation or air movement is impeded by the surrounding formation, the pressure signals can be dampened and delayed; these effects are accounted for using constant values referred to as “amplitude adjustment” and “time shift”, respectively. The signal processing software attempts to simulate the barometric signal felt at each monitoring location by modifying the barometric signal (or smoothed versions of it) by adjusting the amplitude and phase shift constants. This custom, “synthesized” barometric signal is then used to cancel out the barometric effects measured at the particular well/pressure transducer for which it was developed.

This customized barometric signal is unique for each well/pressure transducer and must be developed during a period when only atmospheric fluctuations affect the pressure signal, called a fitting period (that is, a period when no pumping stress is present). Once the signal is developed for the fitting period, it then is extrapolated to the entire time series for the given well/transducer to represent the barometric fluctuations over the entire period of record. The customized barometric signal for the well/transducer is then subtracted from the raw pressure time series resulting in data representing pressure responses solely from vapor extraction.

L.2 Data

Figures L-1 through L-4 present the unprocessed vapor pressure data to HAR-19 vapor extraction at multilevel piezometers PZ-201a-d, PZ-202a-d, PZ-203a-d (and PZ-203Av), and PZ-204a-d, respectively. Figure L-5 presents the unprocessed pressure data recorded at the existing wells/piezometers HAR-20, PZ-156, RD-104, PZ-61, and PZ-70.

The period of record from each well, August 26, 2014 12:00 to September 15, 2014 12:10, were processed. All time series were concurrent, and transducers were programmed to record data at 10-minute intervals. A barometric transducer (that is, a barologger) was used to collect the barometric fluctuation data at the land surface and is used as the basis for the custom barometric signal generated for each well/transducer.

L.3 Signal Processing of Time-Vacuum Data

This section describes the steps followed to complete the signal processing. First, the pressure time series measured by the transducers from all monitoring wells were combined into a single SeriesSee Excel file. In a few instances, soil vapor sampling or other field activities interfered with the transducer pressure measurements and a small number of measurements (264 out of 63,404 total) were removed from the time series. SeriesSee cannot deconvolve time series with missing data; therefore, these gaps were replaced with a linear interpolation between the nearest time-adjacent pressure measurements from the same well/transducer that appeared to be unaffected by such field activity.

The first step in the development of the well by well synthetic barometric time series was to select a fitting period. The beginning and ending times of a fitting period were chosen as 4:00 AM of the day following the shutdown of the first week's extraction test (8/30/14 04:00) through 4:00 AM of the day prior to the startup of the second week of extraction (9/2/14 04:00). The process assumes that any changes in pressure recorded by the transducers during this period are solely due to barometric fluctuations. This fitting period is the time over which an "amplitude adjustment" and "time shift" parameters are chosen to minimize the differences between the measured well pressure series and the synthetic background barometric signal. That is, any difference in the magnitude or timing of pressure data between the barologger (at the surface) and transducers deployed in the monitoring network is assumed to be due to the impediment of air flow through the subsurface (unique to each well/transducer). There were slight variations in the fitting period start and ending times for some wells where field activity was influencing well pressure measurement, but these were on the order of hours and do not greatly impact the duration of the fitting period.

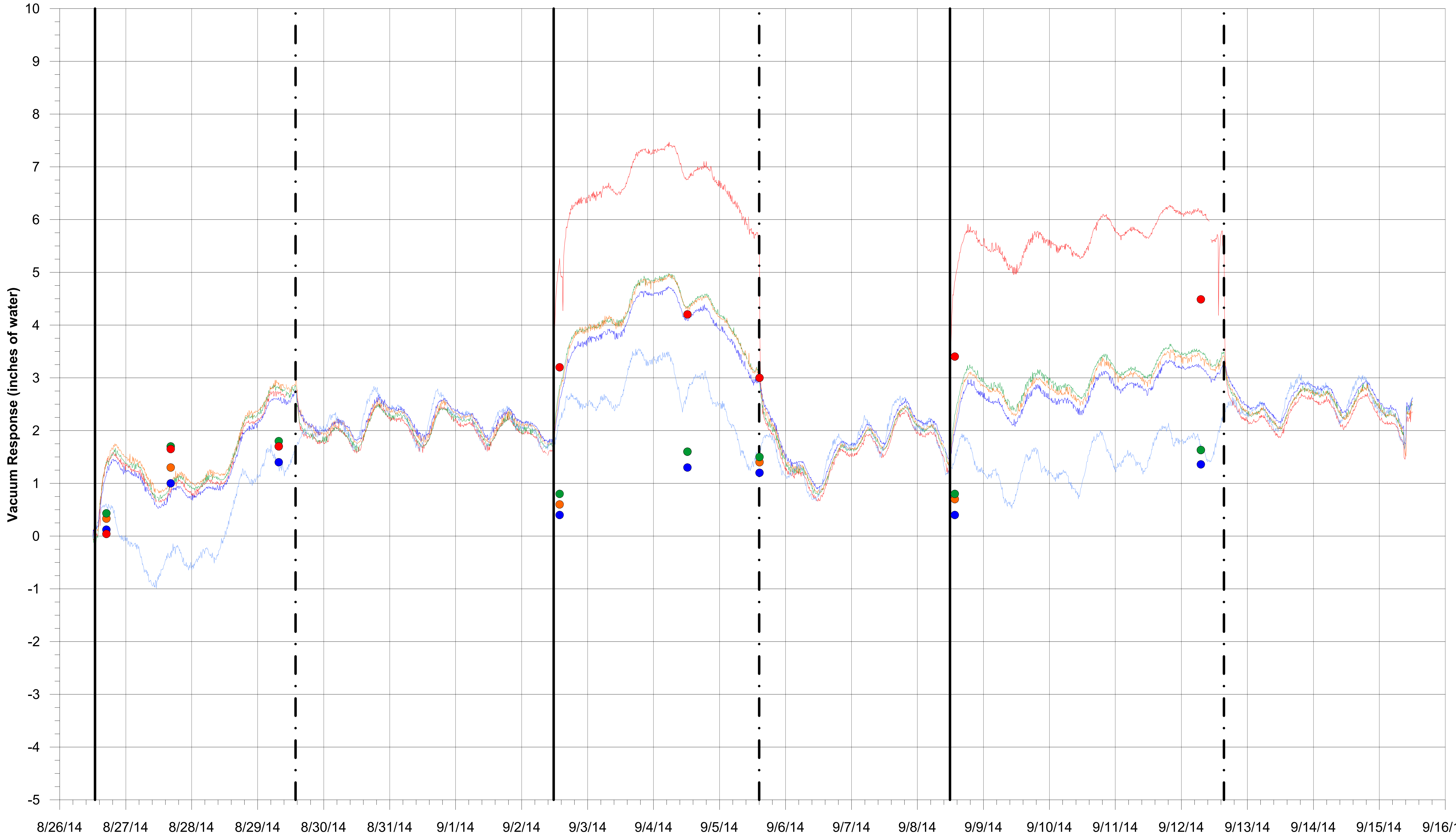
The signal processing tool was used to create a hypothetical barometric fluctuation time series for each well/transducer over the fitting period by applying various moving average smoothing filters to, and adjusting the phase shift and amplitude of, the barometric signal. SeriesSee was used to minimize the difference between the barometric signal recorded by the barologger and the pressure measurements during the fitting period for each well. This results in a combined synthetic barometric time series that best fits the transducer pressure measurements for each observation well during the fitting period, minimizing the root mean square (RMS) error. The average RMS error for the 22 synthetic barometric time series for the fitting period was 0.044 inches water (H_2O), with a minimum and maximum RMS error of 0.028 and 0.207 inches H_2O.

The resulting synthetic barometric signals for the fitting period were then extrapolated to calculate synthetic background barometric time series for the entire period of record for each well/transducer. This is an estimate of what the pressure variations would have been in the monitoring wells in the absence of the imposed vacuum.

The change in pressure resulting from the imposed vacuum is then estimated as the difference between the raw pressure transducer data and the synthetic background barometric data series for each well/transducer. An example of a comparison of the un-processed and processed transducer data is presented on Figure L-6 for PZ-201d.

L.4 Works Cited

United States Geological Survey (USGS). 2012. *Advanced Methods for Modeling Water-Levels and Estimating Drawdowns with SeriesSEE, an Excel Add-In.* USGS Techniques and Methods4–F4.



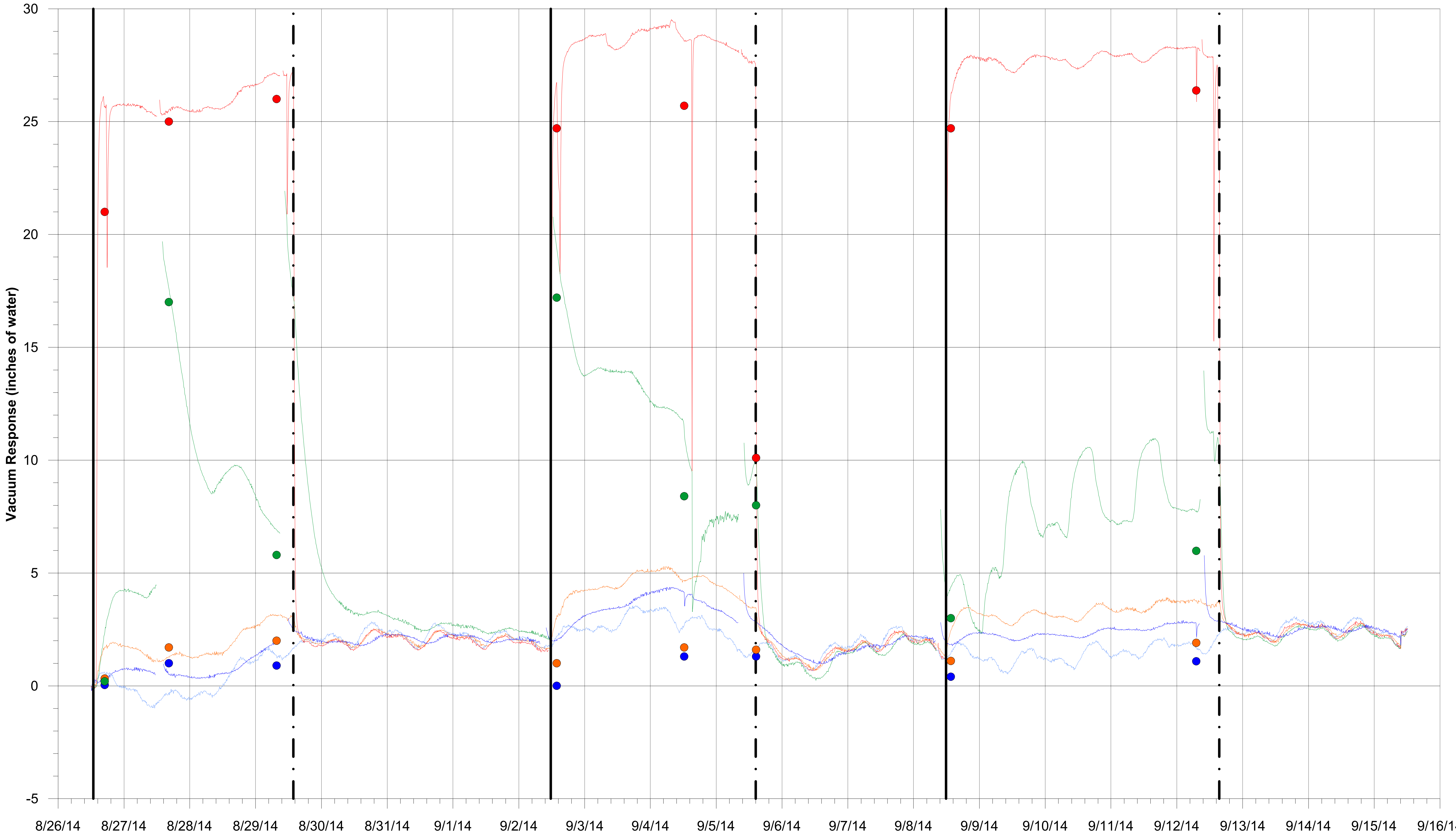
Notes:
1. ft bgs = feet below ground surface.
2. PZ-201 is located approximately 90 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer.

BaroLogger
System Start-up
System Shut-down

	Transducer Data	Manual Data
PZ-201a (55 to 65 ft bgs)		
PZ-201b (100 to 115 ft bgs)		
PZ-201c (124.9 to 139.9 ft bgs)		
PZ-201d (149.8 to 164.8 ft bgs)		

Figure L-1
Vacuum Response at PZ-201; Un-Processed Data
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

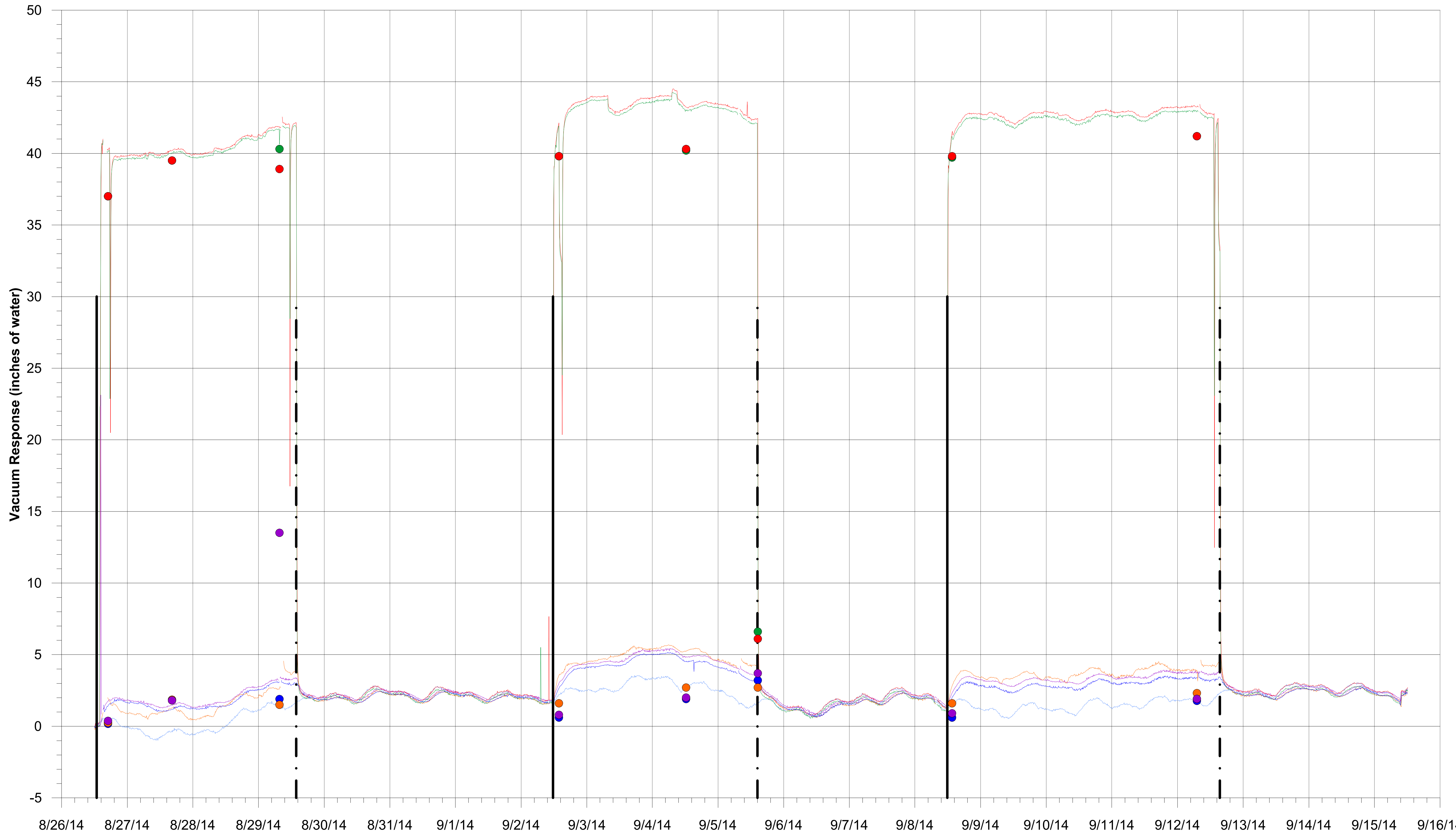
SCO474867.BV.01 SSFL_bravo_pz201_unprocessed.ai 6/15



Notes:
1. ft bgs = feet below ground surface.
2. PZ-202 is located approximately 85 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer.

	Transducer Data	Manual Data
BaroLogger		
System Start-up		
System Shut-down		
PZ-202a (50.9 to 60.9 ft bgs)		
PZ-202b (80.8 to 90.8 ft bgs)		
PZ-202c (116 to 131 ft bgs)		
PZ-202d (146.2 to 156.2 ft bgs)		

Figure L-2
Vacuum Response at PZ-202; Un-Processed Data
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

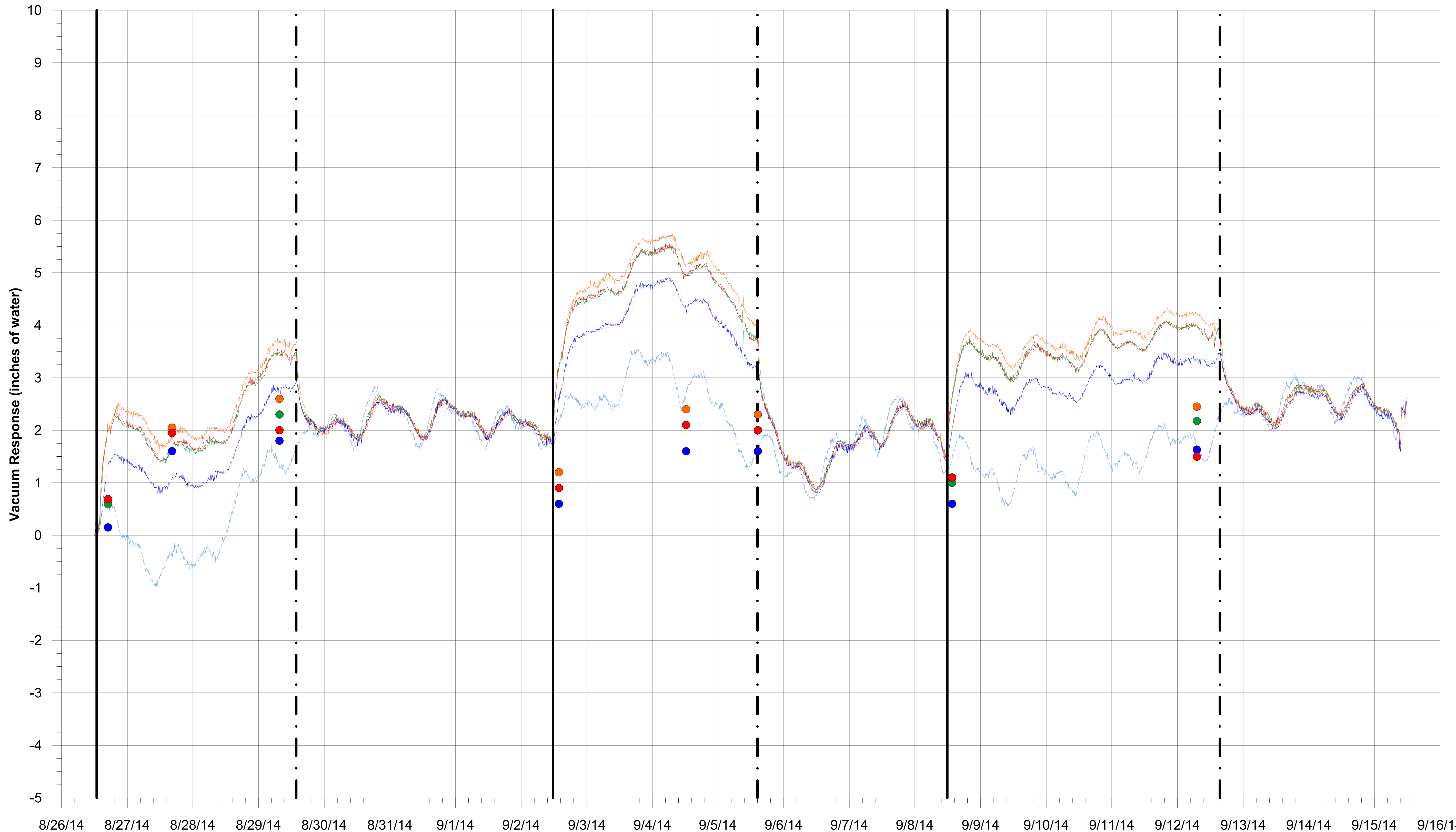


Notes:
1. ft bgs = feet below ground surface.
2. PZ-203 is located approximately 35 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer.

	Transducer Data	Manual Data
BaroLogger		
System Start-up		
System Shut-down		
PZ-203a (52 to 62 ft bgs)		
PZ-203b (84.8 to 99.8 ft bgs)		
PZ-203c (131 to 146 ft bgs)		
PZ-203d (154.9 to 164.9 ft bgs)		
PZ-203Av (70 to 75 ft bgs)		

Figure L-3
Vacuum Response at PZ-203; Un-Processed Data
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz203_unprocessed.ai 6/15

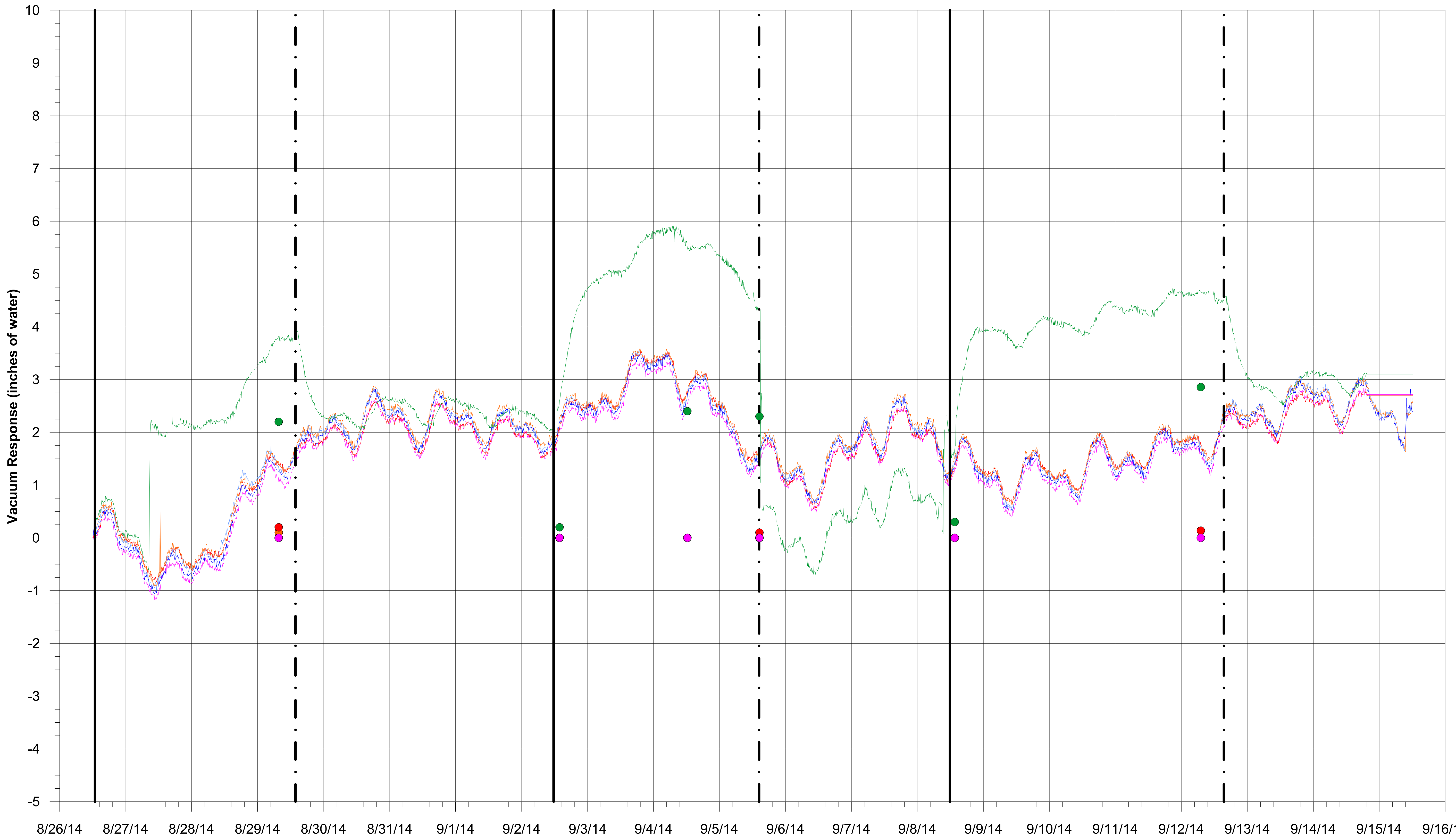


Notes:
1. ft bgs = feet below ground surface.
2. PZ-204 is located approximately 45 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer.

	Transducer Data	Manual Data
BaroLogger		
System Start-up		
System Shut-down		
PZ-204a (50.2 to 60.2 ft bgs)		
PZ-204b (75.3 to 90.3 ft bgs)		
PZ-204c (122.4 to 137.4 ft bgs)		
PZ-204d (149 to 164 ft bgs)		

Figure L-4
Vacuum Response at PZ-204; Un-Processed Data
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_pz204_unprocessed.ai 6/15

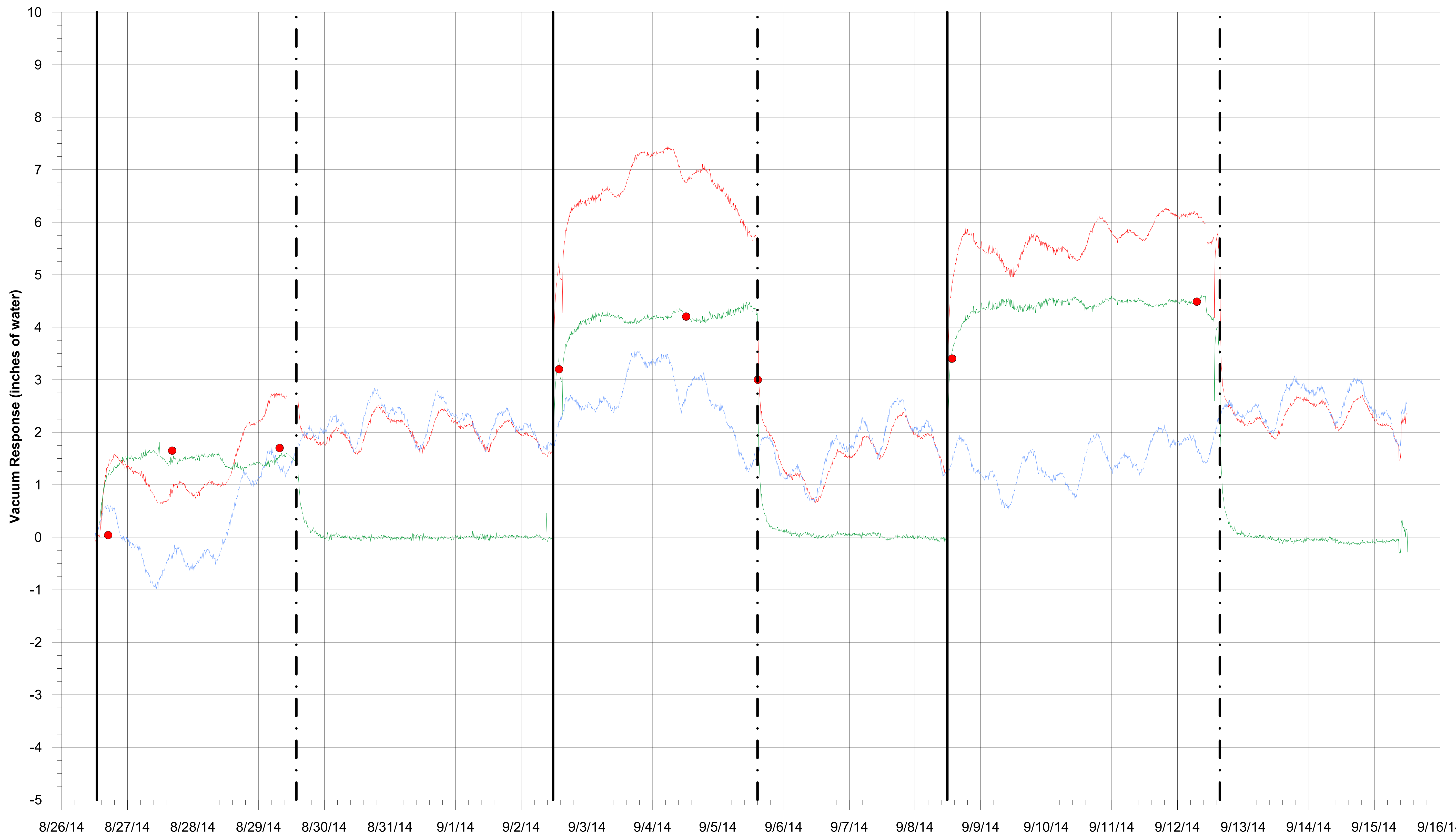


Notes:
1. ft bgs = feet below ground surface.
2. Discontinuities in vacuum response curves represent sampling at individual piezometer, data is omitted from plot.
3. Circles represent manually measured vacuum data.

	Transducer Data	Manual Data
BaroLogger		
System Start-up		
System Shut-down		
RD-104 (30 to 60.5 ft bgs)		
HAR-20 (30 to 230 ft bgs)		
PZ-156 (104 to 114 ft bgs)		
PZ-070 (13 to 23 ft bgs)		
PZ-061 (5 to 15 ft bgs)		

Figure L-5
Vacuum Response at Existing Wells; Un-Processed Data
Bravo BVE Treatability Study Summary
anta Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_existing_well_unprocessed.ai 6/15



Notes:
1. ft bgs = feet below ground surface.
2. PZ-201 is located approximately 90 feet from BVE well HAR-19.
3. Discontinuities in vacuum response curves represent sampling at individual piezometer.

System Start-up
System Shut-down
BaroLogger
PZ-201d (unprocessed transducer data)
PZ-201d (processed transducer data)
PZ-201d (manual measurement)

Figure L-6
Comparison of Unprocessed and Processed Transducer Data, PZ-201d
Bravo BVE Treatability Study Summary
Santa Susana Field Laboratory
Ventura County, California

SCO474867.BV.01 SSFL_bravo_transducer_PZ201D.ai 6/15

Appendix M
Groundwater Analytical Data

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TABLE M-1

HAR-19 Groundwater Analytical Data - Before and After BVE Testing

Bravo Bedrock Vapor Extraction Treatability Study Summary

Parameter Name	Analytical Method	Result Value (µg/L)				Comparison
		7/14/2014		*10/23/2014*		
1,1,1,2-Tetrachloroethane	SW8260B	0.4	U	0.2	U	No change
1,1,1-Trichloroethane	SW8260B	0.3	U	0.2	U	No change
1,1,2,2-Tetrachloroethane	SW8260B	0.41	U	0.2	U	No change
1,1,2-Trichloro-1,2,2-trifluoroethane	SW8260B	0.45	U	8.8	=	Increase
1,1,2-Trichloroethane	SW8260B	0.38	U	0.2	U	No change
1,1-Dichloroethane	SW8260B	0.28	U	0.2	U	No change
1,1-Dichloroethene	SW8260B	2.5	J	1.4	=	Decrease
1,1-Dichloropropene	SW8260B	0.46	U	0.2	U	No change
1,2,3-Trichlorobenzene	SW8260B	0.51	U	0.3	U	No change
1,2,3-Trichloropropane	SW8260B	NM		0.5	U	N/A
1,2,4-Trichlorobenzene	SW8260B	0.5	U	0.3	U	No change
1,2,4-Trimethylbenzene	SW8260B	0.36	U	0.2	U	No change
1,2-Dibromo-3-chloropropane	SW8260B	NM		0.5	U	N/A
1,2-Dibromoethane (EDB)	SW8260B	NM		0.2	U	N/A
1,2-Dichlorobenzene	SW8260B	0.46	U	0.2	U	No change
1,2-Dichloroethane	SW8260B	0.24	U	0.2	U	No change
1,2-Dichloropropane	SW8260B	0.42	U	0.2	U	No change
1,3,5-Trimethylbenzene	SW8260B	0.28	U	0.2	U	No change
1,3-Dichlorobenzene	SW8260B	0.4	U	0.2	U	No change
1,3-Dichloropropane	SW8260B	0.3	U	0.2	U	No change
1,4-Dichlorobenzene	SW8260B	0.43	U	0.2	U	No change
2,2-Dichloropropane	SW8260B	0.36	U	0.2	U	No change
2-Butanone (MEK)	SW8260B	2.2	U	4	U	No change
2-Chloro-1,1,1-trifluoroethane	SW8260B	NM		0.2	U	N/A
2-Chloroethyl vinyl ether	SW8260B	16	R	1	U	Decrease
2-Chlorotoluene	SW8260B	0.24	U	0.2	U	No change
2-Hexanone	SW8260B	2.1	U	4	U	No change
4-Chlorotoluene	SW8260B	0.13	U	0.2	U	No change
4-Methyl-2-pentanone (MIBK)	SW8260B	4.4	U	4	U	No change
Acetone	SW8260B	6	U	5	U	No change
Benzene	SW8260B	0.23	J	0.32	J	Increase
Bromobenzene	SW8260B	0.3	U	0.2	U	No change
Bromochloromethane	SW8260B	0.48	U	0.2	U	No change
Bromodichloromethane	SW8260B	0.21	U	0.2	U	No change
Bromoform	SW8260B	0.5	U	0.3	U	No change
Bromomethane	SW8260B	3.9	UJ	0.3	U	No change
Carbon tetrachloride	SW8260B	0.23	U	0.2	U	No change
Chlorobenzene	SW8260B	0.17	U	0.2	U	No change
Chloroethane	SW8260B	2.3	U	0.3	U	No change
Chloromethane	SW8260B	1.8	U	0.3	U	No change
Chlorotrifluoroethylene	SW8260B	NM		24	J	N/A
cis-1,2-Dichloroethene	SW8260B	730	=	370	=	Decrease
cis-1,3-Dichloropropene	SW8260B	0.25	U	0.2	U	No change

TABLE M-1

HAR-19 Groundwater Analytical Data - Before and After BVE Testing

Bravo Bedrock Vapor Extraction Treatability Study Summary

Parameter Name	Analytical Method	Result Value (µg/L)				Comparison
		7/14/2014		*10/23/2014*		
Dibromochloromethane	SW8260B	0.25	U	0.2	U	No change
Dibromomethane	SW8260B	0.46	U	0.2	U	No change
Dichlorodifluoromethane	SW8260B	0.46	U	0.3	U	No change
Diisopropyl ether	SW8260B	NM		0.2	U	N/A
Ethylbenzene	SW8260B	0.14	U	0.2	U	No change
Hexachlorobutadiene	SW8260B	0.32	U	0.3	U	No change
Isopropylbenzene	SW8260B	0.58	U	0.2	U	No change
m,p-Xylenes	SW8260B	0.3	U	0.4	U	No change
Methyl-tert-butyl Ether (MTBE)	SW8260B	0.31	U	0.2	U	No change
Methylene chloride	SW8260B	0.64	U	0.5	U	No change
n-butylbenzene	SW8260B	0.23	U	0.2	U	No change
n-Propylbenzene	SW8260B	0.17	U	0.2	U	No change
o-Xylene	SW8260B	0.23	U	0.2	U	No change
p-Isopropyltoluene	SW8260B	0.16	U	0.2	U	No change
sec-Butylbenzene	SW8260B	0.25	U	0.2	U	No change
Styrene	SW8260B	0.17	U	0.2	U	No change
tert-Amyl methyl ether	SW8260B	NM		0.2	U	N/A
tert-Butyl alcohol	SW8260B	NM		5	U	N/A
tert-Butyl ethyl ether	SW8260B	NM		0.2	U	N/A
tert-Butylbenzene	SW8260B	0.28	U	0.2	U	No change
Tetrachloroethene	SW8260B	0.39	U	0.2	U	No change
Toluene	SW8260B	0.24	U	0.2	U	No change
trans-1,2-Dichloroethene	SW8260B	220	=	94	=	Decrease
trans-1,3-Dichloropropene	SW8260B	0.25	U	0.2	U	No change
Trichloroethene	SW8260B	480	=	1100	=	Increase
Trichlorofluoromethane	SW8260B	1.7	U	0.3	U	No change
Trichloromethane (Chloroform)	SW8260B	0.46	U	0.2	U	No change
Vinyl chloride	SW8260B	77	=	6.9	=	Decrease

Notes:

Laboratory analytical data information, including method detection limits and report limits for the data provided in this table are included in Appendix I.

µg/L = micrograms per liter

"=" = Detected concentration

J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (estimated).

N/A = not applicable

NM = not measured

U = Analyte was analyzed for but not detected above the reported sample quantitation limit, or this analyte was considered not detected due to laboratory or field blank contamination.

Appendix N
Data Usability Assessment Report

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Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report

Santa Susana Field Laboratory, Ventura County, California

Prepared for

National Aeronautics and Space Administration

September 2020

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Contents

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Acronyms and Abbreviations

2-CLEVE	2-chloroethylvinyl ether
APPL	Agriculture & Priority Pollutants Laboratories, Inc.
BVE	bedrock vapor extraction
CASS	ALS Environmental
CEL	Eurofins Calscience Laboratories
EMXT	EMAX Laboratories, Inc
EPA	Environmental Protection Agency
ESTI	Environmental Support Technologies
FD	field duplicate
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MDL	method detection limit
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PARCCS	precision, accuracy, representativeness, completeness, comparability and sensitivity
QAPP	quality assurance project plan
RPD	relative percent difference
SDG	sample delivery group
SSFL	Santa Susana Field Laboratory
VOC	volatile organic compound

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SECTION 1

Introduction

The objective of this data usability assessment report is to assess the data quality of analytical results for groundwater, rock core, and soil vapor samples collected during the bedrock vapor extraction (BVE) treatability study activities at the National Aeronautics and Space Administration (NASA) Santa Susana Field Laboratory (SSFL) in Ventura County, California. Samples were collected in accordance with the *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan* (NASA, 2014a) and the BVE Technical Memorandum (NASA, 2014b). Samples were analyzed to provide additional data to supplement the BVE treatability study.

Individual method requirements and guidelines from the *Quality Assurance Project Plan, SSFL RFI Surficial Media Operable Unit, Revision 5* (SSFL QAPP) (MEC^{X}, 2013) were used in this assessment. The SSFL QAPP includes the quality assurance/quality control procedures to confirm the quality of field and laboratory data and to evaluate that project work meets the data quality objectives for the intended use of the data for NASA SSFL. This report is intended as a general data quality evaluation designed to summarize data issues and to provide an overall data usability assessment.

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SECTION 2
Analytical Data

This data usability assessment report covers 61 environmental soil gas samples, 30 environmental rock core and 2 rock core field duplicate (FD) samples, 2 environmental groundwater samples, 6 field equipment blanks, and 5 trip blanks. These samples were reported under 18 sample delivery groups (SDGs) by the laboratories. Samples were collected between July 14 and October 23, 2014. A total of four methods were used to analyze the environmental samples and are listed in Table N-1. The analyses were performed by Agriculture & Priority Pollutants Laboratories, Inc. (APPL) in Clovis, California; ALS Environmental (under subcontract to EMAX Laboratories, Inc [EMXT]) in Simi Valley, California (CASS); Eurofins Calscience Laboratories in Garden Grove, California (CEL); EMXT in Torrance, California; and Environmental Support Technologies (ESTI), an onsite mobile laboratory. Samples were collected and delivered by laboratory courier or overnight carrier to the laboratories. Selected samples were analyzed for one or more of the methods presented in Table N-1.

TABLE N-1
Analytical Parameters by Laboratory
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report,
NASA Santa Susana Field Laboratory, Ventura County, California

Parameter	Method	Laboratory
Fixed Gases	E3C	CASS
VOCs	SW8260B	CEL; EMXT; ESTI
1,4-Dioxane	SW8260B-SIM	APPL
VOCs (soil vapor)	TO15	CASS

Parameter Notes:
VOC = volatile organic compound

Laboratory Notes:
APPL = Agriculture & Priority Pollutants Laboratories, Inc.
CASS = ALS Environmental
CEL = Eurofins Calscience Laboratories
EMXT = EMAX Laboratories, Inc
ESTI = Environmental Support Technologies

The chains of custody and case narratives associated with each of the laboratory SDGs are included in the laboratory data summary reports provided in Attachment A. The data validation reports associated with each of these SDGs are provided in Attachment B.

One hundred percent of the data was evaluated on an SDG-by-SDG basis by CH2M HILL, Inc. chemists for data quality using Level V validation, as specified in the SSFL QAPP (MEC^{X}, 2013). The data evaluation included a review of: (1) chain-of-custody documentation; (2) holding-time compliance; (3) required quality control samples at the specified frequencies; (4) flagging for analytical blanks; (5) laboratory control sample/laboratory control sample duplicates (LCS/LCSDs); (6) surrogate spike recoveries for organic analyses; (7) matrix spike/matrix spike duplicate (MS/MSD) recoveries; and (8) other method-specific criteria as defined by the SSFL QAPP.

Field samples were also reviewed to ascertain field compliance and data quality issues. This included a review of field blanks and FDs.

Data flags were assigned according to the SSFL QAPP (MEC^{X}, 2013). These flags, as well as the reason for each flag, are uploaded into the NASA electronic database and are included in the data validation summary reports (provided in Attachment B). Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but there will be only one final flag. A final flag is applied to the data and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts. The data flags are those listed in the SSFL QAPP and are defined as follows:

- J = Analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (estimated).
- R = Data are unusable. The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.
- U = Analyte was analyzed for but not detected above the reported sample quantitation limit, or this analyte was considered not detected due to laboratory or field blank contamination.
- UJ = Analyte was analyzed for but not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
- N = Analysis indicates the presence of an analyte that has been “tentatively identified” and the associated numerical value represents its approximate concentration.

SECTION 3
Findings

The overall summaries of the data validation findings are outlined in the following sections. Specific analyte results and samples that were qualified are discussed in the data validation summary reports (Attachment B).

3.1 Calibration

Level V validation, as defined in the SSFL QAPP (MEC^X, 2013), does not include review of initial or continuing calibration information. The laboratories did not report any criteria exceedances in the case narrative.

3.2 Holding Times

Analytical holding times were evaluated against the criteria listed in Table 5-1 of the SSFL QAPP (MEC^X, 2013). For methods requiring both sample preparation and analysis, the preparation/extraction holding time will be calculated from the time of sampling to the initiation of preparation/extraction. The analysis holding time will be calculated from the time of completion of preparation/extraction to the time of completion of the analysis, including any required dilutions, confirmation analysis, and reanalysis. For methods requiring analysis only, the holding time is calculated from the time of sampling to completion of the analysis, including any required dilutions, confirmation analysis, and reanalysis. Holding times were met for all analytical methods.

3.3 Analytical Blanks

Analytical blanks are used to monitor each preparation and/or analytical batch for interference and/or contamination from glassware, reagents, and other potential contaminant sources within the laboratory. A method blank (that is, analytical blank) is an analyte-free matrix (laboratory reagent water for aqueous samples; humidified zero air for air samples) to which all reagents are added in the same amount or proportions as are added to samples. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. At least one method blank is prepared for each analytical batch of 20 samples or fewer.

Method blanks were analyzed at the required frequency and were free of contamination that would affect the sample results.

3.4 Field Blanks

Field blanks (ambient blanks) and equipment rinsate blanks are collected to monitor interference and/or contamination from potential sources associated with field collection activities. One ambient blank is collected during each soil vapor sampling event to evaluate the ambient air conditions. One equipment rinsate blank is collected each day for nondedicated sampling equipment being used onsite for which site samples are being collected for laboratory analysis. For sample locations where the monitoring well has an associated dedicated pump, collection of an equipment rinsate blank is not necessary. The equipment rinsate blank is passed over the sampling equipment following all decontamination procedures.

Ambient blanks and equipment rinsate blanks were collected and analyzed at the required frequency, and were free of contamination that would affect the sample results.

3.5 Trip Blanks

Trip blanks are used to monitor for cross-contamination of VOC samples during sample shipping and handling of aqueous (that is, groundwater) samples. One trip blank was placed in each sample cooler containing aqueous field samples for VOC analyses. Trip blanks are supplied by the fixed laboratory doing the analysis. The trip blanks were submitted and analyzed for VOC analyses only.

The trip blanks were collected and analyzed at the required frequency and were free of contamination that would affect the sample results.

3.6 Field Duplicates

An FD, or collocated sample, is an independent sample collected as close as possible to the original sample from the same source under identical conditions. FDs are to be collected in the field for 5% or more of the samples collected for analysis during each sampling event, by matrix and method, and are used to document sampling and analytical precision and representativeness. Precision is expressed in terms of the relative percent difference (RPD) between the native and FD sample results. The RPD criterion for FDs for soil vapor samples is 50%. Qualification is performed on the native sample and associated FD results in accordance with the SSFL QAPP (MEC^{X}, 2013).

FDs were collected and analyzed at the required frequency and precision criteria were generally acceptable, with the exceptions listed in Table N-2.

TABLE N-2
Primary/Field Duplicate Qualification Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report,
NASA Santa Susana Field Laboratory, Ventura County, California

Method	Number of Primary/FD Pairs	Number of Primary/FD Results	Number of Results Flagged as Estimated Detect/ Nondetect as a Result of FD Precision Exceptions		Percentage of Qualified Results
			J Flag	UJ Flag	
SW8260B VOC	2	284	4	0	1%

FD = field duplicate
VOC = volatile organic compound

Data qualification flags were applied to the individual results as indicated in Table N-2. Four detected results were qualified as estimated and flagged “J.” Sample results that have been qualified as estimated due to precision criteria are usable for project decisions; however, data users should consider the impact to any result that is qualified as estimated (“J”) because it may contain a bias and should be accounted for during the decision-making process.

3.7 Matrix Spike Samples

A sample matrix fortified with known quantities of specific compounds is called a “matrix spike” and is subjected to the same preparation and analytical procedures as the native sample. The results of MS/MSD analyses provide information about the possible influence of the matrix on either the accuracy or precision of the measurements. Samples used for MS/MSD analysis were either collected in the field for 5% of the samples collected for analysis during each sampling event, by matrix and method, or were reported by the laboratory as part of their analytical batch requirements. Qualification of sample results due to MS/MSD recovery or precision exceedances was performed on the parent sample only for organic methods in accordance with the SSFL QAPP (MEC^{X}, 2013). Accuracy and precision criteria are listed in Table 6-1 of the SSFL QAPP.

Accuracy and precision limits were generally met, with the exceptions listed in Table N-3.

TABLE N-3
Matrix Spike/Matrix Spike Duplicate Qualification Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report,
NASA Santa Susana Field Laboratory, Ventura County, California

Method	Number of Native/MS/MSD Pairs	Number of Associated Native Sample Results	Number of Results Flagged as Estimated Detect or Nondetect as a Result of MS/MSD Recovery and/or Precision Exceptions		Number of Results Flagged as Rejected as a Result of MS/MSD Recovery Exceptions	Percentage of Qualified Results
			J Flag	UJ Flag	R Flag	
SW8260B VOC	1	63	0	1	0	2%
SW8260B-SIM 1,4-Dioxane	1	1	1	0	0	100%
Totals	**2**	**64**	**1**	**1**	**0**	**--**

MS = matrix spike
MSD = matrix spike duplicate
VOC = volatile organic compound

Data qualification flags were applied to the individual results as indicated in Table N-3. One detected result was qualified as estimated and flagged "J," and one nondetected result was qualified as estimated and flagged "UJ." Sample results that have been qualified as estimated due to accuracy or precision criteria are usable for project decisions; however, data users should consider the impact to any result that is qualified as estimated ("J") because it may contain a bias and should be accounted for during the decision-making process.

3.8 Surrogates

Surrogates are organic analytes that behave similarly as the analytes of interest, or have been chemically altered (that is, chemically deuterated), but are not expected to occur naturally in the samples. They are spiked into the standards, field samples, and laboratory quality control samples prior to sample preparation. The results of surrogate spikes provide additional information about the possible influence of the matrix on the accuracy of the measurements for organic analyses only. Accuracy criteria are listed in Table B-IV of the SSFL QAPP (MEC^{X}, 2013).

Accuracy limits were generally met, with the exceptions listed in Table N-4.

TABLE N-4
Surrogate Spike Qualification Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report,
NASA Santa Susana Field Laboratory, Ventura County, California

Method	Number of Samples	Number of Results	Number of Results Flagged as Estimated Detect or Nondetect as a Result of Surrogate Recovery Exceptions		Number of Results Flagged as Rejected as a result of Surrogate Recovery Exceptions	Percentage of Qualified Results
			J Flag	UJ Flag	R Flag	
SW8260B VOC	32	2,271	0	6	0	<1%

VOC = volatile organic compound

Data qualification flags were applied to the individual results as indicated in Table N-4. Six nondetected results were qualified as estimated and flagged "UJ." Sample results that have been qualified as estimated due to accuracy or precision criteria are usable for project decisions; however, data users should consider the impact to any result that is qualified as estimated ("J") because it may contain a bias and should be accounted for during the decision-making process.

3.9 Laboratory Control Samples

LCSs are used to monitor method performance for a specific analyte in each matrix. An LCS is an analyte-free matrix (laboratory reagent water for aqueous samples or humified zero air for air samples) spiked with known amounts of analytes that come from a source different than that used for calibration standards. Target analytes specified in the SSFL QAPP (MEC^{X}, 2013) will be spiked into the LCS. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. At least one LCS is prepared for each analytical batch of 20 samples or fewer. Accuracy and precision criteria are listed in Table 6-1 of the SSFL QAPP.

LCSs and LCSDs were analyzed at the required frequency. Accuracy and precision limits were generally met, with the exceptions listed in Table N-5.

TABLE N-5
Laboratory Control Sample Qualification Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report,
NASA Santa Susana Field Laboratory, Ventura County, California

			Number of Results Flagged as Estimated Detect or Nondetect as a Result of LCS Recovery and/or Precision Exceptions		Number of Results Flagged as Rejected as a Result of LCS Recovery Exceptions	
Method	**Number of Samples**	**Number of Results**	**J Flag**	**UJ Flag**	**R Flag**	**Percentage of Qualified Results**
SW8260B VOCs	2	134	1	2	0	2%

LCS = laboratory control sample
VOC = volatile organic compound

Data qualification flags were applied to the individual results as indicated in Table N-5. One detected result was qualified as estimated and flagged "J," and two nondetected results were qualified as estimated and flagged "UJ." Sample results that have been qualified as estimated due to accuracy or precision criteria are usable for project decisions; however, data users should consider the impact to any result that is qualified as estimated ("J") because it may contain a bias and should be accounted for during the decision-making process.

3.10 Laboratory Duplicates

A laboratory duplicate is a separate sample aliquot that is subjected to the same preparation and analytical procedures as the native sample. Laboratory duplicates were analyzed to measure the precision of sample results reported as required by the analytical method. Precision is expressed in terms of the RPD between the native and laboratory duplicate sample results. The RPD criterion for laboratory duplicates is 20%.

Laboratory duplicates were analyzed at the required frequency, and precision criteria were generally acceptable, with the exceptions listed in Table N-6.

TABLE N-6
Primary/Laboratory Duplicate Qualification Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report, NASA Santa Susana Field Laboratory, Ventura County, California

Method	Number of Primary/Laboratory Duplicate Pairs	Number of Primary/Laboratory Duplicate Results	Number of Results Flagged as Estimated Detect/Nondetect as a Result of FD Precision Exceptions		Percentage of Qualified Results
			J Flag	UJ Flag	
SW8260B VOC	6	144	2	0	1%

VOC = volatile organic compound

Data qualification flags were applied to the individual results as indicated in Table N-6. Two detected results were qualified as estimated and flagged "J." Sample results that have been qualified as estimated due to precision criteria are usable for project decisions; however, data users should consider the impact to any result that is qualified as estimated ("J") because it may contain a bias and should be accounted for during the decision-making process.

3.11 Tentatively Identified Compounds

Tentatively identified compounds were not evaluated for any samples reported at this site.

3.12 Other

All aqueous VOC samples were collected in hydrochloric-acid-preserved containers, which rapidly decomposes 2-chloroethylvinyl ether (2-CLEVE). Therefore, the presence or absence of this compound in the samples could not be verified, and one sample result for 2-CLEVE was rejected. However, 2-CLEVE is not considered an environmental driver for this project (that is, TCE and its daughter products are the primary environmental drivers for VOCs), so this does not significantly impact the overall data quality.

3.13 Chain of Custody

No discrepancies were noted. Chains of custody are provided in the laboratory data summary reports included in Attachment A.

3.14 Overall Assessment

The final activity in the data quality evaluation is an assessment of whether the data meet the data quality objectives. The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected, and the resulting analytical data can be used to support the decision-making process. The precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) are addressed in the SSFL QAPP (MEC^X, 2013). The following summary highlights the data evaluation findings for the previously defined events:

- **Precision** of the data was verified through the review of the field and laboratory data quality indicators that include FD, LCS/LCSD, MS/MSD, and laboratory duplicate RPDs. Precision was generally acceptable, with the exception of a couple of analytical results that were qualified as estimated due to FD or laboratory duplicate RPD issues. Overall, six results out of approximately 3,890 total results (approximately 0.2%) were qualified for precision exceptions.
- **Accuracy** of the data was verified through the review of the LCS, MS/MSD, and surrogate standard recoveries, as well as the evaluation of the method blank/field blank data. Accuracy was generally acceptable, with the exception of some analytical results being qualified as estimated detected and

nondetected results due to LCS, MS/MSD, or surrogate recovery issues. Overall, nine results out of approximately 3,890 total results (approximately 0.2%) were qualified for accuracy exceptions. Analytical/field blank data were free of contamination.

- **Representativeness** of the data was verified through the sample's collection, storage, and the verification of holding-time compliance. There were no issues related to storage or collection of field samples, and all data were reported from analyses within the U.S. Environmental Protection Agency (EPA)-recommended holding times.
- **Completeness** is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. Completeness is expressed as the percentage of valid or usable measurements compared to planned measurements. Valid data are defined as data that are not rejected for project use. The completeness goal of 90% was met for all analytes and methods, as indicated in Table N-7, with the exception of 2-CLEVE. Adequate data could not be obtained for this compound.
- **Comparability** of the data was verified through the use of standard EPA analytical procedures and standard units for reporting. Results obtained are comparable to industry standards in that the collection and analytical techniques followed approved, documented procedures.
- **Sensitivity** is a measurement based on the analytical instrument method reporting limits (MRLs) determined by each subcontract laboratory. The analytical reporting limits were determined based upon the completion of instrument-specific method detection limit (MDL) studies performed annually in accordance with the *Code of Federal Regulations*, Title 40, Part 136, Appendix B (EPA, 1984). The MRLs are generally established by multiplying the MDL by a factor of three to five as recommended by generally accepted laboratory practice and is further supported by the lowest-level analytical standard in the initial calibration process. Sensitivity is ensured through compliance with the MRLs specified in the SSFL QAPP (MEC^X, 2013). Any nondetect results that were reported by the laboratory, or that were flagged nondetect due to blank contamination, have been evaluated against the project screening levels as discussed in the work plan.

Evaluation of 100% of the chemical data was performed by using the SSFL QAPP (MEC^X, 2013) as a guide for data quality evaluation. The overall completeness was met, and with the exception of the improperly preserved sample containers for 2-CLEVE, no other systematic protocol errors were identified during the monitoring of the field or laboratory efforts. This along with the PARCCS evaluation demonstrate that the overall quality of the analytical program and laboratory are sufficient to meet the project data quality objectives.

TABLE N-7
Site Completeness Summary
Bravo Bedrock Vapor Extraction Treatability Study Data Usability Assessment Report, NASA Santa Susana Field Laboratory, Ventura County, California

Method	Total Number of Samples[a]	Total Number of Results	Number of Qualified Results as Nondetect[b]		Number of Qualified Results as Estimated[c]		Number of Qualified Results as Rejected[d]		Percent Completeness	
			Number	%	Number	%	Number	%	Number	%[e]
Groundwater										
SW8260B VOCs	2	134	0	0.0	2	1.5	1	0.7	133	99.3
SW8260B-SIM 1,4-Dioxane	1	1	0	0.0	1	100.0	0	0.0	1	100.0
Rock Core										
SW8260B VOCs	32	2,272	0	0	10	0.4	0	0.0	2,272	100.0
Soil Vapor										
E3C Fixed Gases	3	18	0	0.0	0	0.0	0	0.0	18	100.0
SW8260B VOCs	53	1,272	0	0.0	2	0.2	0	0.0	1,272	100.0
TO-15 VOCs	8	192	0	0.0	0	0.0	0	0.0	192	100.0

[a] Includes FD and normal samples.
[b] Results flagged U.
[c] Results flagged J or UJ.
[d] Results flagged R.
[e] % Complete = (reported results-unusable results]/reported results)*100.
VOC = volatile organic compound

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SECTION 4
References

MEC[X], LP. 2013. *Quality Assurance Project Plan, SSFL RFI Surficial Media Operable Unit, Revision 5*. March.

National Aeronautics and Space Administration (NASA). 2014a. *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan*. Santa Susana Field Laboratory, Ventura County, California. July.

National Aeronautics and Space Administration (NASA). 2014b. *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Technical Memorandum.* Santa Susana Field Laboratory, Ventura County, California. March.

U.S. Environmental Protection Agency (EPA). 1984. *Guidelines Establishing Test Procedures for the Analysis of Pollutants.* Code of Federal Regulations. Title 40, Part 136, Appendix B. Government Printing Office. Washington, DC. March.

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Attachment A
Data Summary Reports

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September 02, 2014

Olivia Edwards

CH2M HILL, Inc.

6 Hutton Center Drive, Suite 700

Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 08/26/14 20:56. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores

Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

CH2M HILL, Inc. 6 Hutton Center Drive, Suite 700 Santa Ana, California 92707	Project: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA. Project Number: EST2722 Project Manager: Olivia Edwards	**Reported:** 02-Sep-14 13:46

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Analyzed
Equipment Blank	3H42601-01	Air	26-Aug-14 10:10	26-Aug-14 10:25
PZ-203D-SV-S001	3H42601-02	Air	26-Aug-14 15:56	26-Aug-14 16:47
PZ-204C-SV-S001	3H42601-03	Air	26-Aug-14 17:10	26-Aug-14 17:47

16510 Aston Street, Irvine, California 92606
Telephone: (949) 679-9500 Fax: (949) 679-9501

Notes and Definitions

QR-04	The RPD result for this analyte in the sample exceeded the QC control limits; however, the RPD for other analytes were within the QC control limits.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

16510 Aston Street, Irvine, California 92606
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SOIL GAS SURVEY
CH2M HILL: BOEING SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CA

LEVEL IV DATA PACKAGE

CH2M HILL
6 HUTTON CENTER DRIVE
SUITE 700
SANTA ANA, CA

EST2722
September 2, 2014

ENVIRONMENTAL SUPPORT TECHNOLOGIES

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CHAIN-OF-CUSTODY RECORD

Environmental Support Technologies
16510 Aston St., Irvine, CA 92606 · Tel (949) 679-9500 · Fax (949) 679-9501

Client: CH2M HILL
Address: 6 Hutton Center Drive
Santa Ana, Ca 92707
Project Manager: Olivia Edwards

Sampler Name: J & H
EST Project#: **EST2722**
Custody Seals:
Site Location: SSFL BOEING SITE
Phone: ( )
Email:
Page: of

Turnaround Time:
(Check one)
Normal:
Rush: X

Sample Receipt
Intact: Yes: X No:
On Ice: Yes: No: X N/A
Custody Seals: Yes: No: X
N/A (Received on Site):

Sample Name	Sample Matrix	Container Type	# of Container	Sampling Date	Sampling Time	Preservative Type	Purge Volume (ml)	Vacuum (inches of H_2O)	8260B VOC's						Special Instructions
Equipment Blank	Air	Glass Bulb	1	9/2/2014	820	Surr			X						Bulb # 4
PZ-203D-SV-S002	Air	Glass Bulb	1	9/2/2014	713	Surr			X						Bulb # 9
PZ-202A-SV-S002	Air	Glass Bulb	1	9/2/2014	743	Surr			X						Bulb # 2
PZ-204D-SV-S002	Air	Glass Bulb	1	9/2/2014	807	Surr			X						Bulb # 1
PZ-201C-SV-S002	Air	Glass Bulb	1	9/2/2014	834	Surr			X						Bulb # 3
PZ-203C-SV-S002	Air	Glass Bulb	1	9/2/2014	1006	Surr			X						Bulb # 7
PZ-203V-SV-S002	Air	Glass Bulb	1	9/2/2014	1047	Surr			X						Bulb # 8
PZ-20~~3~~ 2 AF C-SV-S002	Air	Glass Bulb	1	9/2/2014	1125	Surr			X						Bulb # 11
PZ-156-SV-S002	Air	Glass Bulb	1	9/2/2014	1207	Surr			X						Bulb # 12
HAR-19-SV-S002	Air	Glass Bulb	1	9/2/2014	1328	Surr			X						Bulb # 13
PZ-201B-SV-S002	Air	Glass Bulb	1	9/2/2014	845	Surr			X						Bulb # 5
PZ-204A-SV-S002	Air	Glass Bulb	1	9/2/2014	927	Surr			X						Bulb # 10

Relinquished by: (Signature) [signature] Date/Time: 09/02/14 Received by: Date/Time:

Relinquished by: (Signature) Date/Time: Received by: Date/Time:

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October 09, 2014

Olivia Edwards
CH2M HILL, Inc.
6 Hutton Center Drive, Suite 700
Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 09/02/14 17:25. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores
Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

16510 Aston Street, Irvine, California 92606
Telephone: (949) 679-9500 Fax: (949) 679-9501

CH2M HILL, Inc. 6 Hutton Center Drive, Suite 700 Santa Ana, California 92707	Project: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA. Project Number: EST2722 Project Manager: Olivia Edwards	**Reported:** 09-Oct-14 09:27

Notes and Definitions

J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

SOIL GAS SURVEY
CH2M HILL: BOEING SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CA

LEVEL IV DATA PACKAGE

CH2M HILL
6 HUTTON CENTER DRIVE
SUITE 700
SANTA ANA, CA

EST2722
September 5, 2014

EST
ENVIRONMENTAL SUPPORT TECHNOLOGIES

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CHAIN-OF-CUSTODY RECORD

Environmental Support Technologies
16510 Aston St., Irvine, CA 92606 · Tel (949) 679-9500 · Fax (949) 679-9501

Client: CH2M HILL
Address: 6 Hutton Center Drive
Santa Ana, Ca 92707
Project Manager: Olivia Edwards

Sampler Name: J & H
EST Project#: EST2722
Site Location: SSFL BOEING SITE
Phone: ( )
Page: of
Custody Seals:
Email:

Turnaround Time: (Check one)
Normal:
Rush: X

Sample Receipt
Intact: Yes: X No:
On Ice: Yes: No: X N/A
Custody Seals: Yes: No: X
N/A (Received on Site):

Sample Name	Sample Matrix	Container Type	# of Container	Sampling Date	Sampling Time	Preservative Type	Purge Volume (ml)	Vacuum (inches of H_2O)	8260B VOC's						Special Instructions
Equipment Blank	Air	Glass Bulb	1	9/5/2014	835	Surr			X						Bulb # 9
PZ-203D-SV-S003	Air	Glass Bulb	1	9/5/2014	744	Surr			X						Bulb # 13
PZ-202A-SV-S003	Air	Glass Bulb	1	9/5/2014	840	Surr			X						Bulb # 4
PZ-202D-SV-S003	Air	Glass Bulb	1	9/5/2014	845	Surr			X						Bulb # 1
PZ-204D-SV-S003	Air	Glass Bulb	1	9/5/2014	927	Surr			X						Bulb # 5
PZ-204C-SV-S003	Air	Glass Bulb	1	9/5/2014	932	Surr			X						Bulb # 3
PZ-201B-SV-S003	Air	Glass Bulb	1	9/5/2014	1026	Surr			X						Bulb # 11
PZ-203C-SV-S003	Air	Glass Bulb	1	9/5/2014	1037	Surr			X						Bulb # 12
PZ-061-SV-S003	Air	Glass Bulb	1	9/5/2014	1058	Surr			X						Bulb # 2
PZ-156-SV-S003	Air	Glass Bulb	1	9/5/2014	1122	Surr			X						Bulb # 7
HAR-19-DISCHARGE	Air	Glass Bulb	1	9/5/2014	1355	Surr			X						Bulb # 10

Relinquished by: (Signature) [signature] Date/Time: 09/05/14 Received by: Date/Time:

Relinquished by: (Signature) Date/Time: Received by: Date/Time:

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October 09, 2014

Olivia Edwards

CH2M HILL, Inc.

6 Hutton Center Drive, Suite 700

Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 09/05/14 17:22. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores

Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

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CH2M HILL, Inc. 6 Hutton Center Drive, Suite 700 Santa Ana, California 92707	Project: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA. Project Number: EST2722 Project Manager: Olivia Edwards	**Reported:** 09-Oct-14 09:54

Notes and Definitions

J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

16510 Aston Street, Irvine, California 92606
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SOIL GAS SURVEY
CH2M HILL: BOEING SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CA

LEVEL IV DATA PACKAGE

CH2M HILL
6 HUTTON CENTER DRIVE
SUITE 700
SANTA ANA, CA

EST2722
September 8, 2014

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ENVIRONMENTAL SUPPORT TECHNOLOGIES

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CHAIN-OF-CUSTODY RECORD

Environmental Support Technologies
16510 Aston St., Irvine, CA 92606 · Tel (949) 679-9500 · Fax (949) 679-9501

Client: CH2M HILL
Address: 6 Hutton Center Drive
Santa Ana, Ca 92707
Project Manager: Olivia Edwards

Sampler Name: J & H
Page: of
EST Project#: EST2722
Custody Seals:
Site Location: SSFL BOEING SITE
Phone: ( )
Email:

Turnaround Time: (Check one)
Normal:
Rush: X

Sample Receipt
Intact: Yes: X No:
On Ice: Yes: No: X N/A
Custody Seals: Yes: No: X
N/A (Received on Site):

Sample Name	Sample Matrix	Container Type	# of Container	Sampling Date	Sampling Time	Preservative Type	Purge Volume (ml)	Vacuum (inches of H_2O)	8260B VOC's						Special Instructions
Equipment Blank	Air	Glass Bulb	1	9/8/2014	845	Surr			X						Bulb # 10
PZ-203D-SV-S004	Air	Glass Bulb	1	9/8/2014	753	Surr			X						Bulb # 12
PZ-203V-SV-S004	Air	Glass Bulb	1	9/8/2014	800	Surr			X						Bulb # 5
PZ-202C-SV-S004	Air	Glass Bulb	1	9/8/2014	840	Surr			X						Bulb # 11
PZ-202D-SV-S004	Air	Glass Bulb	1	9/8/2014	844	Surr			X						Bulb # 2
PZ-204D-SV-S004	Air	Glass Bulb	1	9/8/2014	926	Surr			X						Bulb # 3
PZ-204C-SV-S004	Air	Glass Bulb	1	9/8/2014	929	Surr			X						Bulb # 9
PZ-201D-SV-S004	Air	Glass Bulb	1	9/8/2014	1009	Surr			X						Bulb # 7
PZ-201B-SV-S004	Air	Glass Bulb	1	9/8/2014	1012	Surr			X						Bulb # 4
RD-104-SV-S004	Air	Glass Bulb	1	9/8/2014	1127	Surr			X						Bulb # 8
HAR-19-SV-S004	Air	Glass Bulb	1	9/8/2014	1249	Surr			X						Bulb # 1

Relinquished by: (Signature) [signature] Date/Time: 09/08/14 Received by: Date/Time:

Relinquished by: (Signature) Date/Time: Received by: Date/Time:

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September 19, 2014

Olivia Edwards

CH2M HILL, Inc.

6 Hutton Center Drive, Suite 700

Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 09/08/14 16:41. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores

Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

16510 Aston Street, Irvine, California 92606
Telephone: (949) 679-9500   Fax: (949) 679-9501

CH2M HILL, Inc. 6 Hutton Center Drive, Suite 700 Santa Ana, California 92707	Project: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA. Project Number: EST2722 Project Manager: Olivia Edwards	**Reported:** 19-Sep-14 14:13

Notes and Definitions

J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

SOIL GAS SURVEY
CH2M HILL: BOEING SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CA

LEVEL IV DATA PACKAGE

CH2M HILL
6 HUTTON CENTER DRIVE
SUITE 700
SANTA ANA, CA

EST2722
September 12, 2014

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ENVIRONMENTAL SUPPORT TECHNOLOGIES

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CHAIN-OF-CUSTODY RECORD

Environmental Support Technologies
16510 Aston St., Irvine, CA 92606 · Tel (949) 679-9500 · Fax (949) 679-9501

Client: CH2M HILL
Address: 6 Hutton Center Drive
Santa Ana, Ca 92707
Project Manager: Olivia Edwards

Sampler Name: J & H
Page: of
EST Project#: EST2722
Custody Seals:
Site Location: SSFL BOEING SITE
Phone: ( )
Email:

Turnaround Time:
(Check one)

Normal:

Rush: X

Sample Receipt

Intact: Yes: X No:

On Ice: Yes: No: X N/A

Custody Seals: Yes: No: X

N/A (Received on Site):

Sample Name	Sample Matrix	Container Type	# of Container	Sampling Date	Sampling Time	Preservative Type	Purge Volume (ml)	Vacuum (inches of H_2O)	8260B VOC's						Special Instructions
Equipment Blank	Air	Glass Bulb	1	9/12/2014	840	Surr			X						Bulb # 13
PZ-203D-SV-S005	Air	Glass Bulb	1	9/12/2014	801	Surr			X						Bulb # 8
PZ-203C-SV-S005	Air	Glass Bulb	1	9/12/2014	804	Surr			X						Bulb # 11
PZ-202D-SV-S005	Air	Glass Bulb	1	9/12/2014	848	Surr			X						Bulb # 9
PZ-202A-SV-S005	Air	Glass Bulb	1	9/12/2014	853	Surr			X						Bulb # 1
PZ-204D-SV-S005	Air	Glass Bulb	1	9/12/2014	936	Surr			X						Bulb # 7
PZ-204C-SV-S005	Air	Glass Bulb	1	9/12/2014	939	Surr			X						Bulb # 5
PZ-156-SV-S005	Air	Glass Bulb	1	9/12/2014	1025	Surr			X						Bulb # 2
PZ-201D-SV-S005	Air	Glass Bulb	1	9/12/2014	1025	Surr			X						Bulb # 12
HAR-19-SV-S005	Air	Glass Bulb	1	9/12/2014	1112	Surr			X						Bulb # 4
PZ-061-SV-S005	Air	Glass Bulb	1	9/12/2014	1232	Surr			X						Bulb # 3

Relinquished by: (Signature) [signature] Date/Time: 09/12/14 Received by: Date/Time:

Relinquished by: (Signature) Date/Time: Received by: Date/Time:

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September 19, 2014

Olivia Edwards

CH2M HILL, Inc.

6 Hutton Center Drive, Suite 700

Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 09/12/14 20:39. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores

Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

16510 Aston Street, Irvine, California 92606
Telephone: (949) 679-9500 Fax: (949) 679-9501

Notes and Definitions

J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

SOIL GAS SURVEY
CH2M HILL: NASA SANTA SUSANA FIELD LABORATORY
5800 WOOLSEY CANYON ROAD
CANOGA PARK, CA

LEVEL IV DATA PACKAGE

CH2M HILL
6 HUTTON CENTER DRIVE
SUITE 700
SANTA ANA, CA

EST2722
October 22, 2014

EST
ENVIRONMENTAL SUPPORT TECHNOLOGIES

Table of Contents

CHAIN-OF-CUSTODY

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CHAIN-OF-CUSTODY RECORD

Environmental Support Technologies
16510 Aston St., Irvine, CA 92606 · Tel (949) 679-9500 · Fax (949) 679-9501

Client: CH2M HILL
Address: 6 Hutton Center Drive
Santa Ana, Ca 92707
Project Manager: Olivia Edwards

Sampler Name: J & H
Page: of
EST Project#: **EST2722**
Custody Seals:
Site Location: SSFL NASA SITE
Phone: ( )
Email:

Turnaround Time:
(Check one)
Normal:
Rush: X

Sample Receipt
Intact: Yes: X No:
On Ice: Yes: No: X N/A
Custody Seals: Yes: No: X
N/A (Received on Site):

Sample Name	Sample Matrix	Container Type	# of Container	Sampling Date	Sampling Time	Preservative Type	Purge Volume (ml)	Vacuum (inches of H_2O)	8260B VOC's						Special Instructions
Equipment Blank	Air	Glass Bulb	1	10/22/2014	840	Surr			X						Bulb # 2
PZ-202D-SV-S006	Air	Glass Bulb	1	10/22/2014	754	Surr			X						Bulb # 3
PZ-201D-SV-S006	Air	Glass Bulb	1	10/22/2014	838	Surr			X						Bulb # 7
PZ-201B-SV-S006	Air	Glass Bulb	1	10/22/2014	842	Surr			X						Bulb # 12
PZ-204D-SV-S006	Air	Glass Bulb	1	10/22/2014	924	Surr			X						Bulb # 1
PZ-204C-SV-S006	Air	Glass Bulb	1	10/22/2014	926	Surr			X						Bulb # 11
PZ-203D-SV-S006	Air	Glass Bulb	1	10/22/2014	1149	Surr			X						Bulb # 4
PZ-203C-SV-S006	Air	Glass Bulb	1	10/22/2014	1153	Surr			X						Bulb # 13
PZ-156-SV-S006	Air	Glass Bulb	1	10/22/2014	1247	Surr			X						Bulb # 10
HAR-19-1-SV-S006	Air	Glass Bulb	1	10/22/2014	1505	Surr			X						Bulb # 8
HAR-19-2-SV-S006	Air	Glass Bulb	1	10/22/2014	1537	Surr			X						Bulb # 9

Relinquished by: (Signature)	Date/Time: 10/22/14	Received by:	Date/Time:
Relinquished by: (Signature)	Date/Time:	Received by:	Date/Time:

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October 24, 2014

Olivia Edwards
CH2M HILL, Inc.
6 Hutton Center Drive, Suite 700
Santa Ana, California 92707

RE: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.

Enclosed are the results of analyses for soil gas samples received by Environmental Support Technologies laboratory on 10/22/14 16:50. The analyses were performed according to the prescribed method as outlined by EPA 8260B. A shut in test was performed, leak test was performed, equipment blank was run, and selected purge volume was 3PV. If you have any questions concerning this report, please feel free to contact Project Manager.

Sincerely,

Ashley Flores

Ashley Flores
Project Manager

Environmental Support Technologies laboratories are certified by the California Department of Health Services (CDHS), Environmental Laboratory Accreditation Program (ELAP) No's. 2772, 2773, and 2767.

CH2M HILL, Inc.	Project: SSFL 5800 Woolsey Canyon Rd. Canoga Park, CA.	
6 Hutton Center Drive, Suite 700	Project Number: EST2722	**Reported:**
Santa Ana, California 92707	Project Manager: Olivia Edwards	24-Oct-14 09:37

Notes and Definitions

J	Detected but below the Reporting Limit; therefore, result is an estimated concentration (CLP J-Flag).
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 10-14-2014
EMAX Batch No.: 14G152

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: SSFL ROCK SAMPLES

Enclosed is the Laboratory report for samples received on 07/23/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
PZ203RCS001	G152-01	07/17/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS002	G152-02	07/17/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS003	G152-03	07/17/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS004	G152-04	07/18/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS005	G152-05	07/18/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS006	G152-06	07/18/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
CAQWZ022S001	G152-07	07/22/14	WATER	VOLATILE ORGANICS BY GC/MS VOC SIM

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

14G152

Chain of Custody Record

COC Number: **072214E**

CH2MHILL 7/22/2014 3:56:15 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
1	**PZ203RCS001**	17-Jul-14	13:55	N	Soil			
	Rock Core - CH 499 VOC List			Field Filtered ☐		1	4'C	☑
					Total Containers:	1		
2	**PZ203RCS002**	17-Jul-14	14:20	N	Soil			
	Rock Core - CH 499 VOC List			Field Filtered ☐		1	4'C	☑
					Total Containers:	1		
3	**PZ203RCS003**	17-Jul-14	17:20	N	Soil			
	Rock Core - CH 499 VOC List			Field Filtered ☐		1	4'C	☑
					Total Containers:	1		
4	**PZ203RCS004**	18-Jul-14	11:00	N	Soil			
	Rock Core - CH 499 VOC List			Field Filtered ☐		1	4'C	☑
					Total Containers:	1		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/22/14
Received by	FedEx	7/22/14
Relinquished by		
Received by	EMAX [signature]	7/23/14 09:15

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no (yes circled)
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

Temp - 2.5°C

1001

14G152

Chain of Custody Record

COC Number: **072214E**

CH2MHILL *7/22/2014 3:56:15 PM*

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
5	**PZ203RCS005**	18-Jul-14	15:05	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AL	4'C	☑
					Total Containers:	~~3~~ 1 AL		
6	**PZ203RCS006**	18-Jul-14	16:20	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AL	4'C	☑
					Total Containers:	~~3~~ 1 AL		

⑦ CAQW2022500 / 7/22/14 / 0700 / TB / H_2O / for SW8260B 3 containers

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/22/14
Relinquished by		
Received by	FedEx	7/22/14
Relinquished by		
Received by	EMAX [signature]	7/23/14 09:15

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

SAMPLE RECEIPT FORM 1 Reference Number: SM02.7.2

Type of Delivery	Airbill / Tracking Number	ECN 14G152	
☑ Fedex ☐ UPS ☐ GSO ☐ Others	7800 4727 8409	Recipient Maung	
☐ EMAX Courier ☐ Client Delivery		Date 7/23/14	Time 09:15

COC INSPECTION

☑ Client Name ☑ Client PM/FC ☐ Sampler Name ☑ Sampling Date/Time ☑ Sample ID ☑ Matrix
☐ Address ☑ Tel # / Fax # ☐ Courier Signature ☑ Analysis Required ☐ Preservative (if any) ☑ TAT
Safety Issues (if any) ☐ High concentrations expected ☐ From Superfund Site ☐ Rad screening required
Note:

PACKAGING INSPECTION

Container	☑ Cooler	☐ Box	☐ Other		
Condition	☑ Custody Seal	☑ Intact	☐ Damaged		
Packaging	☑ Bubble Pack	☐ Styrofoam	☐ Popcorn	☑ Sufficient	☑ Plastic Bag
Temperatures	☑ Cooler 1 2-5 °C	☐ Cooler 2 ___ °C	☐ Cooler 3 ___ °C	☐ Cooler 4 ___ °C	☐ Cooler 5 ___ °C
(Cool, ≤6 °C but not frozen)	☐ Cooler 6 ___ °C	☐ Cooler 7 ___ °C	☐ Cooler 8 ___ °C	☐ Cooler 9 ___ °C	☐ Cooler 10 ___ °C
Thermometer:	*(A) S/N 130538505*	*B - S/N 101541382*	*C - S/N 122091701*	*D - S/N 122091758*	

Comments: ☐ **Temperature is out of range. PM was informed IMMEDIATELY.**
Note:

DISCREPANCIES

LabSampleID	LabSampleContainerID	Code	ClientSample Label ID / Information	Corrective Action
1-6	1-6	D10		R8
7	7-9	D16	Label preserved w/HCL	R8

7/23/14 YM 7/25/14

☐ pH holding time requirement for water samples is 15 mins. Water samples for pH analysis are received beyond 15 minutes from sampling time.

NOTES/OBSERVATIONS: Depth is not detailed in the COC.

LEGEND: ☐ **Continue to next page.**

Code	Description- Sample Management	Code	Description-Sample Management	Code	Description-Sample Management
D1	Analysis is not indicated in ______	D13	Out of Holding Time	R1	Proceed as indicated in ☐ COC ☐ Label
D2	Analysis mismatch COC vs label	D14	Bubble is >6mm	R2	Refer to attached instruction
D3	Sample ID mismatch COC vs label	D15	No trip blank in cooler	R3	Cancel the analysis
D4	Sample ID is not indicated in ______	(D16)	Preservation not indicated in COC	R4	Use vial with smallest bubble first
D5	Container -[improper] [leaking] [broken]	D17	Preservation mismatch COC vs label	R5	Log-in with latest sampling date and time+1 min
D6	Date/Time is not indicated in ______	D18	Insufficient chemical preservative	R6	Adjust pH as necessary
D7	Date/Time mismatch COC vs label	D19	Insufficient Sample	R7	Filter and preserved as necessary
D8	Sample listed in COC is not received	D20	No filtration info for dissolved analysis	R8	Inform client
D9	Sample received is not listed in COC	D21	No sample for moisture determination	R9	
D10 ✓	No initial/date on corrections in COC (label)	D22		R10	
D11	Container count mismatch COC vs received	D23		R11	
D12	Container size mismatch COC vs received	D24		R12	

REVIEWS:

Sample Labeling MCM **SRF** [signature] **PM** [signature]
Date 7/23/14 7/23/14 **Date** 7/23/14 **Date** 7/25/14

Ye Myint

From: Mark.Fesler@CH2M.com
Sent: Monday, September 22, 2014 2:19 PM
To: Ye Myint
Subject: RE: Rock Samples: SDGs - 14G152 and 14G180

Ye:

Report both the original analysis and re-analysis for carbon tet. Narrate the missed HT in case narrative.

Thanks for the heads up

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 22, 2014 2:04 PM
To: Fesler, Mark/RDD
Cc: Linh Pham
Subject: Rock Samples: SDGs - 14G152 and 14G180

Hello Mark,

I called earlier to notify you about these samples. But you might have been on another line and I did not leave a message to call back. During the final review process for 14G152 and 14G180, it was discovered that carbon tetrachloride was inadvertently missed in the ICAL (8260SIM) used for the analysis of samples from these two SDGs. I regret to notify you also that HT for the two SDGs has already exceeded by 5 days.

The lab will reanalyze the affected samples to include carbon tetrachloride by 8260SIM method, and we will narrate the HT discrepancy in the final data package. Please be informed that only the missing analyte will be evaluated and reported from the re-analysis. Carbon tetrachloride was not detected in the samples by regular 8260B method (MDL : 1 ppb). If it's an option to report the missing analyte from the regular 8260B scan instead of 8260SIM, we can also do so without the HT issue.

I apologize for any inconvenience this has caused you. Please let me know if you have any questions or require additional information.

Thanks.

Ye Myint
Project Manager
EMAX Laboratories, Inc.
1835W 205th. St.
Torrance, CA 90501
Ph: 310-618-8889 x121
Fax: 310-618-0818
E-mail: ymyint@emaxlabs.com

From: (818) 466-8019
Andrew Rippert
CH2MHILL INC
NASA Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Origin ID: SFRA

FedEx Express

E

J142014061903uv

Ship Date: 22JUL14
ActWgt: 30.0 LB
CAD: 106467760/WSXI2500

Dims: 16 X 14 X 26 IN

Delivery Address Bar Code

SHIP TO: (310) 618-8889

BILL SENDER

Ye Myint
EMAX Laboratories
1835 W 205th St

Torrance, CA 90501

Ref # 474867.BV.01/AAB00110069
Invoice #
PO #
Dept #

WED - 23 JUL 10:30A
PRIORITY OVERNIGHT

TRK# 0201 7800 4727 8409

90501
CA-US
LAX

92 HHRA

522G2/ED4F/6AC9

REPORTING CONVENTIONS

DATA QUALIFIERS:

Lab Qualifier	AFCEE Qualifier	Description
J	F	Indicates that the analyte is positively identified and the result is less than RL but greater than MDL.
N		Indicates presumptive evidence of a compound.
B	B	Indicates that the analyte is found in the associated method blank as well as in the sample at above QC level.
E	J	Indicates that the result is above the maximum calibration range.
*	*	Out of QC limit.

Note: The above qualifiers are used to flag the results unless the project requires a different set of qualification criteria.

ACRONYMS AND ABBREVIATIONS:

CRDL	Contract Required Detection Limit
RL	Reporting Limit
MRL	Method Reporting Limit
PQL	Practical Quantitation Limit
MDL	Method Detection Limit
DO	Diluted out

DATES

The date and time information for leaching and preparation reflect the beginning date and time of the procedure unless the method, protocol, or project specifically requires otherwise.

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EMAX

LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 10-14-2014
EMAX Batch No.: 14G180

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: SSFL ROCK SAMPLES

Enclosed is the Laboratory report for samples received on 07/25/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
PZ203RCD012	G180-01	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS007	G180-02	07/21/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS008	G180-03	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS009	G180-04	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS010	G180-05	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS011	G180-06	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS012	G180-07	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS013	G180-08	07/22/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS014	G180-09	07/23/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ203RCS015	G180-10	07/23/14	ROCK	VOLATILE ORGANICS BY GC/MS

Sample ID	Control #	Col Date	Matrix	Analysis
				VOC SIM
PZ203RCS016	G180-11	07/23/14	ROCK	VOLATILE ORGANICS BY GC/MS
				VOC SIM
PZ203RCS017	G180-12	07/23/14	ROCK	VOLATILE ORGANICS BY GC/MS
				VOC SIM

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

for [signature]

Caspar J. Pang
Laboratory Director

This report is confidential and intended solely for the use of the individual or entity to whom it is addressed. This report shall not be reproduced except in full or without the written approval of EMAX.

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Chain of Custody Record

COC Number: **072414E**

CH2MHILL 7/24/2014 3:59:03 PM 14G180

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
1	**PZ203RCD012**	22-Jul-14	17:00	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1		
2	**PZ203RCS007**	21-Jul-14	11:20	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1		
3	**PZ203RCS008**	22-Jul-14	11:15	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1		
4	**PZ203RCS009**	22-Jul-14	11:20	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/24/14
Received by	FEDEX	7/24/14
Relinquished by		
Received by	EMAX MC [signature]	7/25/14 09:15

Shipping Details
Method of Shipment: FedEx
On Ice: yes (circled) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

Temp - 2.3°C

Chain of Custody Record

COC Number: **072414E**

CH2MHILL 7/24/2014 3:59:03 PM 14G180

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
5	**PZ203RCS010**	22-Jul-14	13:00	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1 AR		
6	**PZ203RCS011**	22-Jul-14	15:45	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1 AR		
7	**PZ203RCS012**	22-Jul-14	17:00	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1 AR		
8	**PZ203RCS013**	23-Jul-14	9:00	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1 AR	4'C	☑
					Total Containers:	~~3~~ 1 AR		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/24/14
Relinquished by		
Received by	FEDEX	7/24/14
Relinquished by		
Received by	EMAX me [signature]	7/25/14 09:15

Shipping Details

Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:

Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

1003

Chain of Custody Record

COC Number: **072414E** CH2MHILL 7/24/2014 3:59:04 PM 146180

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
9	**PZ203RCS014**	23-Jul-14	9:45	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1	4'C	☑
					Total Containers:	~~3~~ 1		
10	**PZ203RCS015**	23-Jul-14	10:55	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~	4'C	☑
					Total Containers:	~~3~~ 1		
11	**PZ203RCS016**	23-Jul-14	12:45	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1	4'C	☑
					Total Containers:	~~3~~ 1		
12	**PZ203RCS017**	23-Jul-14	17:30	N	Soil			
	Rock Core - CH 499 VOC List				Field Filtered ☐	~~3~~ 1	4'C	☑
					Total Containers:	~~3~~ 1		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/24/14
Relinquished by		
Received by	FEDEX	7/24/14
Relinquished by		
Received by	EMAX [signature]	7/25/14 09:15

Shipping Details
Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

1401

SAMPLE RECEIPT FORM 1

Reference Number: SM02.7.2

Type of Delivery	Airbill / Tracking Number	ECN 14G180
☑ Fedex ☐ UPS ☐ GSO ☐ Others	7800 5626 4304	Recipient Maung
☐ EMAX Courier ☐ Client Delivery		Date 7/25/14 Time 09:15

COC INSPECTION

☑ Client Name ☑ Client PM/FC ☐ Sampler Name ☑ Sampling Date/Time ☑ Sample ID ☑ Matrix
☐ Address ☑ Tel # / Fax # ☐ Courier Signature ☑ Analysis Required ☐ Preservative (if any) ☑ TAT
Safety Issues (if any) ☐ High concentrations expected ☐ From Superfund Site ☐ Rad screening required
Note:

PACKAGING INSPECTION

Container ☑ Cooler ☐ Box ☐ Other
Condition ☑ Custody Seal ☑ Intact ☐ Damaged
Packaging ☐ Bubble Pack ☐ Styrofoam ☐ Popcorn ☑ Sufficient ☑ Plastic Bag
Temperatures (Cool, ≤6 °C but not frozen) ☑ Cooler 1 2-3 °C ☐ Cooler 2 ___ °C ☐ Cooler 3 ___ °C ☐ Cooler 4 ___ °C ☐ Cooler 5 ___ °C
☐ Cooler 6 ___ °C ☐ Cooler 7 ___ °C ☐ Cooler 8 ___ °C ☐ Cooler 9 ___ °C ☐ Cooler 10 ___ °C
Thermometer: *A - S/N 130538505* *B - S/N 101541382* *(C) S/N 122091701* *D - S/N 122091758*
Comments: ☐ **Temperature is out of range. PM was informed IMMEDIATELY.**
Note:

DISCREPANCIES

LabSampleID	LabSampleContainerID	Code	ClientSample Label ID / Information	Corrective Action
1-12		D10		R8
8	8	D7	DATE 7/23/14 on COC vs label	7/22/14 R1 (7/22/14)
	~~8~~ 7/25/14			

YM 7/25/14 — 7/25/14

☐ pH holding time requirement for water samples is 15 mins. Water samples for pH analysis are received beyond 15 minutes from sampling time.

NOTES/OBSERVATIONS:

LEGEND: ☐ **Continue to next page.**

Code	Description- Sample Management	Code	Description-Sample Management	Code	Description-Sample Management
D1	Analysis is not indicated in ____	D13	Out of Holding Time	R1	Proceed as indicated in ☐ COC ☒ Label
D2	Analysis mismatch COC vs label	D14	Bubble is >6mm	R2	Refer to attached instruction
D3	Sample ID mismatch COC vs label	D15	No trip blank in cooler	R3	Cancel the analysis
D4	Sample ID is not indicated in ____	D16	Preservation not indicated in ____	R4	Use vial with smallest bubble first
D5	Container -[improper] [leaking] [broken]	D17	Preservation mismatch COC vs label	R5	Log-in with latest sampling date and time+1 min
D6	Date/Time is not indicated in ____	D18	Insufficient chemical preservative	R6	Adjust pH as necessary
D7	Date/Time mismatch COC vs label	D19	Insufficient Sample	R7	Filter and preserved as necessary
D8	Sample listed in COC is not received	D20	No filtration info for dissolved analysis	R8	Inform client.
D9	Sample received is not listed in COC	D21	No sample for moisture determination	R9	
D10	No initial/date on corrections in COC/label	D22		R10	
D11	Container count mismatch COC vs received	D23		R11	
D12	Container size mismatch COC vs received	D24		R12	

REVIEWS:

Sample Labeling [signature] Date ~~7/25/14~~ 7/25/14
SRF [signature] Date 7/25/14
PM [signature] Date 7/25/14

EMAX Laboratories, Inc. 1835 W. 205th St., Torrance, Ca 90501

Ye Myint

From: Andrew.Rippert@CH2M.com
Sent: Friday, July 25, 2014 1:39 PM
To: Ye Myint
Cc: Linh Pham
Subject: RE:

Follow what is written on the actual plastic bag, which should be the same as the label, COC is likely wrong.

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Friday, July 25, 2014 1:37 PM
To: Rippert, Andrew/SFL
Cc: Linh Pham
Subject:

Andy,

Please advise. Thanks.

Total Containers: 3 1

3 PZ203RCS013 23-Jul-14 9:00 N Soil 3 2
Rock Core - CH 499 VOC List Field Filtered 3 4°C ✓
Total Containers: 3 2

Date on label shows 7/22/14

MS = Matrix Spike SD = Matrix Spike Duplicate

Thanks.

Ye Myint
Project Manager
EMAX Laboratories, Inc.
1835W 205th. St.
Torrance, CA 90501
Ph: 310-618-8889 x121
Fax: 310-618-0818
E-mail: ymyint@emaxlabs.com

Ye Myint

From: Mark.Fesler@CH2M.com
Sent: Monday, September 22, 2014 2:19 PM
To: Ye Myint
Subject: RE: Rock Samples: SDGs - 14G152 and 14G180

Ye:

Report both the original analysis and re-analysis for carbon tet. Narrate the missed HT in case narrative.

Thanks for the heads up

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 22, 2014 2:04 PM
To: Fesler, Mark/RDD
Cc: Linh Pham
Subject: Rock Samples: SDGs - 14G152 and 14G180

Hello Mark,

I called earlier to notify you about these samples. But you might have been on another line and I did not leave a message to call back. During the final review process for 14G152 and 14G180, it was discovered that carbon tetrachloride was inadvertently missed in the ICAL (8260SIM) used for the analysis of samples from these two SDGs. I regret to notify you also that HT for the two SDGs has already exceeded by 5 days.

The lab will reanalyze the affected samples to include carbon tetrachloride by 8260SIM method, and we will narrate the HT discrepancy in the final data package. Please be informed that only the missing analyte will be evaluated and reported from the re-analysis. Carbon tetrachloride was not detected in the samples by regular 8260B method (MDL : 1 ppb). If it's an option to report the missing analyte from the regular 8260B scan instead of 8260SIM, we can also do so without the HT issue.

I apologize for any inconvenience this has caused you. Please let me know if you have any questions or require additional information.

Thanks.

Ye Myint
Project Manager
EMAX Laboratories, Inc.
1835W 205th. St.
Torrance, CA 90501
Ph: 310-618-8889 x121
Fax: 310-618-0818
E-mail: ymyint@emaxlabs.com

(1)

C=20.3°C

From: (818) 466-8019
Andrew Rippert
CH2MHILL INC
NASA Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Origin ID: SFRA

FedEx Express

E

J142014061903uv

Ship Date: 24JUL14
ActWgt: 35.0 LB
CAD: 106467760/WSXI2500

Dims: 26 X 16 X 14 IN

Delivery Address Bar Code

BILL SENDER

SHIP TO: (310) 618-8889
Ye Myint
EMAX Laboratories
1835 W 205th St

Torrance, CA 90501

Ref # 474867.bv.02/AAB00110069
Invoice #
PO #
Dept #

FRI - 25 JUL 10:30A
PRIORITY OVERNIGHT

TRK# 7800 5626 4304
0201

90501
CA-US
LAX

92 HHRA

522G2/ED4F/8AC9

REPORTING CONVENTIONS

DATA QUALIFIERS:

Lab Qualifier	AFCEE Qualifier	Description
J	F	Indicates that the analyte is positively identified and the result is less than RL but greater than MDL.
N		Indicates presumptive evidence of a compound.
B	B	Indicates that the analyte is found in the associated method blank as well as in the sample at above QC level.
E	J	Indicates that the result is above the maximum calibration range.
*	*	Out of QC limit.

Note: The above qualifiers are used to flag the results unless the project requires a different set of qualification criteria.

ACRONYMS AND ABBREVIATIONS:

CRDL	Contract Required Detection Limit
RL	Reporting Limit
MRL	Method Reporting Limit
PQL	Practical Quantitation Limit
MDL	Method Detection Limit
DO	Diluted out

DATES

The date and time information for leaching and preparation reflect the beginning date and time of the procedure unless the method, protocol, or project specifically requires otherwise.

EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 10-14-2014
EMAX Batch No.: 14G199

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: SSFL ROCK SAMPLES

Enclosed is the Laboratory report for samples received on 07/30/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
CAQW2028S001	G199-01	07/29/14	WATER	VOC SIM
PZ202RCS001	G199-02	07/25/14	ROCK	CANCELLED
PZ202RCS002	G199-03	07/25/14	ROCK	CANCELLED
PZ202RCS003	G199-04	07/25/14	ROCK	CANCELLED
PZ202RCS004	G199-05	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS005	G199-06	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS006	G199-07	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS007	G199-08	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS008	G199-09	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS009	G199-10	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS010	G199-11	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS011	G199-12	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS

Sample ID	Control #	Col Date	Matrix	Analysis
				VOC SIM
PZ202RCS012	G199-13	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS
				VOC SIM
PZ202RCS013	G199-14	07/28/14	ROCK	VOLATILE ORGANICS BY GC/MS
				VOC SIM
PZ203RCS018	G199-15	07/24/14	ROCK	VOLATILE ORGANICS BY GC/MS
				VOC SIM

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

14G199

Chain of Custody Record

COC Number: **072914E**

CH2MHILL 7/29/2014 1:33:03 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

#	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
1	CAQW2028S001	29-Jul-14	7:00	TB	Water			
				Field Filtered ☐		~~3~~ 2 AL	HCl, pH<2, 4'C	☑
				Total Containers:		2 ~~3~~ AL		
2	PZ202RCS001	25-Jul-14	14:10	N	Soil			
	Rock Core			Field Filtered ☐		~~3~~ 2 AL	4'C	☑
				Total Containers:		~~3~~ 2 AL		
3	PZ202RCS002	25-Jul-14	15:45	N	Soil			
	Rock Core			Field Filtered ☐		~~3~~ 2 AL	4'C	☑
				Total Containers:		~~3~~ 2 AL		
4	PZ202RCS003	25-Jul-14	16:40	N	Soil			
	Rock Core			Field Filtered ☐		~~3~~ 2 AL	4'C	☑
				Total Containers:		~~3~~ 2 AL		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/29/14 1610
Relinquished by		
Received by	FEDEX	7/29/14
Relinquished by		
Received by	[signature]	7/30/14 09:10

Shipping Details

Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

Temp- 2.8 °C

1002

14G199

Chain of Custody Record

COC Number: **072914E**

CH2MHILL 7/29/2014 1:33:03 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
5	**PZ202RCS004**	28-Jul-14	8:26	N	Soil			
	Rock Core			Field Filtered ☐		~~3~~ 2	4'C	☑
				Total Containers:		~~3~~ 2		
6	**PZ202RCS005**	28-Jul-14	9:21	N	Soil			
	Rock Core			Field Filtered ☐		3	4'C	☑
				Total Containers:		~~3~~ 2		
7	**PZ202RCS006**	28-Jul-14	10:49	N	Soil			
	Rock Core			Field Filtered ☐		3	4'C	☑
				Total Containers:		~~3~~ 2		
8	**PZ202RCS007**	28-Jul-14	11:18	N	Soil			
	Rock Core			Field Filtered ☐		~~3~~ 2	4'C	☑
				Total Containers:		~~3~~ 2		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/29/14
Relinquished by		
Received by	FEDEX	7/29/14
Relinquished by		
Received by	[signature]	7/30/14 09:10

Shipping Details
Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

1003

14G199

Chain of Custody Record

COC Number: **072914E**

CH2MHILL 7/29/2014 1:33:03 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

#	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
9	PZ202RCS008	28-Jul-14	13:22	N	Soil			
	Rock Core				Field Filtered ☐	~~3~~ 2 AR	4'C	☑
					Total Containers:	~~3~~ 2 AR		
10	PZ202RCS009	28-Jul-14	14:00	N	Soil			
	Rock Core				Field Filtered ☐	~~3~~ 2 AR	4'C	☑
					Total Containers:	~~3~~ 2 AR		
11	PZ202RCS010	28-Jul-14	14:58	N	Soil			
	Rock Core				Field Filtered ☐	~~3~~ 2 AR	4'C	☑
					Total Containers:	~~3~~ 2 AR		
12	PZ202RCS011	28-Jul-14	15:58	N	Soil			
	Rock Core				Field Filtered ☐	~~3~~ 2 AR	4'C	☑
					Total Containers:	~~3~~ 2 AR		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/29/14
Received by	FEDEX	7/29/14
Relinquished by		
Received by	[signature]	7/30/14 09:10

Shipping Details
Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

14G199

Chain of Custody Record

COC Number: **072914E**

CH2MHILL 7/29/2014 1:33:03 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
13	**PZ202RCS012**	28-Jul-14	15:25	N	Soil			
	Rock Core			Field Filtered ☐		3 (corrected to 2)	4'C	☑
				Total Containers:		3 (corrected to 2)		
14	**PZ202RCS013**	28-Jul-14	15:45	N	Soil			
	Rock Core			Field Filtered ☐		3 (corrected to 2)	4'C	☑
				Total Containers:		3 (corrected to 2)		
15	**PZ203RCS018**	24-Jul-14	14:28	N	Soil			
	Rock Core - CH 499 VOC List			Field Filtered ☐		3 (corrected to 2)	4'C	☑
				Total Containers:		3 (corrected to 2)		

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/29/14 1700
Relinquished by		
Received by	FedEx	7/29/14
Relinquished by		
Received by	[signature]	7/30/14 0091·0

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

1095

SAMPLE RECEIPT FORM 1

Reference Number: SM02.7.2

Type of Delivery	Airbill / Tracking Number	ECN 14G199
☑ Fedex ☐ UPS ☐ GSO ☐ Others	7707 0972 1731	Recipient I BATEZ
☐ EMAX Courier ☐ Client Delivery		Date 7/30/14 Time 0910

COC INSPECTION

☑ Client Name ☑ Client PM/FC ☑ Sampler Name ☑ Sampling Date/Time ☑ Sample ID ☑ Matrix

☑ Address ☑ Tel # / Fax # ☐ Courier Signature ☑ Analysis Required ☑ Preservative (if any) ☑ TAT

Safety Issues (if any) ☐ High concentrations expected ☐ From Superfund Site ☐ Rad screening required

Note:

PACKAGING INSPECTION

Container ☑ Cooler ☐ Box ☐ Other

Condition ☑ Custody Seal ☑ Intact ☐ Damaged

Packaging ☑ Bubble Pack ☐ Styrofoam ☐ Popcorn ☑ Sufficient ☑ Plastic Bags

Temperatures (Cool, ≤6 °C but not frozen) A ☑ Cooler 1 2-8 °C ☐ Cooler 2____°C ☐ Cooler 3____°C ☐ Cooler 4____°C ☐ Cooler 5____°C

☐ Cooler 6____°C ☐ Cooler 7____°C ☐ Cooler 8____°C ☐ Cooler 9____°C ☐ Cooler 10____°C

Thermometer: *A - S/N 130538505* *B - S/N 101541382* *C - S/N 122091701* *D - S/N 122091758*

Comments: ☐ **Temperature is out of range. PM was informed IMMEDIATELY.**

Note:

DISCREPANCIES

LabSampleID	LabSampleContainerID	Code	ClientSample Label ID / Information	Corrective Action
01		D5	(2) vials Recd Broken	R8
02, 03, 04		D22	Cancelled	
10	10	D7	Time 1458 on label	R8, R1
11	11	D7	Time 1558 on label	R8, R1
5, 6	5, 6	D23	Label Reads 5 gm. Encore	R1
5, 6, 1-14		D10		R8, R1
			7/30/14	

☐ pH holding time requirement for water samples is 15 mins. Water samples for pH analysis are received beyond 15 minutes from sampling time.

NOTES/OBSERVATIONS:

LEGEND: ☐ **Continue to next page.**

Code	Description- Sample Management	Code	Description-Sample Management	Code	Description-Sample Management
D1	Analysis is not indicated in ______	D13	Out of Holding Time	R1	Proceed as indicated in ☑ COC ☐ Label
D2	Analysis mismatch COC vs label	D14	Bubble is >6mm	R2	Refer to attached instruction
D3	Sample ID mismatch COC vs label	D15	No trip blank in cooler	R3	Cancel the analysis
D4	Sample ID is not indicated in ______	D16	Preservation not indicated in ______	R4	Use vial with smallest bubble first
D5	Container -[improper] [leaking] [broken]	D17	Preservation mismatch COC vs label	R5	Log-in with latest sampling date and time+1 min
D6	Date/Time is not indicated in ______	D18	Insufficient chemical preservative	R6	Adjust pH as necessary
✓D7	Date/Time mismatch COC vs label	D19	Insufficient Sample	R7	Filter and preserved as necessary
D8	Sample listed in COC is not received	D20	No filtration info for dissolved analysis	R8	Inform client
D9	Sample received is not listed in COC	D21	No sample for moisture determination	R9	
D10	No initial/date on corrections in COC/label	D22	Cancelled By client. See Email	R10	
D11	Container count mismatch COC vs received	D23	REC'D core sample in Plastic Bag	R11	
D12	Container size mismatch COC vs received	D24		R12	

REVIEWS:

Sample Labeling [signature] **Date** 7/30/14

SRF [signature] **Date** 7/31/14

PM LP for YO **Date** 7/31/14

EMAX **Laboratories, Inc. 1835 W. 205th St., Torrance, Ca 90501**

Cecilia Chavez

From: Andrew.Rippert@CH2M.com
Sent: Wednesday, July 30, 2014 11:21 AM
To: Ye Myint
Cc: Cecilia Chavez; Linh Pham
Subject: RE: SSFL Rock Core Samples - Need to have shipped back to us

Ye,

Disregard last email. Now I have been instructed to cancel the analyses samples in the first email, we do not need them shipped back and we do not need them analyzed. If EMAX can dispose of them then that would work, but if EMAX cannot dispose of the three rock core samples below, then go ahead and use the shipping label to send them back to me and I will dispose of them.

PZ202RCS001 – 7/25/14 – 14:10 – 12.5 to 13 ft
PZ202RCS002 – 7/25/14 – 15:45 – 24.9 to 25.2 ft
PZ202RCS003 – 7/25/14 – 16:40 – 35.6 to 36 ft

Andy

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Wednesday, July 30, 2014 11:02 AM
To: Rippert, Andrew/SFL
Cc: Cecilia Chavez; Linh Pham
Subject: RE: SSFL Rock Core Samples - Need to have shipped back to us

Hi Andy,

We can ship them back after we inspect/check the samples for the SDG. I am assuming you do not want any analyses performed on these samples. Can you please email me the airbill for the shipment? Thanks.

Ye

310-618-8889 x121

From: Andrew.Rippert@CH2M.com [mailto:Andrew.Rippert@CH2M.com]
Sent: Wednesday, July 30, 2014 8:34 AM
To: Ye Myint
Cc: Cecilia Chavez; Linh Pham
Subject: SSFL Rock Core Samples - Need to have shipped back to us

Ye et al,

I got a last minute request from one of the geologists on the drill rig, and she needs to take another look at the following samples that will arrive at EMAX today. Would it be possible to ship them back to us? I can provide another FedEx Air Bill if that would make it easier for EMAX, just let me know.

Ye Myint

From: Andrew.Rippert@CH2M.com
Sent: Friday, August 01, 2014 8:50 AM
To: Ye Myint
Cc: Mark.Fesler@CH2M.com; Linh Pham
Subject: RE: 14G199

Follow the COC, not the label.

I will make sure to send 6 TBs for both 8260B and 8260BSIM when I ship cores next, which will be Tuesday.

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Thursday, July 31, 2014 6:31 PM
To: Rippert, Andrew/SFL
Cc: Fesler, Mark/RDD; Linh Pham
Subject: 14G199

Andy,

Can you please verify the collection time for sample -10 and -11? Also, two of three TBs were received broken. Since this project needs 8260B and 8260SIM methods, could you please provide 3 trip blanks for each method (6 total) with all future rock samples?

Mark,

We will analyze the remaining intact TB for 8260BSIM as discussed earlier.

Thanks.

Ye Myint
Project Manager
EMAX Laboratories, Inc.
1835W 205th. St.
Torrance, CA 90501
Ph: 310-618-8889 x121
Fax: 310-618-0818
E-mail: ymyint@emaxlabs.com

From: (203) 610-0702
andrew rippert
Origin ID: SFRA
FedEx Express
E

5800 Woolsey Canyon Road
NASA Trailer
Canoga Park, CA 91304

J142014061903uv

Ship Date: 29JUL14
ActWgt: 40.0 LB
CAD: 106824221/INET3550
Dims: 14 X 16 X 26 IN

Delivery Address Bar Code

SHIP TO: (310) 618-8889
BILL SENDER

Ye Myint
EMAX Laboratories
1835 W 205TH ST

TORRANCE, CA 90501

Ref # 474867.BV.01
Invoice #
PO #
Dept #

144199

WED - 30 JUL 10:30A
PRIORITY OVERNIGHT

TRK# 7707 0972 1731
0201

90501
CA-US
LAX

92 HHRA

522G2/ED4F/BAC5

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Use of this system constitutes your agreement to the service conditions in the current FedEx Service Guide, available on fedex.com.FedEx will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery,misdelivery,or misinformation, unless you declare a higher value, pay an additional charge, document your actual loss and file a timely claim.Limitations found in the current FedEx Service Guide apply. Your right to recover from FedEx for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental,consequential, or special is limited to the greater of $100 or the authorized declared value. Recovery cannot exceed actual documented loss.Maximum for items of extraordinary value is $1,000, e.g. jewelry, precious metals, negotiable instruments and other items listed in our ServiceGuide. Written claims must be filed within strict time limits, see current FedEx Service Guide.

REPORTING CONVENTIONS

DATA QUALIFIERS:

Lab Qualifier	AFCEE Qualifier	Description
J	F	Indicates that the analyte is positively identified and the result is less than RL but greater than MDL.
N		Indicates presumptive evidence of a compound.
B	B	Indicates that the analyte is found in the associated method blank as well as in the sample at above QC level.
E	J	Indicates that the result is above the maximum calibration range.
*	*	Out of QC limit.

Note: The above qualifiers are used to flag the results unless the project requires a different set of qualification criteria.

ACRONYMS AND ABBREVIATIONS:

CRDL	Contract Required Detection Limit
RL	Reporting Limit
MRL	Method Reporting Limit
PQL	Practical Quantitation Limit
MDL	Method Detection Limit
DO	Diluted out

DATES

The date and time information for leaching and preparation reflect the beginning date and time of the procedure unless the method, protocol, or project specifically requires otherwise.

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E MAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 10-14-2014
EMAX Batch No.: 14H042

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: SSFL ROCK SAMPLES

Enclosed is the Laboratory report for samples received on 08/08/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
CAQW2030S001	H042-01	08/07/14	WATER	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS014	H042-02	08/01/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS014FD	H042-03	08/01/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM
PZ202RCS015	H042-04	08/01/14	ROCK	VOLATILE ORGANICS BY GC/MS VOC SIM

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Chain of Custody Record

COC Number: **080714E** CH2MHILL 8/7/2014 2:35:05 PM 14H042

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 476119.01.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B	SW8260B SIM
1	**CAQW2030S001**	07-Aug-14	7:00	TB	Water				
					Field Filtered ☐	~~3~~ 6 AR	HCl, pH<2, 4'C	☑	☒
					Total Containers:	~~3~~ 6 AR			
2	**PZ202RCS014**	01-Aug-14	14:30	N	Soil				
	Rock Core				Field Filtered ☐	AR ~~3~~ 1	4'C	☑	☐
					Total Containers:	AR ~~3~~ 1			
3	**PZ202RCS014FD**	01-Aug-14	14:30	N	Soil				
	Rock Core				Field Filtered ☐	AR ~~3~~ 1	4'C	☑	☐
					Total Containers:	AR ~~3~~ 1			
4	**PZ202RCS015**	01-Aug-14	15:00	N	Soil				
	Rock Core				Field Filtered ☐	~~3~~ 1 AR	4'C	☑	☐
					Total Containers:	AR ~~3~~ 1			

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	8/7/14
Received by	EMAX mc [signature]	8/8/14 09:10
Relinquished by		
Received by		

Shipping Details
Method of Shipment: FedEx
On Ice: (yes) / no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

Temp – 2.7°C

1001

SAMPLE RECEIPT FORM 1 Reference Number: SM02.7.2

Type of Delivery	Airbill / Tracking Number	ECN 14H042
☑ Fedex ☐ UPS ☐ GSO ☐ Others	7801 0525 5210	Recipient Maung
☐ EMAX Courier ☐ Client Delivery		Date 8/8/14 Time 09:10

COC INSPECTION

☑ Client Name ☑ Client PM/FC ☐ Sampler Name ☑ Sampling Date/Time ☑ Sample ID ☑ Matrix
☐ Address ☑ Tel # / Fax # ☐ Courier Signature ☑ Analysis Required ☑ Preservative (if any) ☑ TAT
Safety Issues (if any) ☐ High concentrations expected ☐ From Superfund Site ☐ Rad screening required
Note:

PACKAGING INSPECTION

Container	☑ Cooler	☐ Box	☐ Other		
Condition	☑ Custody Seal	☑ Intact	☐ Damaged		
Packaging	☑ Bubble Pack	☐ Styrofoam	☐ Popcorn	☐ Sufficient	☑ Plastic Bag
Temperatures	☑ Cooler 1 2.7 °C	☐ Cooler 2 ___ °C	☐ Cooler 3 ___ °C	☐ Cooler 4 ___ °C	☐ Cooler 5 ___ °C
(Cool, ≤6 °C but not frozen)	☐ Cooler 6 ___ °C	☐ Cooler 7 ___ °C	☐ Cooler 8 ___ °C	☐ Cooler 9 ___ °C	☐ Cooler 10 ___ °C
Thermometer:	*A - S/N 130538505*	*B - S/N 101541382*	*(C) - S/N 122091701*	*D - S/N 122091758*	

Comments: ☐ **Temperature is out of range. PM was informed IMMEDIATELY.**
Note:

DISCREPANCIES

LabSampleID	LabSampleContainerID	Code	ClientSample Label ID / Information	Corrective Action
4	9	D7	Label "17:00"	R1

C 8/8/14

☐ pH holding time requirement for water samples is 15 mins. Water samples for pH analysis are received beyond 15 minutes from sampling time.

NOTES/OBSERVATIONS:

LEGEND: ☐ **Continue to next page.**

Code	Description- Sample Management	Code	Description-Sample Management	Code	Description-Sample Management
D1	Analysis is not indicated in ______	D13	Out of Holding Time	R1	Proceed as indicated in ☒ COC ☐ Label
D2	Analysis mismatch COC vs label	D14	Bubble is >6mm	R2	Refer to attached instruction
D3	Sample ID mismatch COC vs label	D15	No trip blank in cooler	R3	Cancel the analysis
D4	Sample ID is not indicated in ______	D16	Preservation not indicated in ______	R4	Use vial with smallest bubble first
D5	Container -[improper] [leaking] [broken]	D17	Preservation mismatch COC vs label	R5	Log-in with latest sampling date and time+1 min
D6	Date/Time is not indicated in ______	D18	Insufficient chemical preservative	R6	Adjust pH as necessary
(D7)	Date/Time mismatch COC vs label	D19	Insufficient Sample	R7	Filter and preserved as necessary
D8	Sample listed in COC is not received	D20	No filtration info for dissolved analysis	R8	
D9	Sample received is not listed in COC	D21	No sample for moisture determination	R9	
D10	No initial/date on corrections in COC/label	D22		R10	
D11	Container count mismatch COC vs received	D23		R11	
D12	Container size mismatch COC vs received	D24		R12	

REVIEWS:

Sample Labeling MC [signature] Date 8/8/14 [signature] 8/8/14
SRF [signature] Date 8/8/14
PM LP for C Date 8/11/14

From: (818) 466-8019
Andrew Rippert
CH2MHILL INC
NASA Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Origin ID: SFRA

FedEx Express

E

J142014061903uv

Ship Date: 07AUG14
ActWgt: 35.0 LB
CAD: 106467760/WSXI2500

Dims: 26 X 16 X 14 IN

Delivery Address Bar Code

SHIP TO: (310) 618-8889

BILL SENDER

Ye Myint
EMAX Laboratories
1835 W 205th St

Torrance, CA 90501

Ref # 474867.BV.02/AAB00110069
Invoice #
PO #
Dept #

FRI - 08 AUG 10:30A
PRIORITY OVERNIGHT

TRK# 7801 0525 5210
0201

90501
CA-US
LAX

92 HHRA

522G1/ECF2/8AC9

<u>REPORTING CONVENTIONS</u>

DATA QUALIFIERS:

Lab Qualifier	AFCEE Qualifier	Description
J	F	Indicates that the analyte is positively identified and the result is less than RL but greater than MDL.
N		Indicates presumptive evidence of a compound.
B	B	Indicates that the analyte is found in the associated method blank as well as in the sample at above QC level.
E	J	Indicates that the result is above the maximum calibration range.
*	*	Out of QC limit.

Note: The above qualifiers are used to flag the results unless the project requires a different set of qualification criteria.

ACRONYMS AND ABBREVIATIONS:

CRDL	Contract Required Detection Limit
RL	Reporting Limit
MRL	Method Reporting Limit
PQL	Practical Quantitation Limit
MDL	Method Detection Limit
DO	Diluted out

DATES

The date and time information for leaching and preparation reflect the beginning date and time of the procedure unless the method, protocol, or project specifically requires otherwise.

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EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 09-18-2014
EMAX Batch No.: 14H204

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 08/27/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SVS001	H204-01	08/26/14	AIR	VOLATILE ORGANICS BY TO15
HAR19SVS002	H204-02	08/26/14	AIR	CANCELLED
PZ204CSVS001	H204-03	08/26/14	AIR	VOLATILE ORGANICS BY TO15

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Linh Pham

From: Sue Anderson [Sue.Anderson@alsglobal.com]
Sent: Monday, September 08, 2014 2:02 PM
To: Ye Myint
Cc: Linh Pham
Subject: RE: Login for Air samples SDG 14I031

OK, I will cancel the C3-C12 for those 3 jobs and only report the standard SSFL list of 24 analytes.

Sue Anderson
Project Manager
ALS Life Sciences Division | Environmental

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:25 PM
To: Sue Anderson
Cc: Linh Pham
Subject: FW: Login for Air samples SDG 14I031

Hi Sue,

Latest updates on the samples you have received so far as of Friday last week! According to CH2M Hill, those 3 samples groups (P1403465 – received 8/27/14 , P1403556 – received 9/3/14, P1403604 – received 9/5/14) belong to CH 499 and that they only need TO-15 list, not TO-15 extended (TO-15 list + C3-C12). Also, as per Mark's confirmation below, can you please cancel and not report C3-C12 parameters for the 3 SDGs. They only need TO-15 list after all. Sorry for the confusion.

Below is what they will be requiring moving forward. They will clearly note on COCs as well in terms of the analyses that are required for each project.

CH 499 : TO-15 (TO15 list only) by TO15 and/or atmospheric fixed gases by EPA-3C method – See COC
CH 505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 1:14 PM
To: Ye Myint
Subject: RE: Login for Air samples SDG 14I031

Yes, thanks

Mark Fesler
Environmental Scientist

CH2M Hill

2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:02 PM
To: Edwards, Olivia/LAS; Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: RE: Login for Air samples SDG 14I031

Thanks Olivia.

Mark,

Do you want me to ask ALS to cancel C3-C12 for the three SDGs ALS has received so far since CH499 needs TO-15 regular list only as per Olivia's email below? Please advise ASAP. COCs for CH499 had TO-15 extended requested.

Andy,

Can you please be sure to indicate TO-15 only, not TO-15 extended on all future COCs for CH499?

Thanks.

Ye

310-618-8889 x121

From: Olivia.Edwards@CH2M.com [mailto:Olivia.Edwards@CH2M.com]
Sent: Monday, September 08, 2014 12:52 PM
To: Ye Myint; Mark.Fesler@CH2M.com
Cc: Linh Pham; Andrew.Rippert@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

TO-15 extended is only for CH505 only.
TO-15 and EPA-3C is for CH499 only.

However, please confirm that only one EPA-3C is collected for CH499 per event.

Thanks
Olivia

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:34 PM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL; Edwards, Olivia/LAS
Subject: RE: Login for Air samples SDG 14I031

Hi Mark,

When TO 15 is referenced (red below) for both CH505 and 499, I assume you actually need TO-15 extended list (TO15+C3-C12) by TO-15 Mod method as per our discussion at the start of the project. Below is my

understanding on the requirements for CH505 and CH499. Could you please confirm before I send it to ALS?

CH505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC
CH499 : TO-15 extended (TO15 list + C3-C12) by TO15 mod and/or atmospheric fixed gases by EPA-3C method – See COC

ALS also informed me that they pressurized the cans already, and they can't do fixed gases anymore for the three SDGs ALS received below. I have requested ALS to cancel TPH-G by TO3 for all 3 SDGs. It's critical that the correct methods are referenced on COCs moving forward since EMAX and ALS will be going by the analysis requests on COC (EPA-3C or TO-3) for all future air samples.

P1403465 – received 8/27/14
P1403556 – received 9/3/14
P1403604 – received 9/5/14

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 11:52 AM
To: Ye Myint
Cc: Linh Pham; Andrew.Rippert@CH2M.com; Olivia.Edwards@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

Ye:

OK, after talking with Andy Rippert, the following changes should be made:

- For 14H204 (ALS# P1403465), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)
- For 14I034 (ALS# P1403556), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)

The above samples were all for Task CH499. Also, the samples that ALS received on Friday should be for CH499 as well. Andy will make sure the correct method and Task will be added to the COCs for CH499 samples being collected this week.

NOTE: There will be some samples collected on Thursday 9/11 that will be for Task CH505 that needs TO-15 as well as TO-3 (TPH Gas). Again, COC should clearly denote this.

We apologize for any confusion.

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 10:32 AM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: FW: Login for Air samples SDG 14I031

Hi Mark,

For some reason, I can't seem to find their notes being specific to atmospheric gases and not TPH-Gas. They did say TO3 Mod TPHG in their login sheet. I thought atmospheric gases are done by EPA 3C method. Anyhow, can you please confirm that ALS should be reporting the parameter as in the attachment example?

Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 9:11 AM
To: Ye Myint; Linh Pham
Cc: Andrew.Rippert@CH2M.com
Subject: FW: Login for Air samples SDG 14I031

Ye:

I completely overlooked the fact that the TO-3 method in the attached login is for atmospheric gases, NOT TPH-Gas. Please inform ALS Simi of this change.

Thanks

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Linh Pham [mailto:LPham@emaxlabs.com]
Sent: Friday, September 05, 2014 4:54 PM
To: Fesler, Mark/RDD
Cc: Rippert, Andrew/SFL; Ye Myint
Subject: Login for Air samples SDG 14I031

Hello Mark,
Attached please find login for Air Samples SDG 14I031.

Thanks

Linh

Ye Myint

From: Sue.Anderson@alsglobal.com
Sent: Wednesday, August 27, 2014 7:56 AM
To: Jim Carter; Linh Pham; Ye Myint
Cc: Sue.Anderson@alsglobal.com
Subject: Sample Information from ALS Environmental for CH 499 BIOVENT474867.BV.02 (P1403465)

Attachments: SampleConfirmation-P1403465.pdf; DraftInvoice-P1403465.pdf; P1403465.pdf

SampleConfirmation-P1403465.pd... DraftInvoice-P1403465.pdf (138... P1403465.pdf (230 KB)

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

VOLATILE ORGANICS BY TO15

SDG#: 14H204

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

LABORATORY REPORT

September 18, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: CH 499 BIOVENT / 474867.BV.02

Dear Ye:

Enclosed are the results of the samples submitted to our laboratory on August 27, 2014. For your reference, these analyses have been assigned our service request number P1403465.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated   Service Request No: P1403465
Project: CH 499 BIOVENT / 474867.BV.02

CASE NARRATIVE

The samples were received intact under chain of custody on August 27, 2014 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt. At the client's request, the TO-3 analysis listed on the chain of custody was cancelled.

Volatile Organic Compound Analysis

Samples HAR19SVS001 (P1403465-001) and PZ204CSVS001 (P1403465-003) were analyzed for volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The spike recoveries of trichlorofluoromethane and carbon tetrachloride in the Laboratory Control Sample (LCS) were outside the Laboratory generated control criteria. The recovery errors equate to a potential high bias. However, the recoveries in question were within the method criteria, therefore, the data quality is not significantly affected. No corrective action was taken.

The Summa canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

ALS Environmental – Simi Valley

Certifications, Accreditations, and Registrations

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated | Service Request: P1403465

Project ID: CH 499 BIOVENT / 474867.BV.02

Date Received: 8/27/2014

Time Received: 10:35

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	TO-15 - VOC Cans
HAR19SVS001	P1403465-001	Air	8/26/2014	15:45	1SS00122	-4.97	5.39	X
HAR19SVS002	P1403465-002	Air	8/26/2014	16:03	1SS00039	-5.18	1.17	
PZ204CSVS001	P1403465-003	Air	8/26/2014	17:13	1SS00065	-2.05	5.01	X

Air - Chain of Custody Record & Analytical Service Request

Page 2 of 1

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard

ALS Project No P1403464 3465

ALS Contact:

Company Name & Address (Reporting Information): EMAX LABORATORIES, INC TORRANCE, CA

Project Name: CKI 409 BIOVENT

Project Number: 774867.BV.02

Project Manager: YE MYINT

P.O. # / Billing Information:

Phone: 310 618 8889

Fax: 310 618 0318

Email Address for Result Reporting: YMYINT@EMAXLABS.COM

Sampler (Print & Sign): Andrew Rappent

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method: TO 15 extended	Analysis Method: TO 3	Comments e.g. Actual Preservative or specific instructions
HARI9SVS001	1 -4.86	8/26/14	1545	1SS00122		-28	-8	2L	X		
HARI9SVS002	2 -5.11	8/26/14	1603	1SS00039		-28	-3.5	2L		X	
PZ204CSVS002	3 -2.47	8/26/14	1713	1SS00065		-28	-3.5	2L	X		
	-14.23										

Sa 8/27/14

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) ____
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ____ Units: ug/m3

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	8/27/14		[signature]	8/27/14	1035

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated Work order: P1403465
Project: CH 499 BIOVENT / 474867.BV.02
Sample(s) received on: 8/27/14 Date opened: 8/27/14 by: RMARTENIES

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1403465-001.01	1.0 L Source Silonite Canister					
P1403465-002.02	1.0 L Source Silonite Canister					
P1403465-003.01	1.0 L Source Silonite Canister					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

EMAX

LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 09-24-2014
EMAX Batch No.: 14I031

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 09/03/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SV003	I031-01	09/02/14	AIR	VOLATILE ORGANICS BY TO15
HAR19SV004	I031-02	09/02/14	AIR	CANCELLED

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Linh Pham

From:	Mark.Fesler@CH2M.com
Sent:	Thursday, September 04, 2014 12:05 PM
To:	Ye Myint
Cc:	Linh Pham; Andrew.Rippert@CH2M.com
Subject:	RE: Sample Information from ALS Environmental for NASA SSFL (P1403556)

Ye:

Yes, I have confirmed that ALS Simi has the samples logged in correctly (as they stated below).

Mark Fesler
Associate Scientist
Ext. 33273
mark.fesler@ch2m.com

-----Original Message-----
From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Thursday, September 04, 2014 11:39 AM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: FW: Sample Information from ALS Environmental for NASA SSFL (P1403556)

Mark,

Please see the attached login/COC and email from ALS. Can you please confirm the request on the COC is correct?

Thanks.

Ye
310-618-8889 x121

-----Original Message-----
From: Sue.Anderson@alsglobal.com [mailto:Sue.Anderson@alsglobal.com]
Sent: Thursday, September 04, 2014 2:00 AM
To: Ye Myint
Cc: Sue.Anderson@alsglobal.com
Subject: Sample Information from ALS Environmental for NASA SSFL (P1403556)

Please confirm that TO-15 only needed for -001 and TPH-G only for -002. Thanks.

Sue Anderson
Project Manager
ALS Life Sciences Division | Environmental
2655 Park Center Drive, Suite A
Simi Valley, CA 93065USA

D +1 805 577 2086
T +1 805 526 7161
F +1 805 526 7270

is strictly prohibited. If you received this email in error, please notify us by telephone to arrange for the return of the documents.

Linh Pham

From: Sue Anderson [Sue.Anderson@alsglobal.com]
Sent: Monday, September 08, 2014 2:02 PM
To: Ye Myint
Cc: Linh Pham
Subject: RE: Login for Air samples SDG 14I031

OK, I will cancel the C3-C12 for those 3 jobs and only report the standard SSFL list of 24 analytes.

Sue Anderson
Project Manager
ALS Life Sciences Division | Environmental

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:25 PM
To: Sue Anderson
Cc: Linh Pham
Subject: FW: Login for Air samples SDG 14I031

Hi Sue,

Latest updates on the samples you have received so far as of Friday last week! According to CH2M Hill, those 3 samples groups (P1403465 – received 8/27/14 , P1403556 – received 9/3/14, P1403604 – received 9/5/14) belong to CH 499 and that they only need TO-15 list, not TO-15 extended (TO-15 list + C3-C12). Also, as per Mark's confirmation below, can you please cancel and not report C3-C12 parameters for the 3 SDGs. They only need TO-15 list after all. Sorry for the confusion.

Below is what they will be requiring moving forward. They will clearly note on COCs as well in terms of the analyses that are required for each project.

CH 499 : TO-15 (TO15 list only) by TO15 and/or atmospheric fixed gases by EPA-3C method – See COC
CH 505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 1:14 PM
To: Ye Myint
Subject: RE: Login for Air samples SDG 14I031

Yes, thanks

Mark Fesler
Environmental Scientist

CH2M Hill

2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:02 PM
To: Edwards, Olivia/LAS; Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: RE: Login for Air samples SDG 14I031

Thanks Olivia.

Mark,

Do you want me to ask ALS to cancel C3-C12 for the three SDGs ALS has received so far since CH499 needs TO-15 regular list only as per Olivia's email below? Please advise ASAP. COCs for CH499 had TO-15 extended requested.

Andy,

Can you please be sure to indicate TO-15 only, not TO-15 extended on all future COCs for CH499?

Thanks.

Ye

310-618-8889 x121

From: Olivia.Edwards@CH2M.com [mailto:Olivia.Edwards@CH2M.com]
Sent: Monday, September 08, 2014 12:52 PM
To: Ye Myint; Mark.Fesler@CH2M.com
Cc: Linh Pham; Andrew.Rippert@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

TO-15 extended is only for CH505 only.
TO-15 and EPA-3C is for CH499 only.

However, please confirm that only one EPA-3C is collected for CH499 per event.

Thanks
Olivia

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:34 PM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL; Edwards, Olivia/LAS
Subject: RE: Login for Air samples SDG 14I031

Hi Mark,

When TO 15 is referenced (red below) for both CH505 and 499, I assume you actually need TO-15 extended list (TO15+C3-C12) by TO-15 Mod method as per our discussion at the start of the project. Below is my

understanding on the requirements for CH505 and CH499. Could you please confirm before I send it to ALS?

CH505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC
CH499 : TO-15 extended (TO15 list + C3-C12) by TO15 mod and/or atmospheric fixed gases by EPA-3C method – See COC

ALS also informed me that they pressurized the cans already, and they can't do fixed gases anymore for the three SDGs ALS received below. I have requested ALS to cancel TPH-G by TO3 for all 3 SDGs. It's critical that the correct methods are referenced on COCs moving forward since EMAX and ALS will be going by the analysis requests on COC (EPA-3C or TO-3) for all future air samples.

P1403465 – received 8/27/14
P1403556 – received 9/3/14
P1403604 – received 9/5/14

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 11:52 AM
To: Ye Myint
Cc: Linh Pham; Andrew.Rippert@CH2M.com; Olivia.Edwards@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

Ye:

OK, after talking with Andy Rippert, the following changes should be made:

- For 14H204 (ALS# P1403465), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)
- For 14I034 (ALS# P1403556), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)

The above samples were all for Task CH499. Also, the samples that ALS received on Friday should be for CH499 as well. Andy will make sure the correct method and Task will be added to the COCs for CH499 samples being collected this week.

NOTE: There will be some samples collected on Thursday 9/11 that will be for Task CH505 that needs TO-15 as well as TO-3 (TPH Gas). Again, COC should clearly denote this.

We apologize for any confusion.

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 10:32 AM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: FW: Login for Air samples SDG 14I031

Hi Mark,

For some reason, I can't seem to find their notes being specific to atmospheric gases and not TPH-Gas. They did say TO3 Mod TPHG in their login sheet. I thought atmospheric gases are done by EPA 3C method. Anyhow, can you please confirm that ALS should be reporting the parameter as in the attachment example?

Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 9:11 AM
To: Ye Myint; Linh Pham
Cc: Andrew.Rippert@CH2M.com
Subject: FW: Login for Air samples SDG 14I031

Ye:

I completely overlooked the fact that the TO-3 method in the attached login is for atmospheric gases, NOT TPH-Gas. Please inform ALS Simi of this change.

Thanks

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Linh Pham [mailto:LPham@emaxlabs.com]
Sent: Friday, September 05, 2014 4:54 PM
To: Fesler, Mark/RDD
Cc: Rippert, Andrew/SFL; Ye Myint
Subject: Login for Air samples SDG 14I031

Hello Mark,
Attached please find login for Air Samples SDG 14I031.

Thanks

Linh

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

VOLATILE ORGANICS BY TO15

SDG#: 14I031

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
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F: +1 805 526 7270
www.alsglobal.com

LABORATORY REPORT

September 23, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: NASA SSFL

Dear Ye:

Enclosed are the results of the samples submitted to our laboratory on September 3, 2014. For your reference, these analyses have been assigned our service request number P1403556.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated Service Request No: P1403556
Project: NASA SSFL

CASE NARRATIVE

The samples were received intact under chain of custody on September 3, 2014 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the sample(s) at the time of sample receipt. At the client's request, the sample labeled "HAR19SV004" was cancelled.

Volatile Organic Compound Analysis

Sample HAR19SV003 (P1403556-001) was analyzed for volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The spike recoveries of trichlorofluoromethane and carbon tetrachloride in the Laboratory Control Sample (LCS) were outside the Laboratory generated control criteria. The recovery errors equate to a potential high bias. However, the recoveries in question were within the method criteria, therefore, the data quality is not significantly affected. No corrective action was taken.

The Summa canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated
Service Request: P1403556
Project ID: NASA SSFL

Date Received: 9/3/2014
Time Received: 12:40

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	TO-15 - VOC Cans
HAR19SV003	P1403556-001	Air	9/2/2014	13:39	1SC00121	-5.19	5.27	X
HAR19SV004	P1403556-002	Air	9/2/2014	13:46	1SC00927	-6.16	5.90	

Air - Chain of Custody Record & Analytical Service Request

Page ______ of ______

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard

ALS Project No P1403556

ALS Contact:

Company Name & Address (Reporting Information): Emax Laboratories

Project Name: NASA SSFL

Project Number:

Project Manager: ye myint

P.O. # / Billing Information:

Phone: 310 618 8889 Fax: 310 618 0818

Email Address for Result Reporting: ymyint@emaxlabs.com

Sampler (Print & Sign): John Lindquist

Analysis Method

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	TO-3	TO-15 extended	Comments e.g. Actual Preservative or specific instructions
HAR19SV003	① -5.17	9/2/14	1339	1SC00121	OA00185	29.5	12.5	1 l	~~TO-15~~ AIS	TO-15	Extended list
HAR19SV004	② -6.01	9/2/14	1346	1SC00927	OA01247	30.0	13.0	1 l	TO-03		
	-14.14										
	-14.16										

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) X
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ________ Units: ________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
[signature]	9/2/14	1400	[signature]		
[signature]	9/3/14		[signature]	9/3/14	1240

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated   Work order: P1403556
Project: NASA SSFL
Sample(s) received on: 9/3/14   Date opened: 9/3/14   by: KKELPE

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1403556-001.01	1.0 L Source Can					
P1403556-002.01	1.0 L Source Can					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

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EMAX

LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 09-26-2014
EMAX Batch No.: 14I089

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 09/08/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SVS006	I089-01	09/08/14	AIR	FIXED GASES BY EPA 3C VOLATILE ORGANICS BY TO15

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

FIXED GASES BY EPA 3C
VOLATILE ORGANICS BY TO15

SDG#: 14I089

2655 Park Center Dr., Suite A
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www.alsglobal.com

LABORATORY REPORT

September 25, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: NASA - CH499

Dear Ye:

Enclosed are the results of the sample submitted to our laboratory on September 8, 2014. For your reference, the analysis has been assigned our service request number P1403621.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated
Project: NASA - CH499

Service Request No: P1403621

CASE NARRATIVE

The sample was received intact under chain of custody on September 8, 2014 and was stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the sample at the time of sample receipt.

Fixed Gases Analysis

The sample was analyzed for fixed gases (hydrogen, oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD). This procedure is described in laboratory SOP VOA-EPA3C. This method is not included on the laboratory's NELAP or AIHA-LAP scope of accreditation.

Volatile Organic Compound Analysis

The sample was also analyzed for selected volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. The method was modified to include the use of helium as a diluent gas in place of zero-grade air for container pressurization. When necessary, analytical sample volumes were adjusted by a correction factor for containers pressurized with helium. A summary sheet has been included listing the affected samples. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The Summa canister was cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

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ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated — Service Request: P1403621
Project ID: NASA - CH499

Date Received: 9/8/2014
Time Received: 16:15

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	3C Modified - Fxd Gases Can	TO-15 Modified - VOC Cans
HAR19SVS006	P1403621-001	Air	9/8/2014	13:08	1SC00586	-4.89	5.37	X	X

Air - Chain of Custody Record & Analytical Service Request

Page 2 of 2

ALS
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Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard (circled)

ALS Project No. P1403621

ALS Contact:

Company Name & Address (Reporting Information): EMAX LABORATORIES

Project Name: NASA - CH505

Project Number:

Project Manager: VE. MYINT

Phone: 310 618 8889

Fax:

P.O. # / Billing Information:

Email Address for Result Reporting:

Sampler (Print & Sign): John Lindquist / [signature]

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	TO-15	EPA 3C	Comments e.g. Actual Preservative or specific instructions
HAR19SVS006	(1) -4.68	9/8/14	1308	1SC00586	OA 00956	-30+"	-13.5" Hg	1 L	X	X	
~~HAR19SVS006MS~~		~~9/8/14~~	~~1316~~ 1308	~~1SC00730~~	~~OA 00706~~	~~-30+"~~	~~-15.5"~~	~~1 L~~	~~X~~	~~X~~	~~MS/MSA~~
	-5.62										

JL

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) X
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES (circled) / No
Type: ____
Units: ug/L

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT (circled)

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	9/8/14	16:15	[signature]	9/8/14	1615

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated Work order: P1403621
Project: NASA - CH499
Sample(s) received on: 9/8/14 Date opened: 9/8/14 by: RMARTENIES

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1403621-001.01	1.0 L Source Can					

Explain any discrepancies: (include lab sample ID numbers):
Per client change project name to reference NASA - CH499.

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 09-24-2014
EMAX Batch No.: 14I090

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 09/05/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SVS005	I090-01	09/05/14	AIR	VOLATILE ORGANICS BY TO15
HAR19SVS005	I090-02	09/05/14	AIR	HOLD

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Linh Pham

From: Sue Anderson [Sue.Anderson@alsglobal.com]
Sent: Monday, September 08, 2014 2:02 PM
To: Ye Myint
Cc: Linh Pham
Subject: RE: Login for Air samples SDG 14I031

OK, I will cancel the C3-C12 for those 3 jobs and only report the standard SSFL list of 24 analytes.

Sue Anderson
Project Manager
ALS Life Sciences Division | Environmental

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:25 PM
To: Sue Anderson
Cc: Linh Pham
Subject: FW: Login for Air samples SDG 14I031

Hi Sue,

Latest updates on the samples you have received so far as of Friday last week! According to CH2M Hill, those 3 samples groups (P1403465 – received 8/27/14 , P1403556 – received 9/3/14, P1403604 – received 9/5/14) belong to CH 499 and that they only need TO-15 list, not TO-15 extended (TO-15 list + C3-C12). Also, as per Mark's confirmation below, can you please cancel and not report C3-C12 parameters for the 3 SDGs. They only need TO-15 list after all. Sorry for the confusion.

Below is what they will be requiring moving forward. They will clearly note on COCs as well in terms of the analyses that are required for each project.

CH 499 : TO-15 (TO15 list only) by TO15 and/or atmospheric fixed gases by EPA-3C method – See COC
CH 505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 1:14 PM
To: Ye Myint
Subject: RE: Login for Air samples SDG 14I031

Yes, thanks

Mark Fesler
Environmental Scientist

CH2M Hill

2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:02 PM
To: Edwards, Olivia/LAS; Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: RE: Login for Air samples SDG 14I031

Thanks Olivia.

Mark,

Do you want me to ask ALS to cancel C3-C12 for the three SDGs ALS has received so far since CH499 needs TO-15 regular list only as per Olivia's email below? Please advise ASAP. COCs for CH499 had TO-15 extended requested.

Andy,

Can you please be sure to indicate TO-15 only, not TO-15 extended on all future COCs for CH499?

Thanks.

Ye

310-618-8889 x121

From: Olivia.Edwards@CH2M.com [mailto:Olivia.Edwards@CH2M.com]
Sent: Monday, September 08, 2014 12:52 PM
To: Ye Myint; Mark.Fesler@CH2M.com
Cc: Linh Pham; Andrew.Rippert@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

TO-15 extended is only for CH505 only.
TO-15 and EPA-3C is for CH499 only.

However, please confirm that only one EPA-3C is collected for CH499 per event.

Thanks
Olivia

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 1:34 PM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL; Edwards, Olivia/LAS
Subject: RE: Login for Air samples SDG 14I031

Hi Mark,

When TO 15 is referenced (red below) for both CH505 and 499, I assume you actually need TO-15 extended list (TO15+C3-C12) by TO-15 Mod method as per our discussion at the start of the project. Below is my

understanding on the requirements for CH505 and CH499. Could you please confirm before I send it to ALS?

CH505 : TO-15 extended (TO15 list +C3-C12) by TO15 mod and/or TPH-Gas by TO-3 method - See COC
CH499 : TO-15 extended (TO15 list + C3-C12) by TO15 mod and/or atmospheric fixed gases by EPA-3C method – See COC

ALS also informed me that they pressurized the cans already, and they can't do fixed gases anymore for the three SDGs ALS received below. I have requested ALS to cancel TPH-G by TO3 for all 3 SDGs. It's critical that the correct methods are referenced on COCs moving forward since EMAX and ALS will be going by the analysis requests on COC (EPA-3C or TO-3) for all future air samples.

P1403465 – received 8/27/14
P1403556 – received 9/3/14
P1403604 – received 9/5/14

Please let me know if you have any questions. Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 11:52 AM
To: Ye Myint
Cc: Linh Pham; Andrew.Rippert@CH2M.com; Olivia.Edwards@CH2M.com
Subject: RE: Login for Air samples SDG 14I031

Ye:

OK, after talking with Andy Rippert, the following changes should be made:

- For 14H204 (ALS# P1403465), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)
- For 14I034 (ALS# P1403556), please cancel the analysis of TO-3 for TPH Gas (was supposed to have EPA 3C for atmospheric gases requested)

The above samples were all for Task CH499. Also, the samples that ALS received on Friday should be for CH499 as well. Andy will make sure the correct method and Task will be added to the COCs for CH499 samples being collected this week.

NOTE: There will be some samples collected on Thursday 9/11 that will be for Task CH505 that needs TO-15 as well as TO-3 (TPH Gas). Again, COC should clearly denote this.

We apologize for any confusion.

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Ye Myint [mailto:YMyint@emaxlabs.com]
Sent: Monday, September 08, 2014 10:32 AM
To: Fesler, Mark/RDD
Cc: Linh Pham; Rippert, Andrew/SFL
Subject: FW: Login for Air samples SDG 14I031

Hi Mark,

For some reason, I can't seem to find their notes being specific to atmospheric gases and not TPH-Gas. They did say TO3 Mod TPHG in their login sheet. I thought atmospheric gases are done by EPA 3C method. Anyhow, can you please confirm that ALS should be reporting the parameter as in the attachment example?

Thanks.

Ye

310-618-8889 x121

From: Mark.Fesler@CH2M.com [mailto:Mark.Fesler@CH2M.com]
Sent: Monday, September 08, 2014 9:11 AM
To: Ye Myint; Linh Pham
Cc: Andrew.Rippert@CH2M.com
Subject: FW: Login for Air samples SDG 14I031

Ye:

I completely overlooked the fact that the TO-3 method in the attached login is for atmospheric gases, NOT TPH-Gas. Please inform ALS Simi of this change.

Thanks

Mark Fesler
Environmental Scientist

CH2M Hill
2525 Airpark Dr
Redding CA 96001
(530) 229-3273
mark.fesler@ch2m.com

From: Linh Pham [mailto:LPham@emaxlabs.com]
Sent: Friday, September 05, 2014 4:54 PM
To: Fesler, Mark/RDD
Cc: Rippert, Andrew/SFL; Ye Myint
Subject: Login for Air samples SDG 14I031

Hello Mark,
Attached please find login for Air Samples SDG 14I031.

Thanks

Linh

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

VOLATILE ORGANICS BY TO15

SDG#: 14I090

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
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www.alsglobal.com

LABORATORY REPORT

September 24, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: NASA SSFL

Dear Ye:

Enclosed are the results of the sample submitted to our laboratory on September 5, 2014. For your reference, these analyses have been assigned our service request number P1403604.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated
Project: NASA SSFL

Service Request No: P1403604

CASE NARRATIVE

The sample was received intact under chain of custody on September 5, 2014 and was stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the sample at the time of sample receipt. At the client's request, the TO-3 analysis listed on the chain of custody was cancelled.

Volatile Organic Compound Analysis

The sample was analyzed for volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The Summa canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

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www.alsglobal.com

ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated — Service Request: P1403604

Project ID: NASA SSFL

Date Received: 9/5/2014

Time Received: 16:09

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)		TO-15 - VOC Cans
HAR19SVS005	P1403604-001	Air	9/5/2014	14:10	1SC00893	-7.53	5.23		X

Air - Chain of Custody Record & Analytical Service Request

Page ______ of ______

ALS
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Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard

ALS Project No: P1403604

ALS Contact:

Company Name & Address (Reporting Information): EMAX Laboratories

Project Name: NASA SSFL

Project Number:

Project Manager: Ye Myint

Phone: 310 618 8889 | Fax: 310 618 0818

P.O. # / Billing Information:

Email Address for Result Reporting: ymyint@emaxlabs.com

Sampler (Print & Sign): John Lindquist [signature]

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method: TO-15	Analysis Method: TO-3	Comments e.g. Actual Preservative or specific instructions
HAR19SVS005	① -7.5	9/5/14	1410	1SC00893	OA01096	30"	15"	1l	X	X	Ext. List
" "	② -5.0	9/5/14	1420	1SC00899	OA 01093	30+"		1l		~~X~~	Hold

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) ____
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ____________ Units: ________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	9/5/14	1609	[signature]	9/5/14	1609

Cooler / Blank Temperature _____°C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated   Work order: P1403604
Project: NASA SSFL
Sample(s) received on: 9/5/14   Date opened: 9/5/14   by: KKELPE

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1403604-001.01	1.0 L Source Can					
P1403604-002.01	1.0 L Source Can					

Explain any discrepancies: (include lab sample ID numbers): ______

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

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EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 09-30-2014
EMAX Batch No.: 14I164

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 09/12/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SVS006	I164-01	09/12/14	AIR	VOLATILE ORGANICS BY TO15 FIXED GASES BY EPA 3C

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

Linh Pham

From: Ye Myint
Sent: Tuesday, September 16, 2014 12:58 PM
To: 'Sue Anderson'
Cc: Linh Pham
Subject: RE: P1403701 - Clarification

Hi Sue,

Thanks for letting me know about the correction on the ID. CH499 needs TO 15 project standard list (not extended) and EPA 3C.

Ye

310-618-8889 x121

From: Sue Anderson [mailto:Sue.Anderson@alsglobal.com]
Sent: Tuesday, September 16, 2014 12:49 PM
To: Ye Myint
Subject: P1403701 - Clarification

Hi Ye,

My coworker logged this in and I saw that the ID incorrectly entered which I have fixed to HAR19SVS006. But I did also want confirm that it should be run for the standard compound list & 3c Mod and not the extended list. Thanks.

Sue Anderson
Project Manager
ALS Life Sciences Division | Environmental
2655 Park Center Drive, Suite A
Simi Valley, CA 93065USA

D +1 805 577 2086
T +1 805 526 7161
F +1 805 526 7270
How was your customer experience? Please send us your feedback.
http://www.alsglobal.com/

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

VOLATILE ORGANICS BY TO15
FIXED GASES BY EPA 3C

SDG#: 14I164

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
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LABORATORY REPORT

September 29, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: NASA CH499 - BVE

Dear Ye:

Enclosed are the results of the sample submitted to our laboratory on September 12, 2014. For your reference, these analyses have been assigned our service request number P1403701.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated
Project: NASA CH499 - BVE

Service Request No: P1403701

CASE NARRATIVE

The sample was received intact under chain of custody on September 12, 2014 and was stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

Fixed Gases Analysis

The sample was analyzed for fixed gases (hydrogen, oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD). This procedure is described in laboratory SOP VOA-EPA3C. This method is not included on the laboratory's NELAP or AIHA-LAP scope of accreditation.

Volatile Organic Compound Analysis

The sample was also analyzed for volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. The method was modified to include the use of helium as a diluent gas in place of zero-grade air for container pressurization. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The spike recovery of Methylene Chloride for the Laboratory Control Sample (LCS) was outside the laboratory generated control criterion. The recovery error equates to a potential high bias. However, the spike recovery of the analyte in question was within the method criteria; therefore, the data quality has not been significantly affected. No corrective action was taken.

The Summa canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

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www.alsglobal.com

ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated — Service Request: P1403701

Project ID: NASA CH499 - BVE

Date Received: 9/12/2014

Time Received: 15:15

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	3C Modified - Fxd Gases Can	TO-15 - VOC Cans
HAR19SVS006	P1403701-001	Air	9/12/2014	11:13	1SC00419	-5.26	5.52	X	X

Air - Chain of Custody Record & Analytical Service Request

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard

ALS Project No. P1403701

ALS Contact:

Company Name & Address (Reporting Information):

Project Name: NASA CH499 - BVB

Project Number:

Project Manager: Yc Myint

Phone: 310-618-3889

Fax:

P.O. # / Billing Information:

Email Address for Result Reporting:

Sampler (Print & Sign): John Lindquist [signature]

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method: TO-15	Analysis Method: EPA 3C	Comments e.g. Actual Preservative or specific instructions
① HAR19 SV5006		9/12/14	11:13	1SC00419	OA00074	30+	-13.5	1L	X	X	

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) X
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required (YES) No
Type: ____ Units: ug/L

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	9/12/14	1515	[signature]	9/12/14	1515

Cooler / Blank Temperature ____ °C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated   Work order: P1403701

Project: NASA CH499 - BVE

Sample(s) received on: 9/12/14   Date opened: 9/12/14   by: ADAVID

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1403701-001.01	1.0 L Source Can					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

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EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 11-14-2014
EMAX Batch No.: 14J158

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 10/22/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
HAR19SV008	J158-01	10/22/14	AIR	FIXED GASES BY EPA 3C VOLATILE ORGANICS BY TO15
HAR19SV009	J158-02	10/22/14	AIR	VOLATILE ORGANICS BY TO15

Subcontracted to ALS.

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

LABORATORY REPORT FOR

CH2M HILL

NASA SSFL

FIXED GASES BY EPA 3C
VOLATILE ORGANICS BY GC/MS

SDG#: 14J158

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
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www.alsglobal.com

LABORATORY REPORT

November 11, 2014

Ye Myint
Emax Laboratories, Incorporated
1835 W. 205th St.
Torrance, CA 90501

RE: CH499

Dear Ye:

Enclosed are the results of the samples submitted to our laboratory on October 22, 2014. For your reference, these analyses have been assigned our service request number P1404341.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Sue Anderson
Project Manager

2655 Park Center Dr., Suite A
Simi Valley, CA 93065
T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

Client: Emax Laboratories, Incorporated   Service Request No: P1404341
Project: CH499

CASE NARRATIVE

The samples were received intact under chain of custody on October 22, 2014 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

Fixed Gases Analysis

Sample HAR19SV008 (P1404341-001) was analyzed for fixed gases (hydrogen, oxygen/argon, nitrogen, carbon monoxide, methane and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD). This procedure is described in laboratory SOP VOA-EPA3C. This method is not included on the laboratory's NELAP or AIHA-LAP scope of accreditation.

Volatile Organic Compound Analysis

The samples were analyzed for selected volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. The method was modified to include the use of helium as a diluent gas in place of zero-grade air for container pressurization. When necessary, analytical sample volumes were adjusted by a correction factor for containers pressurized with helium. A summary sheet has been included listing the affected samples. This method is not included on the laboratory's AIHA-LAP scope of accreditation. Any analytes flagged with an X are not included on the laboratory's NELAP or DoD-ELAP scope of accreditation.

The Summa canister and Bottle Vac™ were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

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T: +1 805 526 7161
F: +1 805 526 7270
www.alsglobal.com

ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	643428
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	CA200007
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Emax Laboratories, Incorporated

Service Request: P1404341

Project ID: CH499

Date Received: 10/22/2014

Time Received: 16:40

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	3C Modified - Fxd Gases Can	TO-15 Modified - VOC Cans
HAR19SV008	P1404341-001	Air	10/22/2014	15:23	1SC00354	-2.87	4.96	X	X
HAR19SV009	P1404341-002	Air	10/22/2014	15:29	1BV02977	-3.14	5.26		X

ALS ENVIRONMENTAL
Sample Volume Correction for Helium Pressurization
for SCAN Analysis

Sample ID	Pi	Pf	Sample Volume (L)	Adjusted Volume (L)
P1404341-001	-1.18	5.41	0.031	0.0350

Air - Chain of Custody Record & Analytical Service Request

Page ______ of ______

ALS
2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10-Day-Standard

ALS Project No. P1404341

Company Name & Address (Reporting Information): EMAX labs /NASA

Project Name: CH 499

Project Number:

Project Manager: Ye Myint

P.O. # / Billing Information:

Phone:

Fax:

Email Address for Result Reporting: ymyint@EMAXlabs.com

Sampler (Print & Sign): John Lindquist

ALS Contact: Sue Anderson

Analysis Method

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	TO-15	EPA-3C	Comments e.g. Actual Preservative or specific instructions
HAR19SV008	① ~~10/22/14~~	10/22/14	1523	1SC00354	OA01148	28.5	4.5	1 l	X	X	Summa
HAR19SV009	② ~~10/22/14~~	10/22/14	1529	1BV02977	none	—	—		X		Bottle Vac

Report Tier Levels - please select

Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) ____
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ____________ Units: ________

Chain of Custody Seal: (Circle)
INTACT BROKEN ABSENT (circled)

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
[signature]	10/22/14	1000	[signature]	10/22/14	1240

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Emax Laboratories, Incorporated　　Work order: P1404341
Project: CH499
Sample(s) received on: 10/22/14　　Date opened: 10/22/14　　by: ADAVID

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

#	Question	Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ______ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1404341-001.01	1.0 L Source Can					
P1404341-002.01	1.0 L Bottle-Vac™					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

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EMAX
LABORATORIES, INC.
1835 W. 205th Street
Torrance, CA 90501
Tel: (310) 618-8889
Fax: (310) 618-0818

Date: 11-05-2014
EMAX Batch No.: 14J177

Attn: Mark Fesler

CH2M Hill
2525 Airpark Drive
Redding CA 96001

Subject: Laboratory Report
Project: NASA SSFL

Enclosed is the Laboratory report for samples received on 10/24/14.
The data reported relate only to samples listed below :

Sample ID	Control #	Col Date	Matrix	Analysis
CAQW2048Q001	J177-01	10/23/14	WATER	VOLATILE ORGANICS BY GC/MS
HAR19GW01S003	J177-02	10/23/14	WATER	VOLATILE ORGANICS BY GC/MS

The results are summarized on the following pages.

Please feel free to call if you have any questions concerning these results.

Sincerely yours,

Caspar J. Pang
Laboratory Director

EMAX certifies that results included in this report meets all NELAC & DOD requirements unless noted in the Case Narrative.

NELAC Accredited Certificate Number 02116CA
L-A-B Accredited DoD ELAP and ISO/IEC 17025 Certificate Number L2278 Testing

14J177

Chain of Custody Record

COC Number: **102314E**

CH2MHILL 10/23/2014 4:36:48 PM

Project Name SSFL **Location** Santa Susana Field Laboratory
Task Order **Project** CH 499 BVE
Project Number 474867.BV.01
Project Manager Olivia Edwards
Sample Manager Andrew Rippert (818) 466-8019
Turnaround Time 10 Days
PO Number 474867.BV.02

	Sample ID	Sample Date/Time		Type	Matrix	# Containers	Preserv	SW8260B
1	**CAQW2048Q001**	23-Oct-14	12:00	N	Water			
	VOCs				Field Filtered ☐	3	HCl, pH<2, 4'C	☑
					Total Containers:	3		
2	**HAR19GW01S003**	23-Oct-14	13:05	N	Water			
	VOCs				Field Filtered ☐	3	HCl, pH<2, 4'C	☑
					Total Containers:	3		

Temp. 1.0°C

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	10/23/14 1700
Relinquished by		
Received by	FedEx	
Relinquished by		
Received by	[signature]	10/24/14 09:17

Shipping Details
Method of Shipment: FedEx
On Ice: yes (circled) no
Airbill No:
Lab Name: EMAX Laboratories
Lab Phone: (310) 618-8889

ATTN:
Sample Custody
and
Ye Myint

Special Instructions:

Report Copy to
Andrew Rippert
2036100702

SAMPLE RECEIPT FORM 1

Reference Number: SM02.7.3

Type of Delivery	Airbill / Tracking Number	ECN 14J177	
☑ Fedex ☐ UPS ☐ GSO ☐ Others	7716 0976 0592	Recipient Cecelia	
☐ EMAX Courier ☐ Client Delivery		Date 10-24-14	Time 09:17

COC INSPECTION

☑ Client Name ☑ Client PM/FC ☑ Sampler Name ☑ Sampling Date/Time ☑ Sample ID ☑ Matrix

☐ Address ☑ Tel # / Fax # ☐ Courier Signature ☑ Analysis Required ☑ Preservative (if any) ☐ TAT

Safety Issues (if any) ☐ High concentrations expected ☐ From Superfund Site ☐ Rad screening required

Note: ______

PACKAGING INSPECTION

Container	☑ Cooler	☐ Box	☐ Other		
Condition	☑ Custody Seal	☐ Intact	☐ Damaged		
Packaging	☑ Bubble Pack	☐ Styrofoam	☐ Popcorn	☐ Sufficient	☐ ______
Temperatures (Cool, ≤6 °C but not frozen)	(A) ☑ Cooler 1 1.0 °C	☐ Cooler 2 ___ °C	☐ Cooler 3 ___ °C	☐ Cooler 4 ___ °C	☐ Cooler 5 ___ °C
	☐ Cooler 6 ___ °C	☐ Cooler 7 ___ °C	☐ Cooler 8 ___ °C	☐ Cooler 9 ___ °C	☐ Cooler 10 ___ °C
Thermometer:	(A) A - S/N 130538505	*B - S/N* ______	*C - S/N* ______	*D - S/N* ______	

Comments: ☐ **Temperature is out of range. PM was informed IMMEDIATELY.**

Note: ______

DISCREPANCIES

LabSampleID	LabSampleContainerID	Code	ClientSample Label ID / Information	Corrective Action
1,3	2,3	D10		R1

CO 10/24/14 ym 10/24/14

☐ pH holding time requirement for water samples is 15 mins. Water samples for pH analysis are received beyond 15 minutes from sampling time.

NOTES/OBSERVATIONS:

Sample #1-001 Cap improperly closed cap is tilted → R8 ym 10/24/14

LEGEND:

☐ **Continue to next page.**

Code	Description- Sample Management	Code	Description-Sample Management	Code	Description-Sample Management
D1	Analysis is not indicated in ______	D13	Out of Holding Time	R1	Proceed as indicated in ☒ COC ☐ Label
D2	Analysis mismatch COC vs label	D14	Bubble is >6mm	R2	Refer to attached instruction
D3	Sample ID mismatch COC vs label	D15	No trip blank in cooler	R3	Cancel the analysis
D4	Sample ID is not indicated in ______	D16	Preservation not indicated in ______	R4	Use vial with smallest bubble first
D5	Container -[improper] [leaking] [broken]	D17	Preservation mismatch COC vs label	R5	Log-in with latest sampling date and time+1 min
D6	Date/Time is not indicated in ______	D18	Insufficient chemical preservative	R6	Adjust pH as necessary
D7	Date/Time mismatch COC vs label	D19	Insufficient Sample	R7	Filter and preserved as necessary
D8	Sample listed in COC is not received	D20	No filtration info for dissolved analysis	R8	Use vial #2 or 3 first.
D9	Sample received is not listed in COC	D21	No sample for moisture determination	R9	
D10	No initial/date on corrections in COC (label)	D22		R10	
D11	Container count mismatch COC vs received	D23		R11	
D12	Container size mismatch COC vs received	D24		R12	

10/24/14

REVIEWS:

Sample Labeling	[signature]	**SRF**	[signature]	**PM**	[signature]
Date	10/24/14	**Date**	10/24/14	**Date**	10/24/14

From: (818) 466-8019
Andrew Rippert
CH2MHILL INC
NASA Santa Susana Field Laboratory
5800 Woolsey Canyon Road
Canoga Park, CA 91304

Origin ID: SFRA

FedEx Express

E

J142214092303uv

Ship Date: 23OCT14
ActWgt: 25.0 LB
CAD: 106467760/WSXI2500

Dims: 24 X 16 X 14 IN

Delivery Address Bar Code

SHIP TO: (310) 618-8889 BILL SENDER

Ye Myint
EMAX Laboratories
1835 W 205th St

Torrance, CA 90501

Ref # 474867.BV.02/AAB00110069
Invoice #
PO #
Dept #

FRI - 24 OCT 10:30A
PRIORITY OVERNIGHT

TRK# 7716 0976 0592
0201

90501
CA-US
LAX

92 HHRA

522G1/DF64/8AC9

REPORTING CONVENTIONS

DATA QUALIFIERS:

Lab Qualifier	AFCEE Qualifier	Description
J	F	Indicates that the analyte is positively identified and the result is less than RL but greater than MDL.
N		Indicates presumptive evidence of a compound.
B	B	Indicates that the analyte is found in the associated method blank as well as in the sample at above QC level.
E	J	Indicates that the result is above the maximum calibration range.
*	*	Out of QC limit.

Note: The above qualifiers are used to flag the results unless the project requires a different set of qualification criteria.

ACRONYMS AND ABBREVIATIONS:

CRDL	Contract Required Detection Limit
RL	Reporting Limit
MRL	Method Reporting Limit
PQL	Practical Quantitation Limit
MDL	Method Detection Limit
DO	Diluted out

DATES

The date and time information for leaching and preparation reflect the beginning date and time of the procedure unless the method, protocol, or project specifically requires otherwise.

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WORK ORDER NUMBER: 14-07-0897

The difference is service

AIR | SOIL | WATER | MARINE CHEMISTRY

Analytical Report For

Client: CH2M HILL

Client Project Name: 3Q 2014 GW / 478924.14

Attention: Jeremy Hilliard
325 E. Hillcrest Ave, Suite 125
Thousand Oaks, CA 91360-5828

Approved for release on 07/29/2014 by:
Richard Villafania
Project Manager

ResultLink ▸

Email your PM ▸

ACCREDITED IN ACCORDANCE WITH nelac

eurofins | Calscience

Contents

Client Project Name: 3Q 2014 GW / 478924.14
Work Order Number: 14-07-0897

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Work Order Narrative

Work Order: 14-07-0897 Page 1 of 1

Condition Upon Receipt:

Samples were received under Chain-of-Custody (COC) on 07/14/14. They were assigned to Work Order 14-07-0897.

Unless otherwise noted on the Sample Receiving forms all samples were received in good condition and within the recommended EPA temperature criteria for the methods noted on the COC. The COC and Sample Receiving Documents are integral elements of the analytical report and are presented at the back of the report.

Holding Times:

All samples were analyzed within prescribed holding times (HT) and/or in accordance with the Calscience Sample Acceptance Policy unless otherwise noted in the analytical report and/or comprehensive case narrative, if required.

Any parameter identified in 40CFR Part 136.3 Table II that is designated as "analyze immediately" with a holding time of <= 15 minutes (40CFR-136.3 Table II, footnote 4), is considered a "field" test and the reported results will be qualified as being received outside of the stated holding time unless received at the laboratory within 15 minutes of the collection time.

Quality Control:

All quality control parameters (QC) were within established control limits except where noted in the QC summary forms or described further within this report.

Additional Comments:

Air - Sorbent-extracted air methods (EPA TO-4A, EPA TO-10, EPA TO-13A, EPA TO-17): Analytical results are converted from mass/sample basis to mass/volume basis using client-supplied air volumes.

New York NELAP air certification does not certify for all reported methods and analytes, reference the accredited items here: http://www.calscience.com/PDF/New_York.pdf

Solid - Unless otherwise indicated, solid sample data is reported on a wet weight basis, not corrected for % moisture. All QC results are always reported on a wet weight basis.

Subcontractor Information:

Unless otherwise noted below (or on the subcontract form), no samples were subcontracted.

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Sample Summary

Client:	CH2M HILL	Work Order:	14-07-0897
	325 E. Hillcrest Ave, Suite 125	Project Name:	3Q 2014 GW / 478924.14
	Thousand Oaks, CA 91360-5828	PO Number:	
		Date/Time Received:	07/14/14 17:40
		Number of Containers:	27
Attn:	Jeremy Hilliard		

Sample Identification	Lab Number	Collection Date and Time	Number of Containers	Matrix
CAQW2011S001	14-07-0897-1	07/14/14 07:30	6	Aqueous
HAR19GW01S002	14-07-0897-2	07/14/14 09:54	21	Aqueous

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Sample Analysis Summary Report

Work Order: 14-07-0897

Method	Extraction	Chemist ID	Instrument	Analytical Location
EPA 1625C (M)	EPA 3520C	897	GC/MS III	1
EPA 300.0	N/A	811	IC 15	1
EPA 350.1	N/A	650	ACA 1	1
EPA 6850	N/A	110	LC/MS 1	1
EPA 8015B (M)	EPA 3510C	847	GC 48	1
EPA 8260B	EPA 5030C	796	GC/MS Z	2
EPA 8260B SIM	EPA 5030C	486	GC/MS M	2
EPA 8270C SIM	EPA 3510C	449	GC/MS MM	1
EPA 8330	Extraction	886	HPLC 7	1

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Location 1: 7440 Lincoln Way, Garden Grove, CA 92841
Location 2: 7445 Lampson Avenue, Garden Grove, CA 92841

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Glossary of Terms and Qualifiers

Work Order: 14-07-0897 Page 1 of 1

Qualifiers	Definition
*	See applicable analysis comment.
<	Less than the indicated value.
>	Greater than the indicated value.
1	Surrogate compound recovery was out of control due to a required sample dilution. Therefore, the sample data was reported without further clarification.
2	Surrogate compound recovery was out of control due to matrix interference. The associated method blank surrogate spike compound was in control and, therefore, the sample data was reported without further clarification.
3	Recovery of the Matrix Spike (MS) or Matrix Spike Duplicate (MSD) compound was out of control due to suspected matrix interference. The associated LCS recovery was in control.
4	The MS/MSD RPD was out of control due to suspected matrix interference.
5	The PDS/PDSD or PES/PESD associated with this batch of samples was out of control due to suspected matrix interference.
6	Surrogate recovery below the acceptance limit.
7	Surrogate recovery above the acceptance limit.
B	Analyte was present in the associated method blank.
BU	Sample analyzed after holding time expired.
BV	Sample received after holding time expired.
E	Concentration exceeds the calibration range.
ET	Sample was extracted past end of recommended max. holding time.
HD	The chromatographic pattern was inconsistent with the profile of the reference fuel standard.
HDH	The sample chromatographic pattern for TPH matches the chromatographic pattern of the specified standard but heavier hydrocarbons were also present (or detected).
HDL	The sample chromatographic pattern for TPH matches the chromatographic pattern of the specified standard but lighter hydrocarbons were also present (or detected).
J	Analyte was detected at a concentration below the reporting limit and above the laboratory method detection limit. Reported value is estimated.
JA	Analyte positively identified but quantitation is an estimate.
ME	LCS Recovery Percentage is within Marginal Exceedance (ME) Control Limit range (+/- 4 SD from the mean).
ND	Parameter not detected at the indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the parameter concentration in the sample exceeding the spike concentration by a factor of four or greater.
SG	The sample extract was subjected to Silica Gel treatment prior to analysis.
X	% Recovery and/or RPD out-of-range.
Z	Analyte presence was not confirmed by second column or GC/MS analysis.
	Solid - Unless otherwise indicated, solid sample data is reported on a wet weight basis, not corrected for % moisture. All QC results are reported on a wet weight basis.
	Any parameter identified in 40CFR Part 136.3 Table II that is designated as "analyze immediately" with a holding time of <= 15 minutes (40CFR-136.3 Table II, footnote 4), is considered a "field" test and the reported results will be qualified as being received outside of the stated holding time unless received at the laboratory within 15 minutes of the collection time.
	A calculated total result (Example: Total Pesticides) is the summation of each component concentration and/or, if "J" flags are reported, estimated concentration. Component concentrations showing not detected (ND) are summed into the calculated total result as zero concentrations.

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Chain of Custody Record

COC Number: **071414CGW**

CH2MHILL *7/14/2014 2:39:16 PM*

14-07-0897

Project Name **Location** Santa Susana Field Lab
Task Order **Project** 3Q 2014 GW
Project Number 478924.14
Project Manager Jeremy Hilliard
Sample Manager Andrew Rippert 818 466 8019
Turnaround Time 10 Days
PO Number 478924.14.01

Sample ID	Sample Date/Time	Type	Matrix	# Containers	Preserv	300.0	8270CSIM	SM4500NH3F	SW1625M-LL	SW6860	SW8015B	SW8260B	SW8260BSIM-LL	SW8270C	SW8315	SW8315A
(1) CAQW2011S001	14-Jul-14 7:30	TB	Water													
1,4-Dioxane			Field Filtered ☐	3	HCl, pH<2, 4'C	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐
VOCs			Field Filtered ☐	3	HCl, pH<2, 4'C	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐
			Total Containers:	6												

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by	[signature]	7/14/14
Sampled by		
Relinquished by		
Received by	[signature] ECE	7/14/14 1530
Relinquished by	[signature]	7/14/14 1740
Received by	Dannyle ECI	7/14/14 17:40

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: CalScience
Lab Phone: (949) 870-8766

ATTN:
Sample Custody
and
Michele Castro

Special Instructions:

Report Copy to
Jeremy Hillard
203 610 0702

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Chain of Custody Record

COC Number: **071414CGW**

CH2MHILL 7/14/2014 2:39:16 PM Page 2 of 2

0897

Project Name | **Location** Santa Susana Field Lab
Task Order | **Project** 3Q 2014 GW
Project Number 478924.14
Project Manager Jeremy Hilliard
Sample Manager Andrew Rippert 818 466 8019
Turnaround Time 10 Days
PO Number 478924.14.01

Sample ID	Sample Date/Time	Type	Matrix	# Containers	Preserv	300.0	8270CSIM	SM4500NH3F	SW1625M-LL	SW6860	SW8015B	SW8260B	SW8260BSIM-LL	SW8270C	SW8315	SW8315A
(2) HAR19GW01S002	14-Jul-14 9:54	N	Water													
1,4-Dioxane LL			Field Filtered ☐	3	HCl, pH<2, 4'C								X			
Formaldehyde			Field Filtered ☐	2	4'C											X
Fluoride, Nitrate			Field Filtered ☐	1	4'C	X										
Ammonia			Field Filtered ☐	1	H2SO4, pH<2, 4'C			X								
1,1-DMH, UDMH			Field Filtered ☐	2	4'C										X	
NDMA - LL			Field Filtered ☐	2	4'C				X							
incl. Pthalates			Field Filtered ☐	2	4'C		X									
Perchlorate			Field Filtered ☑	1	4'C					X						
Nitrobenzene, 1,3-dinitrobenzene			Field Filtered ☐	2	4'C									X		
DRO, Kerosene, Oils			Field Filtered ☐	2	4'C						X					
VOCs			Field Filtered ☐	3	HCl, pH<2, 4'C							X				

Total Containers: 21

MS = Matrix Spike **SD = Matrix Spike Duplicate**

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	7/14/14 1530
Relinquished by	[signature]	7/14/14 1530
Received by	ECC	7/14/14
Relinquished by	[signature]	7/14/14 1740
Received by	Banuyle EC	7/14/14 17:40

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no (yes circled)
Airbill No:
Lab Name: CalScience
Lab Phone: (949) 870-8766

ATTN:
Sample Custody
and
Michele Castro

Special Instructions:

Report Copy to
Jeremy Hillard
203 610 0702

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WORK ORDER #: 14-07-0897

SAMPLE RECEIPT FORM

Cooler 1 of 2

CLIENT: ______________________ **DATE:** 07/14/14

TEMPERATURE: Thermometer ID: SC1 (Criteria: 0.0 °C – 6.0 °C, not frozen except sediment/tissue)

Temperature 3.0 °C - 0.3 °C (CF) = 2.7 °C ☑ Blank ☐ Sample

☐ Sample(s) outside temperature criteria (PM/APM contacted by: ________)

☐ Sample(s) outside temperature criteria but received on ice/chilled on same day of sampling.

☐ **Received at ambient temperature, placed on ice for transport by Courier.**

Ambient Temperature: ☐ Air ☐ Filter **Checked by:** 820

CUSTODY SEALS INTACT:

☑ Cooler ☐ ________ ☐ No (Not Intact) ☐ Not Present ☐ N/A **Checked by:** 820

☐ Sample ☐ ________ ☐ No (Not Intact) ☑ Not Present **Checked by:** 920

SAMPLE CONDITION:	Yes	No	N/A
Chain-Of-Custody (COC) document(s) received with samples	☑	☐	☐
COC document(s) received complete	☑	☐	☐
☐ Collection date/time, matrix, and/or # of containers logged in based on sample labels.			
☐ No analysis requested. ☐ Not relinquished. ☐ No date/time relinquished.			
Sampler's name indicated on COC	☑	☐	☐
Sample container label(s) consistent with COC	☑	☐	☐
Sample container(s) intact and good condition	☑	☐	☐
Proper containers and sufficient volume for analyses requested	☑	☐	☐
Analyses received within holding time	☑	☐	☐
Aqueous samples received within 15-minute holding time			
☐ pH ☐ Residual Chlorine ☐ Dissolved Sulfides ☐ Dissolved Oxygen	☐	☐	☑
Proper preservation noted on COC or sample container	☑	☐	☐
☐ Unpreserved vials received for Volatiles analysis			
Volatile analysis container(s) free of headspace	☑	☐	☐
Tedlar bag(s) free of condensation	☐	☐	☑

CONTAINER TYPE:

Solid: ☐4ozCGJ ☐8ozCGJ ☐16ozCGJ ☐Sleeve (_____) ☐EnCores® ☐TerraCores® ☐________

Aqueous: ☐VOA ☑VOAh (6) ☐VOAna₂ ☐125AGB ☐125AGBh ☐125AGBp ☑1AGB (12) ☐1AGBna₂ ☑1AGBs

☐500AGB ☐500AGJ ☐500AGJs ☐250AGB ☐250CGB ☐250CGBs ☐1PB ☐1PBna ☐500PB

☐250PB ☐250PBn ☑125PB ☐125PBznna ☑100PJ (filtered) ① ~~☑100PJna₂~~ 619 7/14/14 ☐ ☐________ ☐________

2 of 6 (14070A)

Air: ☐Tedlar® ☐Canister **Other:** ☐________ **Trip Blank Lot#:** 4 of 6 N/A **Labeled/Checked by:** 920

Container: **C:** Clear **A:** Amber **P:** Plastic **G:** Glass **J:** Jar **B:** Bottle **Z:** Ziploc/Resealable Bag **E:** Envelope **Reviewed by:** 619

Preservative: **h:** HCL **n:** HNO_3 **na₂:** $Na_2S_2O_3$ **na:** NaOH **p:** H_3PO_4 **s:** H_2SO_4 **u:** Ultra-pure **znna:** $ZnAc_2$+NaOH **f:** Filtered **Scanned by:** 619

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WORK ORDER #: 14-07-0897

SAMPLE RECEIPT FORM

Cooler 2 of 2

CLIENT: CH2M HILL

DATE: 07/14/14

TEMPERATURE: Thermometer ID: SC1 (Criteria: 0.0 °C – 6.0 °C, not frozen except sediment/tissue)

Temperature 2 . 9 °C - 0.3 °C (CF) = 2 . 6 °C ☑ Blank ☐ Sample

☐ Sample(s) outside temperature criteria (PM/APM contacted by: ______)

☐ Sample(s) outside temperature criteria but received on ice/chilled on same day of sampling.

☐ **Received at ambient temperature, placed on ice for transport by Courier.**

Ambient Temperature: ☐ Air ☐ Filter Checked by: 820

CUSTODY SEALS INTACT:

☑ Cooler ☐ ______ ☐ No (Not Intact) ☐ Not Present ☐ N/A Checked by: 820

☐ Sample ☐ ______ ☐ No (Not Intact) ☑ Not Present Checked by: 920

SAMPLE CONDITION:	Yes	No	N/A
Chain-Of-Custody (COC) document(s) received with samples	☑	☐	☐
COC document(s) received complete	☑	☐	☐
☐ Collection date/time, matrix, and/or # of containers logged in based on sample labels.			
☐ No analysis requested. ☐ Not relinquished. ☐ No date/time relinquished.			
Sampler's name indicated on COC	☑	☐	☐
Sample container label(s) consistent with COC	☑	☐	☐
Sample container(s) intact and good condition	☑	☐	☐
Proper containers and sufficient volume for analyses requested	☑	☐	☐
Analyses received within holding time	☑	☐	☐
Aqueous samples received within 15-minute holding time			
☐ pH ☐ Residual Chlorine ☐ Dissolved Sulfides ☐ Dissolved Oxygen	☐	☐	☑
Proper preservation noted on COC or sample container	☑	☐	☐
☐ Unpreserved vials received for Volatiles analysis			
Volatile analysis container(s) free of headspace	☐	☐	☑
Tedlar bag(s) free of condensation	☐	☐	☑

CONTAINER TYPE:

Solid: ☐4ozCGJ ☐8ozCGJ ☐16ozCGJ ☐Sleeve (______) ☐EnCores® ☐TerraCores® ☐______

Aqueous: ☐VOA ☐VOAh ☐VOAna₂ ☐125AGB ☐125AGBh ☐125AGBp ☑1AGB ☐1AGBna₂ ☐1AGBs ☐500AGB ☐500AGJ ☐500AGJs ☐250AGB ☐250CGB ☐250CGBs ☐1PB ☐1PBna ☐500PB ☐250PB ☐250PBn ☐125PB ☐125PBznna ☐100PJ ☐100PJna₂ ☐______ ☐______ ☐______

Air: ☐Tedlar® ☐Canister **Other:** ☐______ **Trip Blank Lot#:**______ **Labeled/Checked by:** 920

Container: C: Clear A: Amber P: Plastic G: Glass J: Jar B: Bottle Z: Ziploc/Resealable Bag E: Envelope **Reviewed by:** 689

Preservative: h: HCL n: HNO_3 na₂: $Na_2S_2O_3$ na: NaOH p: H_3PO_4 s: H_2SO_4 u: Ultra-pure znna: $ZnAc_2$+NaOH f: Filtered **Scanned by:** 689

Attachment B
Data Validation Reports

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ATTACHMENT B

Data Validation Reports

Data validation reports presented in this attachment were generated using a Microsoft Access-based validation tool created by CH2M HILL, Inc. (a wholly owned subsidiary of Jacobs Engineering Group Inc.). The reports provide a detailed summary of the data validation findings, as well as the final analytical results for each sample, including any data qualification flags that may have been applied. The qualification flag is followed by an annotated validation reason code for applying the flag. Following is a table that lists the validation reason code, a brief description of the reason code, and the corresponding Santa Susana Field Laboratory qualification code.

Validation Reason Code	Description	SSFL Qualification Code
>ICLinearRange	Result greater than linear calibration range	C
AB<RL	Ambient blank concentration less than RL	F
AB>MDL	Ambient blank concentration greater than the MDL	F
AB>RL	Ambient blank concentration greater than the RL	F
CCB<RL	Continuing calibration blank concentration less than RL	B
CCB>RL	Continuing calibration blank concentration exceeds RL	B
CCV<LCL	Continuing calibration recovery less than lower control limit	C
CCV<RF	SPCC exceeds RF > 0.300 criteria	R
CCV>UCL	Continuing calibration recovery greater than upper control limit	C
CF>RPD	Confirmation Precision Exceeded	*DVR
Coelution	Compounds were reported combined on one column	*DVR
EB<RL	Equipment blank concentration less than the RL	F
EB>MDL	Equipment blank concentration greater than the MDL	F
EB>RL	Equipment blank concentration greater than the RL	F
EMPC	Estimated Maximum Possible Concentration	*DVR
exclude	Data not used; another value is appropriate or data was not requested	D
FB<RL	Field blank concentration less than RL	F
FB>RL	Field blank concentration greater than the RL	F
FD>RPD	Field duplicate exceeds RPD criteria	*DVR
HTa>UCL	Analysis holding time exceeded	H
HTp>UCL	Preparation/extraction holding time exceeded	H
IC RRF	Initial calibration relative response factor below LCL	R
IC%RSD	Initial calibration RSD exceeded	C
ICB<RL	Initial calibration blank concentration less than the RL	B
ICVS<LCL	Second source verification std. recovery less than lower control limit	C

Validation Reason Code	Description	SSFL Qualification Code
ICVS>UCL	Second source verification std. recovery greater than upper control limit	C
ImproperPres	Sample improperly preserved or handled prior to analysis	*DVR
InvalidLabFlag	Remove lab UN Flag	(No flag)
IS<LCL	Internal standard response less than lower control limit	I
IS>UCL	Internal standard response greater than upper control limit	I
Lab Dup RPD	Lab duplicate exceeds RPD criteria	E
LB<RL	Laboratory blank contamination less than the RL	B
LB>MDL	Laboratory blank contamination greater than the MDL	B
LB>RL	Laboratory blank contamination greater than the RL	B
LCS<LCL	LCS recovery less than lower control limit	L
LCS>UCL	LCS recovery greater than upper control limit	L
LCSRPD	LCSD RPD criteria exceeded	L
MS<LCL	Matrix spike recovery less than lower limit	Q
MS>UCL	Matrix spike recovery greater than upper limit	Q
MSRPD	Matrix spike RPD criteria exceedance	Q
NoLCS	No LCS in the analytical batch	L
PostSpike<LCL	Post spike recovery less than the lower control limit	P
PostSpike>UCL	Post spike recovery greater than the upper control limit	P
RE	Re-extraction and/or re-analysis	D
RemoveBLabFlag	Lab B flag removed - analyte not detected in sample	$
SD<LCL	Matrix spike duplicate recovery criteria less than lower limit	Q
SD>UCL	Matrix spike duplicate recovery criteria greater than upper limit	Q
SerlDil>UCL	Serial Dilution %D greater than the upper control limit	A
Sur<LCL	Surrogate recovery less than lower limit	S
Sur>UCL	Surrogate recovery greater than upper limit	S
TB<RL	Trip blank concentration less than RL	T
TB>RL	Trip blank concentration greater than the RL	T
TEMP>8C	Temperature Blank>8C	*DVR
TIC	Tentatively identified compound	(No flag)

CH 499 BVE
Data Quality Evaluation

SDG	**3H42601**		**Reviewer:**	**jbeckett**
Method	**SW8260B**		**Date:**	**10/6/2014**
Matrix	**AIR**		**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-203D-SV-S001	N	20			
PZ-203D-SV-S001	N	0.2			
PZ-203D-SV-S001	LR	20			
PZ-203D-SV-S001	LR	0.2			
Equipment Blank	EB	1			
Equipment Blank	EB	0.2			
PZ-204C-SV-S001	N	10			
PZ-204C-SV-S001	N	0.2			

1. Case Narrative

Items of Interest

The following items were noted: LabDupRPD

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met. These samples were out of control: Trichloroethene (PZ-203D-SV-S001, %RPD = 72.29 vs 50),

Matrix Spike

No MS's for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
Matrix Spike: No MS's for this SDG.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **PZ-203D-SV-S001**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**6.6**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**3.1**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**19**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**2.7**	J		0.078	0.4		UG/L	Lab Dup RPD (J)
Trichloroethene	**21**	J		0.23	0.4		UG/L	Lab Dup RPD (J)
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**1.9**			0.2	0.4		UG/L	

Field ID: **PZ-204C-SV-S001**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**7.8**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**0.25**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**30**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	

Validated Form I

Field ID: **PZ-204C-SV-S001**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**2**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

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Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
Lab Dup RPD	Lab duplicate exceeds RPD criteria	Duplicate

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CH 499 BVE
Data Quality Evaluation

SDG	**3I40201**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-203D-SV-S002	LR	20			
PZ-203D-SV-S002	N	0.2			
PZ-203D-SV-S002	N	20			
PZ-203D-SV-S002	LR	0.2			
Equipment Blank_090214	EB	0.2			
Equipment Blank_090214	EB	1			
PZ-202A-SV-S002	N	0.2			
PZ-202A-SV-S002	N	1			
PZ-204D-SV-S002	N	0.2			
PZ-204D-SV-S002	N	20			
PZ-201C-SV-S002	N	5			
PZ-201C-SV-S002	N	0.2			
PZ-203C-SV-S002	N	5			
PZ-203C-SV-S002	N	0.2			
PZ-203V-SV-S002	N	0.2			
PZ-203V-SV-S002	N	5			
PZ-202C-SV-S002	N	0.2			
PZ-202C-SV-S002	N	5			
PZ-156-SV-S002	N	0.2			
PZ-156-SV-S002	N	10			
HAR-19-SV-S002	N	0.2			
HAR-19-SV-S002	N	20			
PZ-201B-SV-S002	N	0.2			
PZ-201B-SV-S002	N	5			
PZ-204A-SV-S002	N	5			
PZ-204A-SV-S002	N	0.2			

1. Case Narrative
Items of Interest

No items of concern.

2. Blank Summary
Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met.

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: ID incorrect for PZ-202C
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

ID incorrect for PZ-202C

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ-203D-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**5**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**2.1**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**5.8**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**1.4**			0.078	0.4		UG/L	
Trichloroethene	**10**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**0.43**			0.2	0.4		UG/L	

Field ID: PZ-202A-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.1**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	0.0094	U	U	0.0094	0.02		UG/L	
Dichlorodifluoromethane	**0.21**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	

Validated Form I

Field ID: PZ-202A-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**0.013**	J	J	0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Field ID: PZ-204D-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**4.7**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**0.93**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**39**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.97**			0.078	0.4		UG/L	
Trichloroethene	**1.9**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**0.62**			0.2	0.4		UG/L	

Field ID: PZ-201C-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**2.5**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**0.41**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**17**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	

Validated Form I

Field ID: PZ-201C-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.14**			0.019	0.1		UG/L	
Trichloroethene	**6**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-203C-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.87**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**1.4**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**2.8**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**1.5**			0.019	0.1		UG/L	
Trichloroethene	**5.3**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	**0.3**			0.051	0.1		UG/L	

Field ID: PZ-203V-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.82**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	

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Field ID: PZ-203V-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
cis-1,2-Dichloroethene	0.047	U	U	0.047	0.1		UG/L	
Dichlorodifluoromethane	**8.4**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	0.019	U	U	0.019	0.1		UG/L	
Trichloroethene	**0.14**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-202C-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.57**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**1.8**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**2.3**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.17**			0.019	0.1		UG/L	
Trichloroethene	**4.7**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-156-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**180**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	

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Field ID: PZ-156-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	0.094	U	U	0.094	0.2		UG/L	
Dichlorodifluoromethane	**94**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**0.65**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: HAR-19-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**92**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**11**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**39**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**1.4**			0.078	0.4		UG/L	
Trichloroethene	**120**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**6.4**			0.2	0.4		UG/L	

Field ID: PZ-201B-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**6.5**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	

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Field ID: PZ-201B-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**0.15**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**27**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	0.019	U	U	0.019	0.1		UG/L	
Trichloroethene	**2**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-204A-SV-S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**2.3**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**0.14**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**9.9**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	0.019	U	U	0.019	0.1		UG/L	
Trichloroethene	**1.1**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

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CH 499 BVE

Data Quality Evaluation

SDG	**3I40501**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-203D-SV-S003	LR	20			
PZ-203D-SV-S003	N	0.2			
PZ-203D-SV-S003	N	20			
PZ-203D-SV-S003	LR	0.2			
Equipment Blank_090514	EB	0.2			
Equipment Blank_090514	EB	1			
PZ-202A-SV-S003	N	0.2			
PZ-202A-SV-S003	N	1			
PZ-202D-SV-S003	N	0.2			
PZ-202D-SV-S003	N	10			
PZ-204D-SV-S003	N	10			
PZ-204D-SV-S003	N	0.2			
PZ-204C-SV-S003	N	10			
PZ-204C-SV-S003	N	0.2			
PZ-201B-SV-S003	N	0.2			
PZ-201B-SV-S003	N	20			
PZ-203C-SV-S003	N	0.2			
PZ-203C-SV-S003	N	20			
PZ-061-SV-S003	N	0.2			
PZ-061-SV-S003	N	1			
PZ-156-SV-S003	N	0.2			
PZ-156-SV-S003	N	50			
HAR-19-DISCHARGE	N	20			
HAR-19-DISCHARGE	N	0.2			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met.

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **PZ-203D-SV-S003**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.4**	J	J	0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**2.2**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**1.9**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.77**			0.078	0.4		UG/L	
Trichloroethene	**7**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**0.41**			0.2	0.4		UG/L	

Field ID: **PZ-202A-SV-S003**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.32**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**0.017**	J	J	0.0094	0.02		UG/L	
Dichlorodifluoromethane	**0.52**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	

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Field ID: PZ-202A-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	**0.011**	J	J	0.0053	0.02		UG/L	
Toluene	**0.006**	J	J	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**0.052**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Field ID: PZ-202D-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.98**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**1.6**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**4.9**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	**0.17**	J	J	0.039	0.2		UG/L	
Trichloroethene	**3.4**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: PZ-204D-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**6.6**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**1.4**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**45**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	

Validated Form I

Field ID: PZ-204D-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	**1.6**			0.039	0.2		UG/L	
Trichloroethene	**2.9**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	**1.3**			0.1	0.2		UG/L	

Field ID: PZ-204C-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**8.4**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**0.43**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**36**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**3.5**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: PZ-201B-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.55**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	

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Field ID: PZ-201B-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
cis-1,2-Dichloroethene	**1.1**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**2**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	**20**			0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.55**			0.078	0.4		UG/L	
Trichloroethene	**3.9**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: PZ-203C-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**5.6**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	0.19	U	U	0.19	0.4		UG/L	
Dichlorodifluoromethane	**25**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	0.078	U	U	0.078	0.4		UG/L	
Trichloroethene	**2**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: PZ-061-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	0.012	U	U	0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	

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Field ID: PZ-061-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	0.0094	U	U	0.0094	0.02		UG/L	
Dichlorodifluoromethane	0.011	U	U	0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	**0.27**			0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	**0.006**	J	J	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**0.033**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Field ID: PZ-156-SV-S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,1-Trichloroethane	0.27	U	U	0.27	1		UG/L	
1,1,2,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,2-Trichloroethane	0.31	U	U	0.31	1		UG/L	
1,1,2-Trichloro-trifluoroethane	**180**			0.59	1		UG/L	
1,1-Dichloroethane	0.31	U	U	0.31	1		UG/L	
1,1-Dichloroethene	0.36	U	U	0.36	1		UG/L	
1,2-Dichloroethane	0.53	U	U	0.53	1		UG/L	
Benzene	0.2	U	U	0.2	1		UG/L	
Carbon tetrachloride	0.58	U	U	0.58	1		UG/L	
Chloroethane	0.8	U	U	0.8	1		UG/L	
Chloroform	0.3	U	U	0.3	1		UG/L	
cis-1,2-Dichloroethene	0.47	U	U	0.47	1		UG/L	
Dichlorodifluoromethane	**98**			0.55	1		UG/L	
Ethylbenzene	0.15	U	U	0.15	1		UG/L	
meta- and para-Xylenes	0.4	U	U	0.4	1		UG/L	
Methylene Chloride	0.52	U	U	0.52	1		UG/L	
ortho-Xylene	0.44	U	U	0.44	1		UG/L	
Tetrachloroethene	0.27	U	U	0.27	1		UG/L	
Toluene	0.21	U	U	0.21	1		UG/L	
trans-1,2-Dichloroethene	0.19	U	U	0.19	1		UG/L	
Trichloroethene	0.58	U	U	0.58	1		UG/L	
Trichlorofluoromethane	0.27	U	U	0.27	1		UG/L	
Vinyl Chloride	0.51	U	U	0.51	1		UG/L	

Field ID: HAR-19-DISCHARGE

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**130**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	

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Field ID: HAR-19-DISCHARGE

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**16**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**39**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.9**			0.078	0.4		UG/L	
Trichloroethene	**200**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**6.4**			0.2	0.4		UG/L	

Validated Form I

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CH 499 BVE
Data Quality Evaluation

SDG	**3I40801**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-203D-SV-S004	LR	20			
PZ-203D-SV-S004	N	0.2			
PZ-203D-SV-S004	N	20			
PZ-203D-SV-S004	LR	0.2			
Equipment Blank_090814	EB	0.2			
Equipment Blank_090814	EB	1			
PZ-203V-SV-S004	N	0.2			
PZ-203V-SV-S004	N	5			
PZ-202C-SV-S004	N	0.2			
PZ-202C-SV-S004	N	5			
PZ-202D-SV-S004	N	5			
PZ-202D-SV-S004	N	0.2			
PZ-204D-SV-S004	N	5			
PZ-204D-SV-S004	N	0.2			
PZ-204C-SV-S004	N	0.2			
PZ-204C-SV-S004	N	5			
PZ-201D-SV-S004	N	0.2			
PZ-201D-SV-S004	N	10			
PZ-201B-SV-S004	N	0.2			
PZ-201B-SV-S004	N	10			
RD-104-SV-S004	N	0.2			
RD-104-SV-S004	N	10			
HAR-19-SV-S004	N	50			
HAR-19-SV-S004	N	0.2			

1. Case Narrative
Items of Interest

No items of concern.

2. Blank Summary
Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates
Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met.

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ-203D-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**12**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**5.2**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**5.3**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**2.3**			0.078	0.4		UG/L	
Trichloroethene	**25**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: PZ-203V-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**1.6**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	0.047	U	U	0.047	0.1		UG/L	
Dichlorodifluoromethane	**9.5**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	

Validated Form I

Field ID: PZ-203V-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	0.019	U	U	0.019	0.1		UG/L	
Trichloroethene	**0.25**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-202C-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.82**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**2.6**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**3.5**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.22**			0.019	0.1		UG/L	
Trichloroethene	**7.2**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	**0.14**			0.051	0.1		UG/L	

Field ID: PZ-202D-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**1.6**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**1.9**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**6.3**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	

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Field ID: PZ-202D-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**25**			0.019	0.1		UG/L	
Trichloroethene	**5.8**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-204D-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**7.4**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**2.3**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**50**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**2.1**			0.019	0.1		UG/L	
Trichloroethene	**6.3**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	**1.3**			0.051	0.1		UG/L	

Field ID: PZ-204C-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**9.4**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	

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Field ID: PZ-204C-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
cis-1,2-Dichloroethene	**0.74**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**42**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.065**	J	J	0.019	0.1		UG/L	
Trichloroethene	**5.1**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-201D-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.69**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**1.2**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**10**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**13**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: PZ-201B-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**6.2**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	

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Field ID: PZ-201B-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	0.094	U	U	0.094	0.2		UG/L	
Dichlorodifluoromethane	**26**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**2.5**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: RD-104-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	0.12	U	U	0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**0.15**	J	J	0.094	0.2		UG/L	
Dichlorodifluoromethane	0.11	U	U	0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	0.039	U	U	0.039	0.2		UG/L	
Trichloroethene	**0.93**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: HAR-19-SV-S004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,1-Trichloroethane	0.27	U	U	0.27	1		UG/L	
1,1,2,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,2-Trichloroethane	0.31	U	U	0.31	1		UG/L	
1,1,2-Trichloro-trifluoroethane	**15**			0.59	1		UG/L	
1,1-Dichloroethane	0.31	U	U	0.31	1		UG/L	

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Field ID: **HAR-19-SV-S004**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-Dichloroethene	0.36	U	U	0.36	1		UG/L	
1,2-Dichloroethane	0.53	U	U	0.53	1		UG/L	
Benzene	0.2	U	U	0.2	1		UG/L	
Carbon tetrachloride	0.58	U	U	0.58	1		UG/L	
Chloroethane	0.8	U	U	0.8	1		UG/L	
Chloroform	0.3	U	U	0.3	1		UG/L	
cis-1,2-Dichloroethene	**2.2**			0.47	1		UG/L	
Dichlorodifluoromethane	**5.6**			0.55	1		UG/L	
Ethylbenzene	0.15	U	U	0.15	1		UG/L	
meta- and para-Xylenes	0.4	U	U	0.4	1		UG/L	
Methylene Chloride	0.52	U	U	0.52	1		UG/L	
ortho-Xylene	0.44	U	U	0.44	1		UG/L	
Tetrachloroethene	0.27	U	U	0.27	1		UG/L	
Toluene	0.21	U	U	0.21	1		UG/L	
trans-1,2-Dichloroethene	0.19	U	U	0.19	1		UG/L	
Trichloroethene	**29**			0.58	1		UG/L	
Trichlorofluoromethane	0.27	U	U	0.27	1		UG/L	
Vinyl Chloride	0.51	U	U	0.51	1		UG/L	

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CH 499 BVE

Data Quality Evaluation

SDG	**3I41201**		**Reviewer:**	**jbeckett**
Method	**SW8260B**		**Date:**	**10/6/2014**
Matrix	**AIR**		**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-203D-SV-S005	LR	20			
PZ-203D-SV-S005	N	0.2			
PZ-203D-SV-S005	N	20			
PZ-203D-SV-S005	LR	0.2			
Equipment Blank_091214	EB	0.2			
Equipment Blank_091214	EB	1			
PZ-203C-SV-S005	N	0.2			
PZ-203C-SV-S005	N	1			
PZ-202D-SV-S005	N	0.2			
PZ-202D-SV-S005	N	1			
PZ-202A-SV-S005	N	1			
PZ-202A-SV-S005	N	0.2			
PZ-204D-SV-S005	N	20			
PZ-204D-SV-S005	N	0.2			
PZ-204C-SV-S005	N	0.2			
PZ-204C-SV-S005	N	5			
PZ-156-SV-S005	N	0.2			
PZ-156-SV-S005	N	50			
PZ-201D-SV-S005	N	0.2			
PZ-201D-SV-S005	N	20			
HAR-19-SV-S005	N	0.2			
HAR-19-SV-S005	N	50			
PZ-061-SV-S005	N	1			
PZ-061-SV-S005	N	0.2			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met.

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ-203D-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	0.24	U	U	0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**2.7**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**2**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.88**			0.078	0.4		UG/L	
Trichloroethene	**8.6**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**0.54**			0.2	0.4		UG/L	

Field ID: PZ-203C-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	0.012	U	U	0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	0.0094	U	U	0.0094	0.02		UG/L	
Dichlorodifluoromethane	0.011	U	U	0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	

Validated Form I

Field ID: PZ-203C-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	**0.006**	J	J	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**0.038**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Field ID: PZ-202D-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.9**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**1.7**			0.0094	0.02		UG/L	
Dichlorodifluoromethane	**4.3**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	**0.0056**	J	J	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	**0.32**			0.0039	0.02		UG/L	
Trichloroethene	**4**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	**0.018**	J	J	0.01	0.02		UG/L	

Field ID: PZ-202A-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.92**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**0.23**			0.0094	0.02		UG/L	
Dichlorodifluoromethane	**0.67**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	

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Field ID: PZ-202A-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	**0.01**	J	J	0.0053	0.02		UG/L	
Toluene	**0.005**	J	J	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**5.1**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	**0.038**			0.01	0.02		UG/L	

Field ID: PZ-204D-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**3.1**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**1.1**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**19**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**0.92**			0.078	0.4		UG/L	
Trichloroethene	**2.8**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**1.5**			0.2	0.4		UG/L	

Field ID: PZ-204C-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**8.8**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	

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Field ID: PZ-204C-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
cis-1,2-Dichloroethene	**0.88**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**40**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.14**			0.019	0.1		UG/L	
Trichloroethene	**6.3**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	**0.28**			0.051	0.1		UG/L	

Field ID: PZ-156-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,1-Trichloroethane	0.27	U	U	0.27	1		UG/L	
1,1,2,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,2-Trichloroethane	0.31	U	U	0.31	1		UG/L	
1,1,2-Trichloro-trifluoroethane	**44**			0.59	1		UG/L	
1,1-Dichloroethane	0.31	U	U	0.31	1		UG/L	
1,1-Dichloroethene	0.36	U	U	0.36	1		UG/L	
1,2-Dichloroethane	0.53	U	U	0.53	1		UG/L	
Benzene	0.2	U	U	0.2	1		UG/L	
Carbon tetrachloride	0.58	U	U	0.58	1		UG/L	
Chloroethane	0.8	U	U	0.8	1		UG/L	
Chloroform	0.3	U	U	0.3	1		UG/L	
cis-1,2-Dichloroethene	0.47	U	U	0.47	1		UG/L	
Dichlorodifluoromethane	**26**			0.55	1		UG/L	
Ethylbenzene	0.15	U	U	0.15	1		UG/L	
meta- and para-Xylenes	0.4	U	U	0.4	1		UG/L	
Methylene Chloride	0.52	U	U	0.52	1		UG/L	
ortho-Xylene	0.44	U	U	0.44	1		UG/L	
Tetrachloroethene	0.27	U	U	0.27	1		UG/L	
Toluene	**0.4**	J	J	0.21	1		UG/L	
trans-1,2-Dichloroethene	0.19	U	U	0.19	1		UG/L	
Trichloroethene	0.58	U	U	0.58	1		UG/L	
Trichlorofluoromethane	0.27	U	U	0.27	1		UG/L	
Vinyl Chloride	0.51	U	U	0.51	1		UG/L	

Field ID: PZ-201D-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**0.37**	J	J	0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	

Validated Form I

Field ID: PZ-201D-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**1.5**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**7.6**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	0.078	U	U	0.078	0.4		UG/L	
Trichloroethene	**8.3**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: HAR-19-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,1-Trichloroethane	0.27	U	U	0.27	1		UG/L	
1,1,2,2-Tetrachloroethane	0.45	U	U	0.45	1		UG/L	
1,1,2-Trichloroethane	0.31	U	U	0.31	1		UG/L	
1,1,2-Trichloro-trifluoroethane	**240**			0.59	1		UG/L	
1,1-Dichloroethane	0.31	U	U	0.31	1		UG/L	
1,1-Dichloroethene	0.36	U	U	0.36	1		UG/L	
1,2-Dichloroethane	0.53	U	U	0.53	1		UG/L	
Benzene	0.2	U	U	0.2	1		UG/L	
Carbon tetrachloride	0.58	U	U	0.58	1		UG/L	
Chloroethane	0.8	U	U	0.8	1		UG/L	
Chloroform	0.3	U	U	0.3	1		UG/L	
cis-1,2-Dichloroethene	**28**			0.47	1		UG/L	
Dichlorodifluoromethane	**80**			0.55	1		UG/L	
Ethylbenzene	0.15	U	U	0.15	1		UG/L	
meta- and para-Xylenes	0.4	U	U	0.4	1		UG/L	
Methylene Chloride	0.52	U	U	0.52	1		UG/L	
ortho-Xylene	0.44	U	U	0.44	1		UG/L	
Tetrachloroethene	0.27	U	U	0.27	1		UG/L	
Toluene	0.21	U	U	0.21	1		UG/L	
trans-1,2-Dichloroethene	**2**			0.19	1		UG/L	
Trichloroethene	**400**			0.58	1		UG/L	
Trichlorofluoromethane	0.27	U	U	0.27	1		UG/L	
Vinyl Chloride	**12**			0.51	1		UG/L	

Field ID: PZ-061-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	0.012	U	U	0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	

Validated Form I

Field ID: PZ-061-SV-S005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	0.0094	U	U	0.0094	0.02		UG/L	
Dichlorodifluoromethane	0.011	U	U	0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	0.0039	U	U	0.0039	0.02		UG/L	
Trichloroethene	**0.016**	J	J	0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Validated Form I

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CH 499 BVE
Data Quality Evaluation

SDG	**3J42201**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**12/9/2014**
Matrix	**AIR**	**Reviewed:**	**12/11/2014**

Field Samples
Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
PZ-202D-SV-S006	LR	1			
PZ-202D-SV-S006	N	0.2			
PZ-202D-SV-S006	N	1			
PZ-202D-SV-S006	LR	0.2			
Equipment Blank_102214	EB	0.2			
Equipment Blank_102214	EB	1			
PZ-201D-SV-S006	N	0.2			
PZ-201D-SV-S006	N	1			
PZ-201B-SV-S006	N	0.2			
PZ-201B-SV-S006	N	1			
PZ-204D-SV-S006	N	5			
PZ-204D-SV-S006	N	0.2			
PZ-204C-SV-S006	N	5			
PZ-204C-SV-S006	N	0.2			
PZ-203D-SV-S006	N	0.2			
PZ-203D-SV-S006	N	1			
PZ-203D-SV-S006	N	20			
PZ-203C-SV-S006	N	0.2			
PZ-203C-SV-S006	N	10			
PZ-156-SV-S006	N	0.2			
PZ-156-SV-S006	N	20			
HAR-19-1-SV-S006	N	0.2			
HAR-19-1-SV-S006	N	20			
HAR-19-2-SV-S006	N	20			
HAR-19-2-SV-S006	N	0.2			

1. Case Narrative
Items of Interest
No items of concern.

2. Blank Summary
Field Blanks
No Field Blank detects were found.

Method Blanks
No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

All acceptance criteria were met.

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

All acceptance criteria were met.

COC Review

No discrepancies.

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Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ-202D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**1.4**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**1**			0.0094	0.02		UG/L	
Dichlorodifluoromethane	**4.9**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	**0.31**			0.0039	0.02		UG/L	
Trichloroethene	**3.3**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	0.01	U	U	0.01	0.02		UG/L	

Field ID: PZ-201D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**1.4**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**1.7**			0.0094	0.02		UG/L	
Dichlorodifluoromethane	**20**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	

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Field ID: PZ-201D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	0.0043	U	U	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	**0.27**			0.0039	0.02		UG/L	
Trichloroethene	**15**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	**0.29**			0.01	0.02		UG/L	

Field ID: PZ-201B-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.0054	U	U	0.0054	0.02		UG/L	
1,1,2,2-Tetrachloroethane	0.0089	U	U	0.0089	0.02		UG/L	
1,1,2-Trichloroethane	0.0063	U	U	0.0063	0.02		UG/L	
1,1,2-Trichloro-trifluoroethane	**8.4**			0.012	0.02		UG/L	
1,1-Dichloroethane	0.0062	U	U	0.0062	0.02		UG/L	
1,1-Dichloroethene	0.0072	U	U	0.0072	0.02		UG/L	
1,2-Dichloroethane	0.011	U	U	0.011	0.02		UG/L	
Benzene	0.0041	U	U	0.0041	0.02		UG/L	
Carbon tetrachloride	0.012	U	U	0.012	0.02		UG/L	
Chloroethane	0.016	U	U	0.016	0.02		UG/L	
Chloroform	0.006	U	U	0.006	0.02		UG/L	
cis-1,2-Dichloroethene	**0.15**			0.0094	0.02		UG/L	
Dichlorodifluoromethane	**36**			0.011	0.02		UG/L	
Ethylbenzene	0.003	U	U	0.003	0.02		UG/L	
meta- and para-Xylenes	0.008	U	U	0.008	0.02		UG/L	
Methylene Chloride	0.01	U	U	0.01	0.02		UG/L	
ortho-Xylene	0.0089	U	U	0.0089	0.02		UG/L	
Tetrachloroethene	0.0053	U	U	0.0053	0.02		UG/L	
Toluene	**0.0074**	J	J	0.0043	0.02		UG/L	
trans-1,2-Dichloroethene	**0.063**			0.0039	0.02		UG/L	
Trichloroethene	**3.8**			0.012	0.02		UG/L	
Trichlorofluoromethane	0.0053	U	U	0.0053	0.02		UG/L	
Vinyl Chloride	**0.098**			0.01	0.02		UG/L	

Field ID: PZ-204D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**9.9**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**0.77**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**45**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	

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Field ID: PZ-204D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**0.067**	J	J	0.019	0.1		UG/L	
Trichloroethene	**5.1**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	0.051	U	U	0.051	0.1		UG/L	

Field ID: PZ-204C-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,1-Trichloroethane	0.027	U	U	0.027	0.1		UG/L	
1,1,2,2-Tetrachloroethane	0.045	U	U	0.045	0.1		UG/L	
1,1,2-Trichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1,2-Trichloro-trifluoroethane	**4.2**			0.059	0.1		UG/L	
1,1-Dichloroethane	0.031	U	U	0.031	0.1		UG/L	
1,1-Dichloroethene	0.036	U	U	0.036	0.1		UG/L	
1,2-Dichloroethane	0.053	U	U	0.053	0.1		UG/L	
Benzene	0.02	U	U	0.02	0.1		UG/L	
Carbon tetrachloride	0.058	U	U	0.058	0.1		UG/L	
Chloroethane	0.08	U	U	0.08	0.1		UG/L	
Chloroform	0.03	U	U	0.03	0.1		UG/L	
cis-1,2-Dichloroethene	**1.6**			0.047	0.1		UG/L	
Dichlorodifluoromethane	**43**			0.055	0.1		UG/L	
Ethylbenzene	0.015	U	U	0.015	0.1		UG/L	
meta- and para-Xylenes	0.04	U	U	0.04	0.1		UG/L	
Methylene Chloride	0.052	U	U	0.052	0.1		UG/L	
ortho-Xylene	0.044	U	U	0.044	0.1		UG/L	
Tetrachloroethene	0.027	U	U	0.027	0.1		UG/L	
Toluene	0.021	U	U	0.021	0.1		UG/L	
trans-1,2-Dichloroethene	**2.7**			0.019	0.1		UG/L	
Trichloroethene	**3.6**			0.058	0.1		UG/L	
Trichlorofluoromethane	0.027	U	U	0.027	0.1		UG/L	
Vinyl Chloride	**1.5**			0.051	0.1		UG/L	

Field ID: PZ-203D-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.009	U	U	0.009	0.02		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**27**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	

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Field ID: **PZ-203D-SV-S006**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
cis-1,2-Dichloroethene	**4.7**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**12**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**3.6**			0.078	0.4		UG/L	
Trichloroethene	**25**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: **PZ-203C-SV-S006**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.09	U	U	0.09	0.2		UG/L	
1,1,1-Trichloroethane	0.054	U	U	0.054	0.2		UG/L	
1,1,2,2-Tetrachloroethane	0.089	U	U	0.089	0.2		UG/L	
1,1,2-Trichloroethane	0.063	U	U	0.063	0.2		UG/L	
1,1,2-Trichloro-trifluoroethane	**1.7**			0.12	0.2		UG/L	
1,1-Dichloroethane	0.062	U	U	0.062	0.2		UG/L	
1,1-Dichloroethene	0.072	U	U	0.072	0.2		UG/L	
1,2-Dichloroethane	0.11	U	U	0.11	0.2		UG/L	
Benzene	0.041	U	U	0.041	0.2		UG/L	
Carbon tetrachloride	0.12	U	U	0.12	0.2		UG/L	
Chloroethane	0.16	U	U	0.16	0.2		UG/L	
Chloroform	0.06	U	U	0.06	0.2		UG/L	
cis-1,2-Dichloroethene	**1.4**			0.094	0.2		UG/L	
Dichlorodifluoromethane	**2.2**			0.11	0.2		UG/L	
Ethylbenzene	0.03	U	U	0.03	0.2		UG/L	
meta- and para-Xylenes	0.08	U	U	0.08	0.2		UG/L	
Methylene Chloride	0.1	U	U	0.1	0.2		UG/L	
ortho-Xylene	0.089	U	U	0.089	0.2		UG/L	
Tetrachloroethene	0.053	U	U	0.053	0.2		UG/L	
Toluene	0.043	U	U	0.043	0.2		UG/L	
trans-1,2-Dichloroethene	**2.1**			0.039	0.2		UG/L	
Trichloroethene	**7.3**			0.12	0.2		UG/L	
Trichlorofluoromethane	0.053	U	U	0.053	0.2		UG/L	
Vinyl Chloride	0.1	U	U	0.1	0.2		UG/L	

Field ID: **PZ-156-SV-S006**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**100**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	

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Field ID: PZ-156-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	0.19	U	U	0.19	0.4		UG/L	
Dichlorodifluoromethane	**58**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	0.078	U	U	0.078	0.4		UG/L	
Trichloroethene	0.23	U	U	0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	0.2	U	U	0.2	0.4		UG/L	

Field ID: HAR-19-1-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**96**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**15**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**51**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**1.8**			0.078	0.4		UG/L	
Trichloroethene	**190**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**5.4**			0.2	0.4		UG/L	

Field ID: HAR-19-2-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,1-Trichloroethane	0.11	U	U	0.11	0.4		UG/L	
1,1,2,2-Tetrachloroethane	0.18	U	U	0.18	0.4		UG/L	
1,1,2-Trichloroethane	0.13	U	U	0.13	0.4		UG/L	
1,1,2-Trichloro-trifluoroethane	**99**			0.24	0.4		UG/L	
1,1-Dichloroethane	0.12	U	U	0.12	0.4		UG/L	

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Field ID: HAR-19-2-SV-S006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-Dichloroethene	0.14	U	U	0.14	0.4		UG/L	
1,2-Dichloroethane	0.21	U	U	0.21	0.4		UG/L	
Benzene	0.081	U	U	0.081	0.4		UG/L	
Carbon tetrachloride	0.23	U	U	0.23	0.4		UG/L	
Chloroethane	0.32	U	U	0.32	0.4		UG/L	
Chloroform	0.12	U	U	0.12	0.4		UG/L	
cis-1,2-Dichloroethene	**16**			0.19	0.4		UG/L	
Dichlorodifluoromethane	**51**			0.22	0.4		UG/L	
Ethylbenzene	0.06	U	U	0.06	0.4		UG/L	
meta- and para-Xylenes	0.16	U	U	0.16	0.4		UG/L	
Methylene Chloride	0.21	U	U	0.21	0.4		UG/L	
ortho-Xylene	0.18	U	U	0.18	0.4		UG/L	
Tetrachloroethene	0.11	U	U	0.11	0.4		UG/L	
Toluene	0.085	U	U	0.085	0.4		UG/L	
trans-1,2-Dichloroethene	**1.6**			0.078	0.4		UG/L	
Trichloroethene	**190**			0.23	0.4		UG/L	
Trichlorofluoromethane	0.11	U	U	0.11	0.4		UG/L	
Vinyl Chloride	**5.2**			0.2	0.4		UG/L	

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CH 499 BVE
Data Quality Evaluation

SDG	**14G152**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/23/2014**
Matrix	**Soil/Water**	**Reviewed:**	**10/24/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
SOIL					
PZ203RCS001	N	49			
PZ203RCS002	N	49			
PZ203RCS003	N	47			
PZ203RCS004	N	49			
PZ203RCS005	N	49			
PZ203RCS006	N	49			
WATER					
CAQW2022S001	TB	1			

1. Case Narrative

Items of Interest

The following items were noted: LCS>UCL, LCSD>UCL, LCSRPD

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CARBON TETRACHLORIDE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).

Matrix	QAQC Type	Field ID	Analyte	Recovery	Lower Limit	Upper Limit

SOIL	BD	LCD3S	CHLOROETHANE	138	60	120
SOIL	BS	LCS3S	CHLOROETHANE	133	60	120

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

These NativeIDs exceeded holding time: PZ203RCS001, PZ203RCS002, PZ203RCS003, PZ203RCS004, PZ203RCS005, PZ203RCS006. For rock core analysis, samples were extracted with Methanol within 14 days of sample collection, and allowed to equilibrate over a 5-wk period prior to analysis. Holding time was not exceeded, and no flagging was applied.

Field ID	LabsampleID	AnalysisDate	ExtractDate	Sample Date	Method Time	Actual HT
PZ203RCS001	G152-01I	9/14/2014	9/14/2014	7/17/2014	14	59
PZ203RCS001	G152-01I	9/12/2014	9/12/2014	7/17/2014	14	57
PZ203RCS001	G152-01N	9/24/2014	9/24/2014	7/17/2014	14	69
PZ203RCS002	G152-02I	9/12/2014	9/12/2014	7/17/2014	14	57
PZ203RCS002	G152-02I	9/14/2014	9/14/2014	7/17/2014	14	59
PZ203RCS002	G152-02N	9/24/2014	9/24/2014	7/17/2014	14	69
PZ203RCS003	G152-03I	9/14/2014	9/14/2014	7/17/2014	14	59
PZ203RCS003	G152-03I	9/12/2014	9/12/2014	7/17/2014	14	57
PZ203RCS003	G152-03N	9/24/2014	9/24/2014	7/17/2014	14	69
PZ203RCS004	G152-04I	9/14/2014	9/14/2014	7/18/2014	14	58
PZ203RCS004	G152-04I	9/12/2014	9/12/2014	7/18/2014	14	56
PZ203RCS004	G152-04N	9/24/2014	9/24/2014	7/18/2014	14	68
PZ203RCS005	G152-05I	9/12/2014	9/12/2014	7/18/2014	14	56
PZ203RCS005	G152-05I	9/14/2014	9/14/2014	7/18/2014	14	58
PZ203RCS005	G152-05N	9/24/2014	9/24/2014	7/18/2014	14	68
PZ203RCS006	G152-06I	9/12/2014	9/12/2014	7/18/2014	14	56
PZ203RCS006	G152-06I	9/14/2014	9/14/2014	7/18/2014	14	58
PZ203RCS006	G152-06N	9/24/2014	9/24/2014	7/18/2014	14	68

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV

Initial Calibration: No DV
Continuing Calibration: No DV
Laboratory Control Sample: These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CARBON TETRACHLORIDE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).
Holding Time: These NativeIDs exceeded holding time: PZ203RCS001, PZ203RCS002, PZ203RCS003, PZ203RCS004, PZ203RCS005, PZ203RCS006.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ203RCS001

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS001

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	LCSD>UCL (none)
	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	LCSRPD (none)
	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	470	U	U	230	470		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	470	U	U	94	470		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
2-HEXANONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
ACETONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMOFORM	230	U	U	94	230		UG/KG	HTa>UCL (none)
BROMOMETHANE	470	U	U	94	470		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	230	U	U	47	230		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
	2.4	U	U	1.2	2.4		UG/KG	LCSRPD (none)
CHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
CHLOROETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
	230	U	U	94	230		UG/KG	LCS>UCL (none)

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Field ID: PZ203RCS003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
	230	U	U	94	230		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.4	U	U	4.7	9.4		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	230	U	U	47	230		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	230	U	U	47	230		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
	230	U	U	94	230		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.7	U	U	2.4	4.7		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	470	U	U	230	470		UG/KG	HTa>UCL (none)
MTBE	230	U	U	47	230		UG/KG	HTa>UCL (none)
NAPHTHALENE	470	U	U	94	470		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
	230	U	U	47	230		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
	230	U	U	47	230		UG/KG	LCSRPD (none)
STYRENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	940	U	U	470	940		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	LCSD>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	LCSRPD (none)
	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Validation Flag Abbreviations

Abbreviation	Validation Reason	Category
HTa>UCL	Holding time exceeded	HoldingTime
LCS>UCL	LCS recovery greater than the upper control limit	LaboratoryControlSample
LCSD>UCL	LCSD recovery greater than the upper control limit	LaboratoryControlSample
LCSRPD	LCS RPD criteria exceeded	LaboratoryControlSample

CH 499 BVE

Data Quality Evaluation

SDG	**14G180**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/23/2014**
Matrix	**SOIL**	**Reviewed:**	**10/24/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
SOIL					
PZ203RCD012	FD	49			
PZ203RCS007	N	49			
PZ203RCS008	N	48			
PZ203RCS009	N	49			
PZ203RCS010	N	48			
PZ203RCS011	N	49			
PZ203RCS012	N	49			
PZ203RCS013	N	48			
PZ203RCS014	N	48			
PZ203RCS015	N	49			
PZ203RCS016	N	49			
PZ203RCS017	N	49			

1. Case Narrative

Items of Interest

The following items were noted: FD>RPD, LCS>UCL, LCSD>UCL, LCSRPD, Sur<LCL, Sur>UCL

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

These samples were out of control: TRICHLOROETHENE (PZ203RCS012, %RPD = 58.82 vs 50).

Matrix /Analyte/SampleID	*Result*	*Field Duplicate Qualifier**	*Criteria*
SOIL			
TRICHLOROETHENE			
PZ203RCD012	30 UG/KG	J	FD>RPD
PZ203RCS012	55 UG/KG	J	FD>RPD

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CARBON TETRACHLORIDE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).

Matrix	QAQC Type	Field ID	Analyte	Recovery	Lower Limit	Upper Limit
SOIL	BD	LCD3S	CHLOROETHANE	138	60	120
SOIL	BS	LCS3S	CHLOROETHANE	133	60	120

5. Surrogates

These surrogates were out of control: 1,2-DICHLOROETHANE-D4 (PZ203RCS009), 1,2-DICHLOROETHANE-D4 (PZ203RCS014), 4-BROMOFLUOROBENZENE (PZ203RCS008), 4-BROMOFLUOROBENZENE (PZ203RCS009), 4-BROMOFLUOROBENZENE (PZ203RCS013), 4-BROMOFLUOROBENZENE (PZ203RCS014), 4-BROMOFLUOROBENZENE (PZ203RCS016), TOLUENE-D8 (PZ203RCS009), TOLUENE-D8 (PZ203RCS014), TOLUENE-D8 (PZ203RCS017).

Field ID	LabsampleID	UpperLimit	LowerLimit	Result	Surrogate
PZ203RCS008	G180-03N	121	74	62.1	4-BROMOFLUOROBENZENE
PZ203RCS009	G180-04I	121	74	57.3	4-BROMOFLUOROBENZENE
PZ203RCS009	G180-04N	129	78	73.2	1,2-DICHLOROETHANE-D4
PZ203RCS009	G180-04N	121	74	141	4-BROMOFLUOROBENZENE
PZ203RCS009	G180-04N	124	77	74	TOLUENE-D8
PZ203RCS013	G180-08I	121	74	67.4	4-BROMOFLUOROBENZENE
PZ203RCS013	G180-08N	121	74	63.6	4-BROMOFLUOROBENZENE
PZ203RCS014	G180-09N	129	78	70.4	1,2-DICHLOROETHANE-D4
PZ203RCS014	G180-09N	121	74	148	4-BROMOFLUOROBENZENE
PZ203RCS014	G180-09N	124	77	76.2	TOLUENE-D8
PZ203RCS016	G180-11N	121	74	71.6	4-BROMOFLUOROBENZENE
PZ203RCS017	G180-12N	124	77	72.9	TOLUENE-D8

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

These NativeIDs exceeded holding time: PZ203RCD012, PZ203RCS007, PZ203RCS008, PZ203RCS009, PZ203RCS010, PZ203RCS011, PZ203RCS012, PZ203RCS013, PZ203RCS014, PZ203RCS015, PZ203RCS016, PZ203RCS017. For rock core analysis, samples were extracted with Methanol within 14 days of sample collection, and allowed to equilibrate over a 5-wk period prior to analysis. Holding time was not exceeded, and no flagging was applied.

Field ID	LabsampleID	AnalysisDate	ExtractDate	Sample Date	Method Time	Actual HT
PZ203RCD012	G180-01I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCD012	G180-01I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCD012	G180-01N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS007	G180-02I	9/12/2014	9/12/2014	7/21/2014	14	53

PZ203RCS007	G180-02I	9/13/2014	9/13/2014	7/21/2014	14	54
PZ203RCS007	G180-02N	9/24/2014	9/24/2014	7/21/2014	14	65
PZ203RCS008	G180-03I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS008	G180-03I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS008	G180-03N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS009	G180-04I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS009	G180-04I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS009	G180-04N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS010	G180-05I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS010	G180-05I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS010	G180-05N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS011	G180-06I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS011	G180-06I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS011	G180-06N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS012	G180-07I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS012	G180-07I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS012	G180-07N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS013	G180-08I	9/12/2014	9/12/2014	7/22/2014	14	52
PZ203RCS013	G180-08I	9/13/2014	9/13/2014	7/22/2014	14	53
PZ203RCS013	G180-08N	9/24/2014	9/24/2014	7/22/2014	14	64
PZ203RCS014	G180-09I	9/12/2014	9/12/2014	7/23/2014	14	51
PZ203RCS014	G180-09I	9/13/2014	9/13/2014	7/23/2014	14	52
PZ203RCS014	G180-09N	9/24/2014	9/24/2014	7/23/2014	14	63
PZ203RCS015	G180-10I	9/12/2014	9/12/2014	7/23/2014	14	51
PZ203RCS015	G180-10I	9/13/2014	9/13/2014	7/23/2014	14	52
PZ203RCS015	G180-10N	9/24/2014	9/24/2014	7/23/2014	14	63
PZ203RCS016	G180-11I	9/12/2014	9/12/2014	7/23/2014	14	51
PZ203RCS016	G180-11I	9/14/2014	9/14/2014	7/23/2014	14	53
PZ203RCS016	G180-11N	9/24/2014	9/24/2014	7/23/2014	14	63
PZ203RCS017	G180-12I	9/12/2014	9/12/2014	7/23/2014	14	51
PZ203RCS017	G180-12I	9/14/2014	9/14/2014	7/23/2014	14	53
PZ203RCS017	G180-12N	9/24/2014	9/24/2014	7/23/2014	14	63

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: These samples were out of control: TRICHLOROETHENE (PZ203RCS012, %RPD = 58.82 vs 50).
Form I Review: No samples were excluded for dilutions or re-extractions.
Surrogates: These surrogates were out of control: 1,2-DICHLOROETHANE-D4 (PZ203RCS009), 1,2-DICHLOROETHANE-D4 (PZ203RCS014), 4-BROMOFLUOROBENZENE (PZ203RCS008), 4-BROMOFLUOROBENZENE (PZ203RCS009), 4-BROMOFLUOROBENZENE (PZ203RCS013), 4-BROMOFLUOROBENZENE (PZ203RCS014), 4-BROMOFLUOROBENZENE (PZ203RCS016), TOLUENE-D8 (PZ203RCS009), TOLUENE-D8 (PZ203RCS014), TOLUENE-D8 (PZ203RCS017).
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
Laboratory Control Sample: These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CARBON TETRACHLORIDE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).
Holding Time: These NativeIDs exceeded holding time: PZ203RCD012, PZ203RCS007, PZ203RCS008, PZ203RCS009, PZ203RCS010, PZ203RCS011, PZ203RCS012, PZ203RCS013, PZ203RCS014, PZ203RCS015, PZ203RCS016, PZ203RCS017.
COC: No discrepancies.

VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ203RCD012

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	**2.1**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCD012

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	**3.2**	J	J	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	**1.4**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**30**	J		1.2	2.5		UG/KG	HTa>UCL (none)
	30	J		1.2	2.5		UG/KG	FD>RPD (J)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS007

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS007

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS008

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	UJ	U	1.2	2.4		UG/KG	LCSRPD (none)
	2.4	UJ	U	1.2	2.4		UG/KG	Sur<LCL (UJ)
	2.4	UJ	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS008

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS009

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	UJ	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	UJ	U	1.2	2.5		UG/KG	LCSRPD (none)
	2.5	UJ	U	1.2	2.5		UG/KG	Sur<LCL (UJ)
	2.5	UJ	U	1.2	2.5		UG/KG	Sur<LCL (UJ)
	2.5	UJ	U	1.2	2.5		UG/KG	Sur<LCL (UJ)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**3.3**			1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS011

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**10**			1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	**3.9**			1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**55**	J		1.2	2.5		UG/KG	FD>RPD (J)
	55	J		1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	UJ	U	1.2	2.4		UG/KG	HTa>UCL (none)
	2.4	UJ	U	1.2	2.4		UG/KG	LCSRPD (none)
	2.4	UJ	U	1.2	2.4		UG/KG	Sur<LCL (UJ)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**1.3**	J	J	1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	**1.9**	J	J	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	UJ	U	1.2	2.4		UG/KG	Sur<LCL (UJ)
	2.4	UJ	U	1.2	2.4		UG/KG	Sur<LCL (UJ)
	2.4	UJ	U	1.2	2.4		UG/KG	LCSRPD (none)
	2.4	UJ	U	1.2	2.4		UG/KG	HTa>UCL (none)
	2.4	UJ	U	1.2	2.4		UG/KG	Sur>UCL (none)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	**1.9**	J	J	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS014

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	**7.3**			1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**5.4**			1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS015

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ203RCS015

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	LCSRPD (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**2.3**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS016

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	UJ	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	UJ	U	1.2	2.5		UG/KG	LCSRPD (none)
	2.5	UJ	U	1.2	2.5		UG/KG	Sur<LCL (UJ)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	**4.6**			1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Field ID: **PZ203RCS016**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	**8.2**			1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**25**			1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: **PZ203RCS017**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS017

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	UJ	U	1.2	2.5		UG/KG	HTa>UCL (none)
	2.5	UJ	U	1.2	2.5		UG/KG	LCSRPD (none)
	2.5	UJ	U	1.2	2.5		UG/KG	Sur<LCL (UJ)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	LCSRPD (none)
	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	**1.7**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**3.8**			1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Validation Flag Abbreviations

Abbreviation	Validation Reason	Category
FD>RPD	Field duplicate exceeds RPD criteria	FieldDuplicate
HTa>UCL	Holding time exceeded	HoldingTime
LCS>UCL	LCS recovery greater than the upper control limit	LaboratoryControlSample
LCSD>UCL	LCSD recovery greater than the upper control limit	LaboratoryControlSample
LCSRPD	LCS RPD criteria exceeded	LaboratoryControlSample
Sur<LCL	Surrogate recovery less than the lower control limit	SurrogateRecovery
Sur>UCL	Surrogate recovery greater than the upper control limit	SurrogateRecovery

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CH 499 BVE

Data Quality Evaluation

SDG	**14G199**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/23/2014**
Matrix	**Soil/Water**	**Reviewed:**	**10/24/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
SOIL					
PZ202RCS004	N	50			
PZ202RCS005	N	49			
PZ202RCS006	N	48			
PZ202RCS007	N	490			
PZ202RCS007	N	49			
PZ202RCS008	N	47			
PZ202RCS009	N	49			
PZ202RCS010	N	49			
PZ202RCS011	N	49			
PZ202RCS012	N	49			
PZ202RCS013	N	49			
PZ203RCS018	N	49			
WATER					
CAQW2028S001	TB	1			

1. Case Narrative

Items of Interest

The following items were noted: LCS>UCL, LCSD>UCL, LCSRPD

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CHLOROETHANE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).

Matrix	QAQC Type	Field ID	Analyte	Recovery	Lower Limit	Upper Limit
SOIL	BD	LCD1S	CHLOROETHANE	138	60	120
SOIL	BS	LCS1S	CHLOROETHANE	133	60	120

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

These NativeIDs exceeded holding time: PZ202RCS004, PZ202RCS005, PZ202RCS006, PZ202RCS007, PZ202RCS008, PZ202RCS009, PZ202RCS010, PZ202RCS011, PZ202RCS012, PZ202RCS013, PZ203RCS018. For rock core analysis, samples were extracted with Methanol within 14 days of sample collection, and allowed to equilibrate over a 5-wk period prior to analysis. Holding time was not exceeded, and no flagging was applied.

Field ID	LabsampleID	AnalysisDate	ExtractDate	Sample Date	Method Time	Actual HT
PZ202RCS004	G199-05I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS004	G199-05I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS005	G199-06I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS005	G199-06I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS006	G199-07I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS006	G199-07I	9/23/2014	9/23/2014	7/28/2014	14	57
PZ202RCS007	G199-08I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS007	G199-08I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS007DL	G199-08J	9/23/2014	9/23/2014	7/28/2014	14	57
PZ202RCS008	G199-09I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS008	G199-09I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS009	G199-10I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS009	G199-10I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS010	G199-11I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS010	G199-11I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS011	G199-12I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS011	G199-12I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS012	G199-13I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS012	G199-13I	9/22/2014	9/22/2014	7/28/2014	14	56
PZ202RCS013	G199-14I	9/14/2014	9/14/2014	7/28/2014	14	48
PZ202RCS013	G199-14I	9/23/2014	9/23/2014	7/28/2014	14	57
PZ203RCS018	G199-15I	9/23/2014	9/23/2014	7/24/2014	14	61

PZ203RCS018	G199-15I	9/14/2014	9/14/2014	7/24/2014	14	52

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: These NativeIDs had dilutions or re-extractions that were flagged Exclude: PZ202RCS007.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
Laboratory Control Sample: These LCS analytes were out of control: CHLOROETHANE (BD), CHLOROETHANE (BS). These LCS RPD analytes were out of control: CHLOROETHANE (BS), HEXACHLOROBUTADIENE (BS), N-BUTYLBENZENE (BS), SEC-BUTYLBENZENE (BS).
Holding Time: These NativeIDs exceeded holding time: PZ202RCS004, PZ202RCS005, PZ202RCS006, PZ202RCS007, PZ202RCS008, PZ202RCS009, PZ202RCS010, PZ202RCS011, PZ202RCS012, PZ202RCS013, PZ203RCS018.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

These NativeIDs had dilutions or re-extractions that were flagged Exclude: PZ202RCS007.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **PZ202RCS004**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	100	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	100	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	500	U	U	250	500		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	500	U	U	100	500		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
2-HEXANONE	500	U	U	250	500		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
ACETONE	500	U	U	250	500		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	100	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	500	U	U	100	500		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	50	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	100	250		UG/KG	LCS>UCL (none)
	250	U	U	100	250		UG/KG	LCSD>UCL (none)
	250	U	U	100	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	10	U	U	5	10		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS004

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
DIBROMOMETHANE	250	U	U	50	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	100	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	50	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	50	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
	250	U	U	100	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	100	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	5	U	U	2.5	5		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	500	U	U	250	500		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	500	U	U	250	500		UG/KG	HTa>UCL (none)
MTBE	250	U	U	50	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	500	U	U	100	500		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
	250	U	U	50	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
	250	U	U	50	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	50	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	1000	U	U	500	1000		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	50	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	100	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS005

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
	240	U	U	96	240		UG/KG	LCS>UCL (none)
	240	U	U	96	240		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
	240	U	U	96	240		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
	240	U	U	48	240		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
	240	U	U	48	240		UG/KG	LCSRPD (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)

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Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
CHLOROMETHANE	98	exclude	U	49	98		UG/KG	HTa>UCL (none)
	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
	98	exclude	U	49	98		UG/KG	RE (exclude)
CIS-1,2-DICHLOROETHENE	**84**			1.2	2.5		UG/KG	HTa>UCL (none)

mfesler

Validated Form I

Field ID: PZ202RCS007

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
	78	exclude		12	25		UG/KG	HTa>UCL (none)
	78	exclude		12	25		UG/KG	RE (exclude)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	**1.2**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	LCSRPD (none)
	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	49	exclude	U	25	49		UG/KG	RE (exclude)
	49	exclude	U	25	49		UG/KG	HTa>UCL (none)
	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
TOLUENE	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
	1.4	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)
	11			1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**630**			12	25		UG/KG	HTa>UCL (none)
	670	exclude	E	1.2	2.5		UG/KG	RE (exclude)
	670	exclude	E	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
	25	exclude	U	12	25		UG/KG	RE (exclude)
	25	exclude	U	12	25		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS008

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	470	U	U	230	470		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	470	U	U	94	470		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
2-HEXANONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
ACETONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
BROMOFORM	230	U	U	94	230		UG/KG	HTa>UCL (none)
BROMOMETHANE	470	U	U	94	470		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	230	U	U	47	230		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
CHLOROETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
	230	U	U	94	230		UG/KG	LCS>UCL (none)
	230	U	U	94	230		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.4	U	U	4.7	9.4		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	230	U	U	47	230		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	230	U	U	47	230		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	230	U	U	47	230		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
	230	U	U	94	230		UG/KG	LCSRPD (none)

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Validated Form I

Field ID: PZ202RCS008

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
ISOPROPYLBENZENE	230	U	U	94	230		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.7	U	U	2.4	4.7		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	470	U	U	230	470		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	470	U	U	230	470		UG/KG	HTa>UCL (none)
MTBE	230	U	U	47	230		UG/KG	HTa>UCL (none)
NAPHTHALENE	470	U	U	94	470		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
	230	U	U	47	230		UG/KG	LCSRPD (none)
N-PROPYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
	230	U	U	47	230		UG/KG	LCSRPD (none)
STYRENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	230	U	U	47	230		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	940	U	U	470	940		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	230	U	U	47	230		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	230	U	U	94	230		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS009

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS009

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCS>UCL (none)
	250	U	U	98	250		UG/KG	LCSD>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	LCSRPD (none)
	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
	250	U	U	49	250		UG/KG	LCSRPD (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS010

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS010

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS011

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS011

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS012

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS012

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

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Field ID: PZ202RCS012

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS013

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS013

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ203RCS018

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ203RCS018

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
	250	U	U	98	250		UG/KG	LCSRPD (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: **PZ203RCS018**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	**1.4**	J	J	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	**3.9**			1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**3.2**			1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
HTa>UCL	Holding time exceeded	HoldingTime
LCS>UCL	LCS recovery greater than the upper control limit	LaboratoryControlSample
LCSD>UCL	LCSD recovery greater than the upper control limit	LaboratoryControlSample
LCSRPD	LCS RPD criteria exceeded	LaboratoryControlSample
RE	Re-extraction and/or re-analysis	Re-analysis

CH 499 BVE

Data Quality Evaluation

SDG	**14H042**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**10/23/2014**
Matrix	**Soil/Water**	**Reviewed:**	**10/24/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
SOIL					
PZ202RCS014	N	49			
PZ202RCS014FD	FD	49			
PZ202RCS015	N	48			
WATER					
CAQW2030S001	TB	1			

1. Case Narrative

Items of Interest

The following items were noted: FD>RPD

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

These samples were out of control: TRICHLOROETHENE (PZ202RCS014, %RPD = 67 vs 50).

Matrix /Analyte/SampleID	*Result*	*Field Duplicate Qualifier**	*Criteria*
SOIL			
TRICHLOROETHENE			
PZ202RCS014	8.2 UG/KG	J	FD>RPD
PZ202RCS014FD	4.1 UG/KG	J	FD>RPD

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

These NativeIDs exceeded holding time: PZ202RCS014, PZ202RCS014FD, PZ202RCS015. For rock core analysis, samples were extracted with Methanol within 14 days of sample collection, and allowed to equilibrate over a 5-wk period prior to analysis. Holding time was not exceeded, and no flagging was applied.

Field ID	LabsampleID	AnalysisDate	ExtractDate	Sample Date	Method Time	Actual HT
PZ202RCS014	H042-02I	9/23/2014	9/23/2014	8/1/2014	14	53
PZ202RCS014FD	H042-03I	9/23/2014	9/23/2014	8/1/2014	14	53
PZ202RCS015	H042-04I	9/23/2014	9/23/2014	8/1/2014	14	53

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: These samples were out of control: TRICHLOROETHENE (PZ202RCS014, %RPD = 67 vs 50).
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
Holding Time: These NativeIDs exceeded holding time: PZ202RCS014, PZ202RCS014FD, PZ202RCS015.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: PZ202RCS014

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS014

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**8.2**	J		1.2	2.5		UG/KG	FD>RPD (J)
	8.2	J		1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Field ID: PZ202RCS014FD

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS014FD

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
2,2-DICHLOROPROPANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	490	U	U	250	490		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
2-HEXANONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
ACETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
BENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
BROMOBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
BROMOFORM	250	U	U	98	250		UG/KG	HTa>UCL (none)
BROMOMETHANE	490	U	U	98	490		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
CHLOROETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
CHLOROFORM	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.8	U	U	4.9	9.8		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	250	U	U	49	250		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	250	U	U	49	250		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	250	U	U	98	250		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.9	U	U	2.5	4.9		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	490	U	U	250	490		UG/KG	HTa>UCL (none)
METHYLENE CHLORIDE	490	U	U	250	490		UG/KG	HTa>UCL (none)
MTBE	250	U	U	49	250		UG/KG	HTa>UCL (none)
NAPHTHALENE	490	U	U	98	490		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
O-XYLENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
STYRENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	250	U	U	49	250		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	980	U	U	490	980		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TOLUENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	250	U	U	49	250		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**4.1**	J		1.2	2.5		UG/KG	FD>RPD (J)
	4.1	J		1.2	2.5		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	250	U	U	98	250		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.5	U	U	1.2	2.5		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS015

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1,1-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2,2-TETRACHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON-113)	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,1,2-TRICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,1-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,1-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,3-TRICHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2,4-TRICHLOROBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2,4-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,2-DIBROMO-3-CHLOROPROPANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DIBROMOETHANE (EDB)	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,2-DICHLOROETHANE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
1,2-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3,5-TRIMETHYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,3-DICHLOROPROPANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
1,4-DICHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2,2-DICHLOROPROPANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
2-BUTANONE (MEK)	480	U	U	240	480		UG/KG	HTa>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
2-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
2-HEXANONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
4-CHLOROTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
ACETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)
BENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
BROMOBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMODICHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
BROMOFORM	240	U	U	96	240		UG/KG	HTa>UCL (none)
BROMOMETHANE	480	U	U	96	480		UG/KG	HTa>UCL (none)
CARBON DISULFIDE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CARBON TETRACHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
CHLOROETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
CHLOROFORM	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
CHLOROMETHANE	9.6	U	U	4.8	9.6		UG/KG	HTa>UCL (none)
CIS-1,2-DICHLOROETHENE	**2.8**			1.2	2.4		UG/KG	HTa>UCL (none)
CIS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOCHLOROMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DIBROMOMETHANE	240	U	U	48	240		UG/KG	HTa>UCL (none)
DICHLORODIFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
DIISOPROPYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYL TERTIARY BUTYL ETHER (ETBE)	240	U	U	48	240		UG/KG	HTa>UCL (none)
ETHYLBENZENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
HEXACHLOROBUTADIENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
ISOPROPYLBENZENE	240	U	U	96	240		UG/KG	HTa>UCL (none)
M,P-XYLENES	4.8	U	U	2.4	4.8		UG/KG	HTa>UCL (none)
METHYL ISOBUTYL KETONE	480	U	U	240	480		UG/KG	HTa>UCL (none)

Validated Form I

Field ID: PZ202RCS015

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
METHYLENE CHLORIDE	480	U	U	240	480		UG/KG	HTa>UCL (none)
MTBE	240	U	U	48	240		UG/KG	HTa>UCL (none)
NAPHTHALENE	480	U	U	96	480		UG/KG	HTa>UCL (none)
N-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
N-PROPYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
O-XYLENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
P-ISOPROPYLTOLUENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
SEC-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
STYRENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERT-BUTYLBENZENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY AMYL METHYL ETHER	240	U	U	48	240		UG/KG	HTa>UCL (none)
TERTIARY BUTYL ALCOHOL (TBA)	960	U	U	480	960		UG/KG	HTa>UCL (none)
TETRACHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TOLUENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,2-DICHLOROETHENE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)
TRANS-1,3-DICHLOROPROPENE	240	U	U	48	240		UG/KG	HTa>UCL (none)
TRICHLOROETHENE	**30**			1.2	2.4		UG/KG	HTa>UCL (none)
TRICHLOROFLUOROMETHANE	240	U	U	96	240		UG/KG	HTa>UCL (none)
VINYL CHLORIDE	2.4	U	U	1.2	2.4		UG/KG	HTa>UCL (none)

mfesler

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
FD>RPD	Field duplicate exceeds RPD criteria	FieldDuplicate
HTa>UCL	Holding time exceeded	HoldingTime

CH 499 BVE
Data Quality Evaluation

SDG	**14H204**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS001	N	4120			
HAR19SVS001	N	2060			
HAR19SVS001	N	40			
PZ204CSVS001	N	104			
PZ204CSVS001	N	62.4			
PZ204CSVS001	N	40			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: HAR19SVS001

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	1000	U	UX	470	1000		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	1000	U	U	350	1000		UG/M3	
1,1,2,2-TETRACHLOROETHANE	1000	U	U	310	1000		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**64000**			350	1000		UG/M3	
1,1,2-TRICHLOROETHANE	1000	U	U	330	1000		UG/M3	
1,1-DICHLOROETHANE	1000	U	U	330	1000		UG/M3	
1,1-DICHLOROETHENE	1000	U	U	350	1000		UG/M3	
1,2-DICHLOROETHANE	1000	U	U	330	1000		UG/M3	
BENZENE	1000	U	U	330	1000		UG/M3	
CARBON TETRACHLORIDE	1000	U	U	310	1000		UG/M3	
CHLOROETHANE	1000	U	U	350	1000		UG/M3	
CHLOROFORM	1000	U	U	350	1000		UG/M3	
cis-1,2-DICHLOROETHYLENE	**33000**			330	1000		UG/M3	
DICHLORODIFLUOROMETHANE	**36000**			350	1000		UG/M3	
ETHYLBENZENE	1000	U	U	330	1000		UG/M3	
m,p-Xylene	2100	U	U	620	2100		UG/M3	
METHYLENE CHLORIDE	1000	U	U	350	1000		UG/M3	
o-Xylene	1000	U	U	310	1000		UG/M3	
TETRACHLOROETHYLENE(PCE)	1000	U	U	290	1000		UG/M3	
TOLUENE	1000	U	U	350	1000		UG/M3	
TRANS-1,2-DICHLOROETHENE	**6200**			390	1000		UG/M3	
TRICHLOROETHYLENE (TCE)	**240000**		D	580	2100		UG/M3	
TRICHLOROFLUOROMETHANE	1000	U	U	350	1000		UG/M3	
VINYL CHLORIDE	**9300**			350	1000		UG/M3	

Field ID: PZ204CSVS001

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	31	U	UX	14	31		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	31	U	U	11	31		UG/M3	
1,1,2,2-TETRACHLOROETHANE	31	U	U	9.4	31		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**5800**			11	31		UG/M3	
1,1,2-TRICHLOROETHANE	31	U	U	10	31		UG/M3	
1,1-DICHLOROETHANE	31	U	U	10	31		UG/M3	
1,1-DICHLOROETHENE	31	U	U	11	31		UG/M3	
1,2-DICHLOROETHANE	31	U	U	10	31		UG/M3	
BENZENE	31	U	U	10	31		UG/M3	
CARBON TETRACHLORIDE	31	U	U	9.4	31		UG/M3	
CHLOROETHANE	31	U	U	11	31		UG/M3	
CHLOROFORM	**34**			11	31		UG/M3	
cis-1,2-DICHLOROETHYLENE	**290**			10	31		UG/M3	
DICHLORODIFLUOROMETHANE	**7800**		D	18	52		UG/M3	
ETHYLBENZENE	31	U	U	10	31		UG/M3	
m,p-Xylene	62	U	U	19	62		UG/M3	
METHYLENE CHLORIDE	31	U	U	11	31		UG/M3	
o-Xylene	31	U	U	9.4	31		UG/M3	

Validated Form I

Field ID: PZ204CSVS001

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
TETRACHLOROETHYLENE(PCE)	31	U	U	8.7	31		UG/M3	
TOLUENE	**68**			11	31		UG/M3	
TRANS-1,2-DICHLOROETHENE	**35**			12	31		UG/M3	
TRICHLOROETHYLENE (TCE)	**1800**			8.7	31		UG/M3	
TRICHLOROFLUOROMETHANE	31	U	U	11	31		UG/M3	
VINYL CHLORIDE	31	U	U	11	31		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

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CH 499 BVE
Data Quality Evaluation

SDG	**14I031**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS003	N	3000			
HAR19SVS003	N	40			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19SVS003**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	1500	U	UX	690	1500		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	1500	U	U	510	1500		UG/M3	
1,1,2,2-TETRACHLOROETHANE	1500	U	U	450	1500		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**150000**			510	1500		UG/M3	
1,1,2-TRICHLOROETHANE	1500	U	U	480	1500		UG/M3	
1,1-DICHLOROETHANE	1500	U	U	480	1500		UG/M3	
1,1-DICHLOROETHENE	1500	U	U	510	1500		UG/M3	
1,2-DICHLOROETHANE	1500	U	U	480	1500		UG/M3	
BENZENE	1500	U	U	480	1500		UG/M3	
CARBON TETRACHLORIDE	1500	U	U	450	1500		UG/M3	
CHLOROETHANE	1500	U	U	510	1500		UG/M3	
CHLOROFORM	1500	U	U	510	1500		UG/M3	
cis-1,2-DICHLOROETHYLENE	**27000**			480	1500		UG/M3	
DICHLORODIFLUOROMETHANE	**19000**			510	1500		UG/M3	
ETHYLBENZENE	1500	U	U	480	1500		UG/M3	
m,p-Xylene	3000	U	U	900	3000		UG/M3	
METHYLENE CHLORIDE	1500	U	U	510	1500		UG/M3	
o-Xylene	1500	U	U	450	1500		UG/M3	
TETRACHLOROETHYLENE(PCE)	1500	U	U	420	1500		UG/M3	
TOLUENE	1500	U	U	510	1500		UG/M3	
TRANS-1,2-DICHLOROETHENE	**2700**			570	1500		UG/M3	
TRICHLOROETHYLENE (TCE)	**250000**			420	1500		UG/M3	
TRICHLOROFLUOROMETHANE	1500	U	U	510	1500		UG/M3	
VINYL CHLORIDE	**4100**			510	1500		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

Data Quality Evaluation

SDG	**Reviewer:**
Method	**Date:**
Matrix	**Reviewed:**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS006	N	2.05			

1. Case Narrative
Items of Interest

2. Blank Summary
Field Blanks

Method Blanks

3. Spikes and Duplicates
Field Duplicates

Laboratory Duplicates

Matrix Spike

4. Laboratory Control Sample

5. Surrogates

6. Tuning and Mass Calibration

7. Internal Standard

8. Calibration Information
Initial Calibration
Continuing Calibration

9. Holding Time

10. Confirmation

11. Summary

General Comments
Data Package Completeness
Forms Review/ Items of Interest
COC Review

Validated Form I

mfesler

CH 499 BVE
Data Quality Evaluation

SDG	**14I089**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS006	N	5125			
HAR19SVS006	N	40			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: HAR19SVS006

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	2600	U	UX	1200	2600		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	2600	U	U	870	2600		UG/M3	
1,1,2,2-TETRACHLOROETHANE	2600	U	U	770	2600		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**100000**			870	2600		UG/M3	
1,1,2-TRICHLOROETHANE	2600	U	U	820	2600		UG/M3	
1,1-DICHLOROETHANE	2600	U	U	820	2600		UG/M3	
1,1-DICHLOROETHENE	2600	U	U	870	2600		UG/M3	
1,2-DICHLOROETHANE	2600	U	U	820	2600		UG/M3	
BENZENE	2600	U	U	820	2600		UG/M3	
CARBON TETRACHLORIDE	2600	U	U	770	2600		UG/M3	
CHLOROETHANE	2600	U	U	870	2600		UG/M3	
CHLOROFORM	2600	U	U	870	2600		UG/M3	
cis-1,2-DICHLOROETHYLENE	**29000**			820	2600		UG/M3	
DICHLORODIFLUOROMETHANE	**23000**			870	2600		UG/M3	
ETHYLBENZENE	2600	U	U	820	2600		UG/M3	
m,p-Xylene	5100	U	U	1500	5100		UG/M3	
METHYLENE CHLORIDE	2600	U	U	870	2600		UG/M3	
o-Xylene	2600	U	U	770	2600		UG/M3	
TETRACHLOROETHYLENE(PCE)	2600	U	U	720	2600		UG/M3	
TOLUENE	2600	U	U	870	2600		UG/M3	
TRANS-1,2-DICHLOROETHENE	2600	U	U	970	2600		UG/M3	
TRICHLOROETHYLENE (TCE)	**280000**			720	2600		UG/M3	
TRICHLOROFLUOROMETHANE	2600	U	U	870	2600		UG/M3	
VINYL CHLORIDE	**4000**			870	2600		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

CH 499 BVE
Data Quality Evaluation

SDG	**14I090**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples
Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS005	N	5560			
HAR19SVS005	N	40			

1. Case Narrative
Items of Interest

No items of concern.

2. Blank Summary
Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates
Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample
All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates
All acceptance criteria were met.

6. Tuning and Mass Calibration
No DV

7. Internal Standard
No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19SVS005**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	2800	U	UX	1300	2800		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	2800	U	U	950	2800		UG/M3	
1,1,2,2-TETRACHLOROETHANE	2800	U	U	830	2800		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**150000**			950	2800		UG/M3	
1,1,2-TRICHLOROETHANE	2800	U	U	890	2800		UG/M3	
1,1-DICHLOROETHANE	2800	U	U	890	2800		UG/M3	
1,1-DICHLOROETHENE	2800	U	U	950	2800		UG/M3	
1,2-DICHLOROETHANE	2800	U	U	890	2800		UG/M3	
BENZENE	2800	U	U	890	2800		UG/M3	
CARBON TETRACHLORIDE	2800	U	U	830	2800		UG/M3	
CHLOROETHANE	2800	U	U	950	2800		UG/M3	
CHLOROFORM	2800	U	U	950	2800		UG/M3	
cis-1,2-DICHLOROETHYLENE	**35000**			890	2800		UG/M3	
DICHLORODIFLUOROMETHANE	**28000**			950	2800		UG/M3	
ETHYLBENZENE	2800	U	U	890	2800		UG/M3	
m,p-Xylene	5600	U	U	1700	5600		UG/M3	
METHYLENE CHLORIDE	2800	U	U	950	2800		UG/M3	
o-Xylene	2800	U	U	830	2800		UG/M3	
TETRACHLOROETHYLENE(PCE)	2800	U	U	780	2800		UG/M3	
TOLUENE	2800	U	U	950	2800		UG/M3	
TRANS-1,2-DICHLOROETHENE	2800	U	U	1100	2800		UG/M3	
TRICHLOROETHYLENE (TCE)	**340000**			780	2800		UG/M3	
TRICHLOROFLUOROMETHANE	2800	U	U	950	2800		UG/M3	
VINYL CHLORIDE	**4500**			950	2800		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

CH 499 BVE

Data Quality Evaluation

SDG	**14I164**		**Reviewer:**	**jbeckett**
Method	**E3C**		**Date:**	**10/6/2014**
Matrix	**AIR**		**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS007	N	2.14			

1. Case Narrative

Items of Interest

No items of interest

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

No surrogates in this SDG.

6. Tuning and Mass Calibration

N/A

7. Internal Standard

N/A

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

N/A

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Surrogates: No surrogates in this SDG.
Initial Calibration: No DV
Continuing Calibration: No DV
Matrix Spike: No MS's for this SDG.
COC: No discrepancies
VDMS4.46

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: HAR19SVS007

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON DIOXIDE	**4.68**				0.21		%V/V	
CARBON MONOXIDE	0.21	U	U		0.21		%V/V	
HYDROGEN	0.21	U	U		0.21		%V/V	
METHANE	0.21	U	U		0.21		%V/V	
NITROGEN	**82.5**				0.21		%V/V	
Oxygen + Argon	**12.8**				0.21		%V/V	

Validated Form I

mfesler

CH 499 BVE
Data Quality Evaluation

SDG	**14I164**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**10/6/2014**
Matrix	**AIR**	**Reviewed:**	**10/9/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SVS007	N	5350			
HAR19SVS007	N	40			
HAR19SVS007	LR	5350			
HAR19SVS007	LR	40			

1. Case Narrative
Items of Interest
No items of concern.

2. Blank Summary
Field Blanks
No Field Blanks were found.

Method Blanks
No Method Blank detects were found.

3. Spikes and Duplicates
Field Duplicates
No FD Associated.

Laboratory Duplicates
All acceptance criteria were met.

Matrix Spike
No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample
All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates
All acceptance criteria were met.

6. Tuning and Mass Calibration
No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: No samples were excluded for dilutions or re-extractions.
Tuning and Mass Calibration: No DV
Internal Standard Area/Retention Time: No DV
Initial Calibration: No DV
Continuing Calibration: No DV
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

No samples were excluded for dilutions or re-extractions.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19SVS007**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	2700	U	UX	1200	2700		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	2700	U	U	910	2700		UG/M3	
1,1,2,2-TETRACHLOROETHANE	2700	U	U	800	2700		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**140000**			910	2700		UG/M3	
1,1,2-TRICHLOROETHANE	2700	U	U	860	2700		UG/M3	
1,1-DICHLOROETHANE	2700	U	U	860	2700		UG/M3	
1,1-DICHLOROETHENE	2700	U	U	910	2700		UG/M3	
1,2-DICHLOROETHANE	2700	U	U	860	2700		UG/M3	
BENZENE	2700	U	U	860	2700		UG/M3	
CARBON TETRACHLORIDE	2700	U	U	800	2700		UG/M3	
CHLOROETHANE	2700	U	U	910	2700		UG/M3	
CHLOROFORM	2700	U	U	910	2700		UG/M3	
cis-1,2-DICHLOROETHYLENE	**31000**			860	2700		UG/M3	
DICHLORODIFLUOROMETHANE	**13000**			910	2700		UG/M3	
ETHYLBENZENE	2700	U	U	860	2700		UG/M3	
m,p-Xylene	5400	U	U	1600	5400		UG/M3	
METHYLENE CHLORIDE	2700	U	U	910	2700		UG/M3	
o-Xylene	2700	U	U	800	2700		UG/M3	
TETRACHLOROETHYLENE(PCE)	2700	U	U	750	2700		UG/M3	
TOLUENE	2700	U	U	910	2700		UG/M3	
TRANS-1,2-DICHLOROETHENE	2700	U	U	1000	2700		UG/M3	
TRICHLOROETHYLENE (TCE)	**360000**			750	2700		UG/M3	
TRICHLOROFLUOROMETHANE	2700	U	U	910	2700		UG/M3	
VINYL CHLORIDE	**3800**			910	2700		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

CH 499 BVE
Data Quality Evaluation

SDG	**14J158**	**Reviewer:**	**jbeckett**
Method	**E3C**	**Date:**	**12/9/2014**
Matrix	**AIR**	**Reviewed:**	**12/11/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SV008	N	1.66			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

No surrogates in this SDG.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Surrogates: No surrogates in this SDG.
Tuning and Mass Calibration: NA
Internal Standard Area/Retention Time: NA
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

All acceptance criteria were met.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19SV008**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
CARBON DIOXIDE	**5.54**				0.17		%V/V	
CARBON MONOXIDE	0.17	U	U		0.17		%V/V	
HYDROGEN	0.17	U	U		0.17		%V/V	
METHANE	0.17	U	U		0.17		%V/V	
NITROGEN	**86.2**				0.17		%V/V	
Oxygen + Argon	**8.25**				0.17		%V/V	

Validated Form I

mfesler

CH 499 BVE
Data Quality Evaluation

SDG	**14J158**	**Reviewer:**	**jbeckett**
Method	**TO15**	**Date:**	**12/9/2014**
Matrix	**AIR**	**Reviewed:**	**12/11/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
AIR					
HAR19SV008	N	#######			
HAR19SV008	N	#######			
HAR19SV008	N	40			
HAR19SV009	N	#######			
HAR19SV009	N	40			

1. Case Narrative

Items of Interest

No items of concern.

2. Blank Summary

Field Blanks

No Field Blanks were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

All acceptance criteria were met. No spike dupes in this SDG.

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
COC: No discrepancies.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

All acceptance criteria were met.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19SV008**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	550	U	UX	250	550		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	550	U	U	190	550		UG/M3	
1,1,2,2-TETRACHLOROETHANE	550	U	U	170	550		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**120000**		D	940	2800		UG/M3	InvalidLabFlag (=)
1,1,2-TRICHLOROETHANE	550	U	U	180	550		UG/M3	
1,1-DICHLOROETHANE	550	U	U	180	550		UG/M3	
1,1-DICHLOROETHENE	**1000**			190	550		UG/M3	
1,2-DICHLOROETHANE	550	U	U	180	550		UG/M3	
BENZENE	550	U	U	180	550		UG/M3	
CARBON TETRACHLORIDE	550	U	U	170	550		UG/M3	
CHLOROETHANE	550	U	U	190	550		UG/M3	
CHLOROFORM	550	U	U	190	550		UG/M3	
cis-1,2-DICHLOROETHYLENE	**38000**			180	550		UG/M3	
DICHLORODIFLUOROMETHANE	**31000**			190	550		UG/M3	
ETHYLBENZENE	550	U	U	180	550		UG/M3	
m,p-Xylene	1100	U	U	330	1100		UG/M3	
METHYLENE CHLORIDE	550	U	U	190	550		UG/M3	
o-Xylene	550	U	U	170	550		UG/M3	
TETRACHLOROETHYLENE(PCE)	550	U	U	150	550		UG/M3	
TOLUENE	550	U	U	190	550		UG/M3	
TRANS-1,2-DICHLOROETHENE	**4400**			210	550		UG/M3	
TRICHLOROETHYLENE (TCE)	**320000**		D	770	2800		UG/M3	InvalidLabFlag (=)
TRICHLOROFLUOROMETHANE	550	U	U	190	550		UG/M3	
VINYL CHLORIDE	**3900**			190	550		UG/M3	

Field ID: **HAR19SV009**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	2500	U	UX	1100	2500		UG/M3	InvalidLabFlag (U)
1,1,1-TRICHLOROETHANE	2500	U	U	840	2500		UG/M3	
1,1,2,2-TETRACHLOROETHANE	2500	U	U	740	2500		UG/M3	
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**120000**			840	2500		UG/M3	
1,1,2-TRICHLOROETHANE	2500	U	U	790	2500		UG/M3	
1,1-DICHLOROETHANE	2500	U	U	790	2500		UG/M3	
1,1-DICHLOROETHENE	2500	U	U	840	2500		UG/M3	
1,2-DICHLOROETHANE	2500	U	U	790	2500		UG/M3	
BENZENE	2500	U	U	790	2500		UG/M3	
CARBON TETRACHLORIDE	2500	U	U	740	2500		UG/M3	
CHLOROETHANE	2500	U	U	840	2500		UG/M3	
CHLOROFORM	2500	U	U	840	2500		UG/M3	
cis-1,2-DICHLOROETHYLENE	**36000**			790	2500		UG/M3	
DICHLORODIFLUOROMETHANE	**31000**			840	2500		UG/M3	
ETHYLBENZENE	2500	U	U	790	2500		UG/M3	
m,p-Xylene	4900	U	U	1500	4900		UG/M3	
METHYLENE CHLORIDE	2500	U	U	840	2500		UG/M3	
o-Xylene	2500	U	U	740	2500		UG/M3	

Validated Form I

Field ID: HAR19SV009

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
TETRACHLOROETHYLENE(PCE)	2500	U	U	690	2500		UG/M3	
TOLUENE	2500	U	U	840	2500		UG/M3	
TRANS-1,2-DICHLOROETHENE	**3900**			940	2500		UG/M3	
TRICHLOROETHYLENE (TCE)	**370000**			690	2500		UG/M3	
TRICHLOROFLUOROMETHANE	2500	U	U	840	2500		UG/M3	
VINYL CHLORIDE	**4100**			840	2500		UG/M3	

Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
InvalidLabFlag	Removed invalid laboratory flag	Blank

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CH 499 BVE

Data Quality Evaluation

SDG	**14J177**	**Reviewer:**	**jbeckett**
Method	**SW8260B**	**Date:**	**12/10/2014**
Matrix	**WATER**	**Reviewed:**	**12/11/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
WATER					
CAQW2048Q001	TB	1			
HAR19GW01S003	N	50			
HAR19GW01S003	N	1			

1. Case Narrative

Items of Interest

The following items were noted: LCS>UCL, LCSD>UCL

2. Blank Summary

Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates

Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

No MS's for this SDG. No SD's for this SDG. MS RPD: None for this SDG.

4. Laboratory Control Sample

These LCS analytes were out of control: 2-BUTANONE (MEK) (BD), 2-HEXANONE (BD), 2-HEXANONE (BS), CHLOROTRIFLUOROETHYLENE (BD), CHLOROTRIFLUOROETHYLENE (BS), HEXACHLOROBUTADIENE (BD), TRICHLOROFLUOROMETHANE (BS). All acceptance criteria were met.

Matrix	QAQC Type	Field ID	Analyte	Recovery	Lower Limit	Upper Limit
WATER	BD	LCD1W	2-BUTANONE (MEK)	122	70	120
WATER	BD	LCD1W	2-HEXANONE	132	70	120
WATER	BD	LCD1W	CHLOROTRIFLUOROETHYLENE	122	70	120
WATER	BD	LCD1W	HEXACHLOROBUTADIENE	121	70	120
WATER	BS	LCS1W	2-HEXANONE	125	70	120

WATER	BS	LCS1W	CHLOROTRIFLUOROETHYLENE	127	70	120
WATER	BS	LCS1W	TRICHLOROFLUOROMETHANE	125	70	120

5. Surrogates
All acceptance criteria were met.

6. Tuning and Mass Calibration
No DV

7. Internal Standard
No DV

8. Calibration Information
Initial Calibration
No DV

Continuing Calibration
No DV

9. Holding Time
All acceptance criteria were met.

10. Confirmation
None for this SDG.

11. Summary
General Comments
Data Package Completeness
Package was complete for level V validation

Forms Review/ Items of Interest
These NativeIDs had dilutions or re-extractions that were flagged Exclude: HAR19GW01S003.

COC Review
No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: HAR19GW01S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-TETRACHLOROETHANE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
1,1,1-TRICHLOROETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,1,2,2-TETRACHLOROETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	**8.8**			0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
1,1,2-TRICHLOROETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,1-DICHLOROETHANE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
1,1-DICHLOROETHENE	**1.4**			0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,1-DICHLOROPROPENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,2,3-TRICHLOROBENZENE	15	exclude	U	15	50		UG/L	RE (exclude)
	0.3	U	U	0.3	1		UG/L	
1,2,3-TRICHLOROPROPANE	25	exclude	U	25	100		UG/L	RE (exclude)
	0.5	U	U	0.5	2		UG/L	
1,2,4-TRICHLOROBENZENE	0.3	U	U	0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
1,2,4-TRIMETHYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,2-DIBROMO-3-CHLOROPROPANE	0.5	U	U	0.5	2		UG/L	
	25	exclude	U	25	100		UG/L	RE (exclude)
1,2-DIBROMOETHANE (EDB)	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,2-DICHLOROBENZENE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
1,2-DICHLOROETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,2-DICHLOROPROPANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,3,5-TRIMETHYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,3-DICHLOROBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,3-DICHLOROPROPANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
1,4-DICHLOROBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
2,2-DICHLOROPROPANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
2-BUTANONE (MEK)	200	exclude	U	200	500		UG/L	RE (exclude)
	200	exclude	U	200	500		UG/L	LCSD>UCL (none)

Validated Form I

Field ID: HAR19GW01S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
	4	U	U	4	10		UG/L	LCSD>UCL (none)
2-CHLORO-1,1,1-TRIFLUOROETHANE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
2-CHLOROETHYL VINYL ETHER	1	U	U	1	2		UG/L	
	50	exclude	U	50	100		UG/L	RE (exclude)
2-CHLOROTOLUENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
2-HEXANONE	200	exclude	U	200	500		UG/L	RE (exclude)
	200	exclude	U	200	500		UG/L	LCS>UCL (none)
	4	U	U	4	10		UG/L	LCS>UCL (none)
	200	exclude	U	200	500		UG/L	LCSD>UCL (none)
	4	U	U	4	10		UG/L	LCSD>UCL (none)
4-CHLOROTOLUENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
4-METHYL-2-PENTANONE (MIBK)	4	U	U	4	10		UG/L	
	200	exclude	U	200	500		UG/L	RE (exclude)
ACETONE	5	U	U	5	10		UG/L	
	250	exclude	U	250	500		UG/L	RE (exclude)
BENZENE	**0.32**	J	J	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
BROMOBENZENE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
BROMOCHLOROMETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
BROMODICHLOROMETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
BROMOFORM	0.3	U	U	0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
BROMOMETHANE	15	exclude	U	15	50		UG/L	RE (exclude)
	0.3	U	U	0.3	1		UG/L	
CARBON TETRACHLORIDE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
CHLOROBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
CHLOROETHANE	0.3	U	U	0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
CHLOROFORM	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
CHLOROMETHANE	0.3	U	U	0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
CHLOROTRIFLUOROETHYLENE	20	exclude	J	10	50		UG/L	RE (exclude)
	20	exclude	J	10	50		UG/L	LCS>UCL (J)
	20	exclude	J	10	50		UG/L	LCSD>UCL (J)
	24	J		0.2	1		UG/L	LCS>UCL (J)
	24	J		0.2	1		UG/L	LCSD>UCL (J)
CIS-1,2-DICHLOROETHENE	**370**			10	50		UG/L	
	420	exclude	E	0.2	1		UG/L	RE (exclude)
CIS-1,3-DICHLOROPROPENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
DIBROMOCHLOROMETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
DIBROMOMETHANE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)

Validated Form I

Field ID: HAR19GW01S003

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
DICHLORODIFLUOROMETHANE	0.3	U	U	0.3	1		UG/L	
	15	exclude	U	15	50		UG/L	RE (exclude)
DIISOPROPYL ETHER	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
ETHYL TERTIARY BUTYL ETHER	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
ETHYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
HEXACHLOROBUTADIENE	0.3	U	U	0.3	1		UG/L	LCSD>UCL (none)
	15	exclude	U	15	50		UG/L	RE (exclude)
	15	exclude	U	15	50		UG/L	LCSD>UCL (none)
ISOPROPYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
M,P-XYLENES	0.4	U	U	0.4	10		UG/L	
	20	exclude	U	20	500		UG/L	RE (exclude)
METHYLENE CHLORIDE	0.5	U	U	0.5	1		UG/L	
	25	exclude	U	25	50		UG/L	RE (exclude)
METHYL-TERT-BUTYL-ETHER (MTBE)	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
N-BUTYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
N-PROPYLBENZENE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
O-XYLENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
P-ISOPROPYLTOLUENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
SEC-BUTYLBENZENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
STYRENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
TERT-BUTYLBENZENE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
TERTIARY AMYL METHYL ETHER	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
TERTIARY BUTYL ALCOHOL	5	U	U	5	10		UG/L	
	250	exclude	U	250	500		UG/L	RE (exclude)
TETRACHLOROETHENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
TOLUENE	0.2	U	U	0.2	1		UG/L	
	10	exclude	U	10	50		UG/L	RE (exclude)
TRANS-1,2-DICHLOROETHENE	88	exclude		10	50		UG/L	RE (exclude)
	94			0.2	1		UG/L	
TRANS-1,3-DICHLOROPROPENE	10	exclude	U	10	50		UG/L	RE (exclude)
	0.2	U	U	0.2	1		UG/L	
TRICHLOROETHENE	610	exclude	E	0.2	1		UG/L	RE (exclude)
	1100			10	50		UG/L	
TRICHLOROFLUOROMETHANE	0.3	U	U	0.3	1		UG/L	LCS>UCL (none)
	15	exclude	U	15	50		UG/L	RE (exclude)
	15	exclude	U	15	50		UG/L	LCS>UCL (none)
VINYL CHLORIDE	10	exclude	U	10	50		UG/L	RE (exclude)
	6.9			0.2	1		UG/L	

Validated Form I

Validation Flag Abbreviations

Abbreviation	Validation Reason	Category
LCS>UCL	LCS recovery greater than the upper control limit	LaboratoryControlSample
LCSD>UCL	LCSD recovery greater than the upper control limit	LaboratoryControlSample
RE	Re-extraction and/or re-analysis	Re-analysis

3Q 2014 GW
Data Quality Evaluation

SDG	**14070897**		**Reviewer:**	**mfesler-autoDV/jbeckett-manDV**
Method	**SW8260B**		**Date:**	**8/29/2014**
Matrix	**WATER**		**Reviewed:**	**9/8/2014**

Field Samples

Field blank association lot values: LotNumber / FieldID / SDG

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
WATER					
CAQW2011S001	TB	1			14071401 / CAQW2011S001 / 14070897
HAR19GW01S002	N	10		23071401 / EBQW2037Q001 / 14071600	14071401 / CAQW2011S001 / 14070897
HAR19GW01S002	N	1		23071401 / EBQW2037Q001 / 14071600	14071401 / CAQW2011S001 / 14070897
HAR19GW01S002MS	MS	1			
HAR19GW01S002SD	SD	1			

Associated Field Blanks (other SDGs)

NativeID	QAQC Type	Dilution	ABLotValue	EBLotValue	TBLotValue
WATER					
EBQW2037Q001	EB	1		23071401 / EBQW2037Q001 / 14071600	14071401 / CAQW2011S001 / 14070897

1. Case Narrative
Items of Interest

The folowing items were noted: MS<LCL, MSRPD, SD<LCL, LCS<LCL, 2Cleve

2. Blank Summary
Field Blanks

No Field Blank detects were found.

Method Blanks

No Method Blank detects were found.

3. Spikes and Duplicates
Field Duplicates

No FD Associated.

Laboratory Duplicates

None in this SDG

Matrix Spike

These MS's were out of control: 2-Chloroethyl Vinyl Ether (MS - HAR19GW01S002MS), c-1,2-Dichloroethene (MS - HAR19GW01S002MS), Trichloroethene (MS - HAR19GW01S002MS). These SD's were out of control: 2-Chloroethyl Vinyl Ether (SD - HAR19GW01S002SD), c-1,2-Dichloroethene (SD - HAR19GW01S002SD), Trichloroethene (SD - HAR19GW01S002SD). These MS/SD RPD's were out of control: 2-Chloroethyl Vinyl Ether (HAR19GW01S002).

Matrix	*Sample ID*	*LR Type*	*Analyte*	*Result*	*MS/MSD Qualifier**	*Criteria*
WATER			2-Chloroethyl Vinyl Ether			
	HAR19GW01S002			16 UG/L	UJ	MS<LCL
	HAR19GW01S002			16 UG/L	none	MSRPD
	HAR19GW01S002			16 UG/L	UJ	SD<LCL
WATER			c-1,2-Dichloroethene			
	HAR19GW01S002	DL		730 UG/L	none	MS<LCL
	HAR19GW01S002	DL		730 UG/L	none	SD<LCL
WATER			Trichloroethene			
	HAR19GW01S002	DL		480 UG/L	none	MS<LCL
	HAR19GW01S002	DL		480 UG/L	none	SD<LCL

4. Laboratory Control Sample

These LCS analytes were out of control: 2-Chloroethyl Vinyl Ether (BS), Bromomethane (BS). No spike dupes in this SDG.

Matrix	QAQC Type	Field ID	Analyte	Recovery	Lower Limit	Upper Limit
WATER	BS	0991624610BS	2-Chloroethyl Vinyl Ether	57	70	120
WATER	BS	0991624610BS	Bromomethane	68	70	120

5. Surrogates

All acceptance criteria were met.

6. Tuning and Mass Calibration

No DV

7. Internal Standard

No DV

8. Calibration Information

Initial Calibration

No DV

Continuing Calibration

No DV

9. Holding Time

All acceptance criteria were met.

10. Confirmation

None for this SDG.

11. Summary

General Comments

Field Duplicates: No FD Associated.
Form I Review: These NativeIDs had dilutions or re-extractions that were flagged Exclude: HAR19GW01S002.
Tuning and Mass Calibration: Tuning and Mass Calibration were not examined by AutoDV.
Internal Standard Area/Retention Time: Internal Standard Area/Retention Time was not examined by AutoDV.
Initial Calibration: Initial Calibration was not examined by AutoDV.
Continuing Calibration: Continuing Calibration was not examined by AutoDV.
Matrix Spike: These MS's were out of control: 2-Chloroethyl Vinyl Ether (MS - HAR19GW01S002MS), c-1,2-Dichloroethene (MS - HAR19GW01S002MS), Trichloroethene (MS - HAR19GW01S002MS). These SD's were out of control: 2-Chloroethyl Vinyl Ether (SD - HAR19GW01S002SD), c-1,2-Dichloroethene (SD - HAR19GW01S002SD), Trichloroethene (SD - HAR19GW01S002SD). These MS/SD RPD's were out of control: 2-Chloroethyl Vinyl Ether (HAR19GW01S002).
Laboratory Control Sample: These LCS analytes were out of control: 2-Chloroethyl Vinyl Ether (BS), Bromomethane (BS). No spike

dupes in this SDG.
VDMS4.25

Data Package Completeness

Package was complete for level V validation

Forms Review/ Items of Interest

These NativeIDs had dilutions or re-extractions that were flagged Exclude: HAR19GW01S002.

COC Review

No discrepancies.

Validated Form I

Final Data Flags*

***When the data evaluation process results in multiple flags, the most severe flag becomes the final data flag. All flags are from the site-specific QAPP, except the "exclude" flag that is used to designate results that are not for risk assessment (for example, a result from a dilution where the original undiluted result is appropriate).**

Field ID: **HAR19GW01S002**

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
1,1,1,2-Tetrachloroethane	0.4	U	U	0.4	5		UG/L	
1,1,1-Trichloroethane	0.3	U	U	0.3	10		UG/L	
1,1,2,2-Tetrachloroethane	0.41	U	U	0.41	10		UG/L	
1,1,2-Trichloro-1,2,2-Trifluoroethane	0.45	U	U	0.45	25		UG/L	
1,1,2-Trichloroethane	0.38	U	U	0.38	10		UG/L	
1,1-Dichloroethane	0.28	U	U	0.28	10		UG/L	
1,1-Dichloroethene	**2.5**	J	J	0.43	25		UG/L	
1,1-Dichloropropene	0.46	U	U	0.46	10		UG/L	
1,2,3-Trichlorobenzene	0.51	U	U	0.51	25		UG/L	
1,2,4-Trichlorobenzene	0.5	U	U	0.5	25		UG/L	
1,2,4-Trimethylbenzene	0.36	U	U	0.36	10		UG/L	
1,2-Dichlorobenzene	0.46	U	U	0.46	10		UG/L	
1,2-Dichloroethane	0.24	U	U	0.24	5		UG/L	
1,2-Dichloropropane	0.42	U	U	0.42	10		UG/L	
1,3,5-Trimethylbenzene	0.28	U	U	0.28	10		UG/L	
1,3-Dichlorobenzene	0.4	U	U	0.4	10		UG/L	
1,3-Dichloropropane	0.3	U	U	0.3	10		UG/L	
1,4-Dichlorobenzene	0.43	U	U	0.43	10		UG/L	
2,2-Dichloropropane	0.36	U	U	0.36	5		UG/L	
2-Butanone	2.2	U	U	2.2	50		UG/L	
2-Chloroethyl Vinyl Ether	**16**	R	U	16	25		UG/L	SD<LCL (UJ)
	16	R	U	16	25		UG/L	MSRPD (none)
	16	R	U	16	25		UG/L	2Cleve (R)
	16	R	U	16	25		UG/L	LCS<LCL (UJ)
	16	R	U	16	25		UG/L	MS<LCL (UJ)
2-Chlorotoluene	0.24	U	U	0.24	25		UG/L	
2-Hexanone	2.1	U	U	2.1	50		UG/L	
4-Chlorotoluene	0.13	U	U	0.13	25		UG/L	
4-Methyl-2-Pentanone	4.4	U	U	4.4	25		UG/L	
Acetone	6	U	U	6	50		UG/L	
Benzene	**0.23**	J	J	0.14	10		UG/L	
Bromobenzene	0.3	U	U	0.3	25		UG/L	
Bromochloromethane	0.48	U	U	0.48	25		UG/L	
Bromodichloromethane	0.21	U	U	0.21	10		UG/L	
Bromoform	0.5	U	U	0.5	25		UG/L	
Bromomethane	3.9	UJ	U	3.9	25		UG/L	LCS<LCL (UJ)
c-1,2-Dichloroethene	**730**		=D	4.8	50		UG/L	MS<LCL (none)
	730		=D	4.8	50		UG/L	SD<LCL (none)
c-1,3-Dichloropropene	0.25	U	U	0.25	10		UG/L	
Carbon Tetrachloride	0.23	U	U	0.23	0.5		UG/L	
Chlorobenzene	0.17	U	U	0.17	10		UG/L	
Chloroethane	2.3	U	U	2.3	25		UG/L	
Chloroform	0.46	U	U	0.46	10		UG/L	
Chloromethane	1.8	U	U	1.8	25		UG/L	
Dibromochloromethane	0.25	U	U	0.25	10		UG/L	
Dibromomethane	0.46	U	U	0.46	5		UG/L	

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Field ID: HAR19GW01S002

Analyte	Result	Final Flag	Lab Flag	MDL	RL	LOD	Units	Validation Reason (Flag)
Dichlorodifluoromethane	0.46	U	U	0.46	25		UG/L	
Ethylbenzene	0.14	U	U	0.14	10		UG/L	
Hexachloro-1,3-Butadiene	0.32	U	U	0.32	25		UG/L	
Isopropanol	37	U	U	37	100		UG/L	
Isopropylbenzene	0.58	U	U	0.58	10		UG/L	
Methylene Chloride	0.64	U	U	0.64	25		UG/L	
Methyl-t-Butyl Ether (MTBE)	0.31	U	U	0.31	25		UG/L	
n-Butylbenzene	0.23	U	U	0.23	25		UG/L	
n-Propylbenzene	0.17	U	U	0.17	10		UG/L	
o-Xylene	0.23	U	U	0.23	10		UG/L	
p/m-Xylene	0.3	U	U	0.3	10		UG/L	
p-Isopropyltoluene	0.16	U	U	0.16	10		UG/L	
sec-Butylbenzene	0.25	U	U	0.25	25		UG/L	
Styrene	0.17	U	U	0.17	10		UG/L	
t-1,2-Dichloroethene	**220**		=D	3.7	100		UG/L	
t-1,3-Dichloropropene	0.25	U	U	0.25	10		UG/L	
tert-Butylbenzene	0.28	U	U	0.28	25		UG/L	
Tetrachloroethene	0.39	U	U	0.39	5		UG/L	
Toluene	0.24	U	U	0.24	10		UG/L	
Trichloroethene	**480**		=D	3.7	50		UG/L	MS<LCL (none)
	480		=D	3.7	50		UG/L	SD<LCL (none)
Trichlorofluoromethane	1.7	U	U	1.7	25		UG/L	
Vinyl Chloride	**77**			0.3	0.5		UG/L	

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Validated Form I

Validation Flag Abbreviations

Abbreviation	*Validation Reason*	*Category*
LCS<LCL	LCS recovery less than the lower control limit	LaboratoryControlSample
MS<LCL	Matrix spike recovery less than the lower control limit	Matrix
MSRPD	Matrix spike RPD criteria exceedance	Matrix
SD<LCL	Matrix spike duplicate recovery criteria less than the lower control limit	Matrix
2Cleve	Acid Preserved Sample	Miscellaneous
RE	Re-extraction and/or re-analysis	Re-analysis

Appendix O
Response to DTSC Comments on the November 11, 2015 *Results from Bravo Bedrock Vapor Extraction Treatability Study Technical Memorandum*

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Response to DTSC Review Comments
Technical Memorandum: Results from Bravo Bedrock Vapor Extraction Treatability Study - November 2015
National Aeronautics and Space Administration
Santa Susana Field Laboratory, Ventura County, California

No.	Reference	Comment	Response
1	Page 2, Paragraph 3	A table and figure summarizing the transducer elevations in HAR-19 and the surrounding piezometers would be helpful for the reviewer to better understand where the transducers are located vertically in relation to each other.	A well profile figure (**Figure 2.1-2**) and table (**Table 2.1-2**) summarizing the requested information are provided in this report.
2	Page 2, Paragraph 5	The text indicates the test occurred for one 5-day and two 4-day periods over 3 weeks. It would be more accurate to state the tests occurred over one 96-hour period and two 72-hour periods.	The test was operating, with the blower on, for 73 hours the first week, 75 hours the second week, and 100 hours the third week. Before the startup and after shutdown, each week, each of the 23 vapor piezometers were sampled for PID readings. These hourly durations have been added to the report text in **Section 2.4 Bedrock Vapor Extraction** for clarity.
3	Page 3, Paragraph 2	The text states that the run of August 29 is not shown in Figures 5 and 6 due to interference. Please provide the data separately (for example, in an appendix).	An obstruction was in the well on August 29, so no PneuLog data are available for that day. The complete Pneulog Report is contained in **Appendix H** of this report.
4	Page 4, Table 2	Explain why vapor samples were not collected on 8/29 and 10/23. Also, according to Figures 9a through 9e, PID readings were not taken while the system was operating on 10/23 making it very difficult to evaluate whether rebound occurred or not.	As presented in **Section 2.4.3 Soil Vapor Sampling and Pressure Measurements**, samples were not collected on August 29 because the Mobile Lab was not available on that day. The rebound test samples were collected on October 22, the first half-day of extraction following six weeks of shutdown. Both a 1-liter summa canister and a 1-liter Bottle-Vac sample were collected, and analyzed by EPA Methods TO-15, 3C and 8260B. These samples, soon after system restart, represent the rebound value. A sample on October 23, the second day of the rebound work, would have not served as well for this purpose, so was not collected.
5	Page 5, Paragraph 4	The text states: "Figures 8a through 8c demonstrate the major lateral influence of HAR-19 in the 100- to 140-foot bgs interval, as well as the lesser (but still significant) influence in the other two depth intervals." Figures 8b and 8c appear to indicate that the study was less effective at depth based on the delineation of the 1% vacuum response (green solid and dashed line). However, the 140-160 foot zone may have been more responsive than the 100-140 foot zone as the vacuum percentages in PZ-203d, PZ-201d and PZ-202d increased over the vacuum percentages in PZ-203c, PZ-201c and PZ-202c, respectively. Further, it appears that there is no data at depth in PZ-156 to assess the 140-160 foot interval. Please evaluate this further and consider revising the text to include further discussion regarding this issue.	Comment acknowledged. The pattern of vacuum propagation is believed to depend primarily on the nature and distribution of fractures. Fractures also represent the primary pathway for migrating contaminants of concern. For these reasons, that vacuum is more or less distributed according to depth may have more to do with local site and fracture heterogeneity; but this concern is probably less relevant for the purpose of removing contaminants: vacuum appears in the most likely places for VOCs to have travelled, or to travel in the future. See discussions in: **Section 3.3 Quantify Vacuum Response in Fractures and Matrix Block**; **Section 4.3 Vacuum Response in Fractures and Matrix Block**; and **Section 5.4 Objective 4: Effect of Lithology, Geology on Advective Flow Paths**.
6	Page 7	The text indicates this is a 13-day test. However, Figure 7a shows approximately 11 24-hour periods of time including the rebound extraction day in October. Please confirm this. See also Comment #2 above.	See response to Comment #2 above, and **Section 2.4 Bedrock Vapor Extraction**. All mentions of test duration stay the same in days, but are clarified in terms of actual hours duration (73, 75, and 100 hours) for the three weeks.

No.	Reference	Comment	Response
7	Page 7 Last Paragraph	The text states: "Overall, this test demonstrated the short-term extraction of air and some VOC mass from an existing corehole, provided the corehole is located in or near a source area and is intersected by an interconnected fracture system providing airflow and VOCs. In order to establish the effectiveness and the broader implementability of BVE, and to address more directly the long-term diffusion from the rock matrix (Objective 5), a longer duration test that includes tracer gases would need to be performed, preferably in a higher-concentration source area. In this longer duration test, a series of VOC rebound measurements in a source area would be taken in piezometers after short periods of extraction, to quantitatively assess the matrix offgas trends. In addition, a tracer gas such as helium would be injected in the injection well, and allowed to absorb in the adjacent bedrock for a short period. Then the well would be placed under extraction, and the arrival time would be tracked of helium that has not become absorbed to allow a quantitative assessment of the rock matrix absorption and the release of vapors. Coupled with the longer term VOC removal phase, this test would establish the operational parameters under which BVE could be expected to remove VOCs from the rock matrix and fractures to eliminate future transport to groundwater." DTSC agrees the short-term extraction test was effective at removing mass from the corehole. It is unclear whether additional mass could be effectively removed from this same location. It is recommended that additional testing be conducted at this location to assess rebound. Further, please evaluate and discuss VOC concentration in groundwater to determine if air sparging in HAR-19 coupled with bedrock vapor extraction may be effective.	Bedrock vapor extraction has been performed at ND-112 in the former LOX Plant AIG, as part of a mass characterization test (*Former LOX Plant Area of Impacted Groundwater Vapor Extraction Test Summary, Santa Susana Field Laboratory, Ventura County, California* [NASA, January 2016; in Appendix A of the May 2017 NASA SSFL Groundwater RFI Report]). This test took place in a borehole largely devoid of fractures, so was operated at and provided insight for BVE under a much higher vacuum. The NASA SSFL groundwater CMS report includes BVE as a technology alternative, and it is carried forward in the CMS evaluation. See **Section 4.6 Remediation Insights from the Test** for more discussion.
8	Pages 7-8	Verify whether this additional testing will be conducted. Please include a recommendations section.	Beyond the high vacuum vapor extraction test at ND-112 at the former LOX Plant AIG (see response to Comment #7 above), no further BVE testing is planned. The NASA SSFL groundwater CMS report carries forward this technology and will assess this remediation technology further. Additional BVE pilot testing may occur as part of the Corrective Measures Design and Implementation, if needed.
9	Pages 7-8	The conclusions fall short of making "next action" recommendations. The results indicate that BVE is a viable measure to reduce VOC mass and thus, I would suggest a Phase II treatability study be initiated, as alluded to in the conclusions.	Please see **Section 4 Results Interpretation and Synthesis** and **Section 5 Conclusions** in the current BVE TS report. Recommendations for additional application of BVE are evaluated and carried forward in the current NASA SSFL groundwater CMS report.
10	Figure 1	Area IV and the Northern Buffer Zone (called "undeveloped land" in the figure) are labeled as "Boeing." Verify whether this should be labeled as Boeing/DOE or DOE instead.	This figure has been removed from the report.
11	Figure 3	The figure notes that the cross sections are provided in Section 3 of the BVE Summary Report, which has not been provided to DTSC. Please provide the referenced summary report or add the cross sections to this tech memo.	This report consitutes the referenced BVE Summary Report and is being provided as an appendix to the NASA SSFL groundwater CMS report. The referenced cross sections are included herein.

Response to DTSC Review Comments
Technical Memorandum: Results from Bravo Bedrock Vapor Extraction Treatability Study - November 2015
National Aeronautics and Space Administration
Santa Susana Field Laboratory, Ventura County, California

No.	Reference	Comment	Response
12	Figure 3	Please provide well construction and water level information for the extraction and observation wells. This should be provided in a table and a cross section figure.	The BVE Summary Report is being provided as an appendix to the NASA SSFL groundwater CMS report and includes well construction information tables (**Tables 2.1-1** and **2.1-2**) and a well profile figure (**Figure 2.1-2**) to show relative screen elevations for the BVE study wells (see also response to Comment #1).
13	Figures 7a-7e	Verify whether the data should be adjusted based on the BaroLogger ambient conditions.	The data were deconvoluted using USGS Series-See (Halford, K.J., Garcia, C.A., Fenelon, J.M., and Mirus, B.B., 2012, A*dvanced Methods for Modeling Water-Levels and Estimating Drawdowns with SeriesSEE, an Excel Add-In.* U.S. Geological Survey Techniques and Methods 4-F4, 28 p.). The data are presented in this report with the barometric effect neutralized. See **Section 3.3 Quantify Vacuum Response in Fracutres and Matrix Block**.
14	Figure 7b	Transducer PZ-202c appears to have increases and decreases where all of the other piezometers generally appear to have somewhat consistent responses. Is this the result of a transducer malfunction or an actual response? Please provide further assessment regarding what is occurring with the transducer results at PZ-202c.	This phenomenon is likely the result of water that was used to cool the rock coring tool at this location, and which at the "c" depth, did not adequately drain. The regular but variable pressure variation strongly suggests water in a confined space, responding dynamically in response to the vacuum and again when the vacuum is turned off and gravity reasserts itself. This phenomenon provides insight on prudent construction techniques for future deployment of BVE.
15	Figure 7e	The transducer in PZ-156 has a negative vacuum response between the 2nd and 3rd round of extraction testing. Please provide an explanation for this or indicate why it is not a concern.	PZ-156 showed a "negative vacuum", or a positive pressure response over the weekend. Being a sealed well, this could have occurred due to a small rise in the water table in its deeper reaches. This pressure pattern is shown on **Figure 3.3-1E** and discussed in **Section 3.3 Quantify Vacuum Response in Fracutres and Matrix Block**.
16	General	Please provide the laboratory reports including the MRL information and tabulated versions of all of the data collected.	The laboratory data is tabulated in the current report in **Appendixes I and M**. Laboratory reports are included in **Appendix N** (the Data Useability Assessment Report).
17	General	Please provide the QA/QC sample results and evaluation.	The QA/QC sample evaluation is included in **Appendix N** (the Data Useability Assessment Report).
18	General	Provide field methodology details (purging the well before sample collection, etc.).	Field methodology followed the *Bedrock Vapor Extraction Treatability Study at the Bravo Test Area Implementation Plan* (BVE IP) (NASA, 2014) and the BVE TM (NASA, 2014) as discussed in **Section 2 Field Investigation** of the current report.
19	General	Please include a table of field readings (Table 4-2 of the Implementation Plan).	PID field measurements are provided in **Table 3.4-1** of the current report. Field vapor sampling logs are included in **Appendix K**.
20	General	Please provide mass removal calculation assumptions and details.	Mass removal is discussed in **Section 3.2 Quantify VOC Removal in BVE Well** and included in **Table 3.2-1** of the current report.
21	General	Refer to attached comparison matrix between the approved work plans and the TM. Address any inconsistencies.	The current report provides more detailed information for the BVE Treatability Study compared to the TM previously reviewed by DTSC to document the work performed.

Note: The figure and table numbers cited in this response to comment table are associated with the original subject report (the *Bravo Bedrock Vapor Extraction Treatability Study for the Santa Susana Field Laboratory, Ventura County, California* dated 11/11/2015) unless specified otherwise.

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Appendix G
Basis of Estimate for Source Area and Seep Alternative Costs

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Appendix G1
Basis of Estimate for High TCE Concentration Groundwater Alternatives

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Basis of Estimate for High TCE Concentration Groundwater Alternatives

Introduction

This basis of estimate has been developed to support the groundwater alternative cost estimates associated with the National Aeronautics and Space Administration (NASA) Phase 1 Groundwater Corrective Measures Study (CMS) at the Santa Susana Field Laboratory (SSFL) site. Although the SSFL site work is being conducted under the Resource Conservation and Recovery Act (RCRA), the process is similar to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. Consequently, cost estimates were developed in accordance with the Feasibility Study (FS) process outlined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), which requires cost as one of the primary evaluation criteria between alternatives. The CMS for groundwater remediation at SSFL includes development of costs for groundwater management as summarized in the following sections.

Cost Estimate Approach

Cost Workbook Overview

The approach taken to complete the cost estimates for the groundwater management in the CMS at SSFL was to develop costs for each alternative. The groundwater Target Treatment Areas (TTAs) include the ND-136 TTA (Alfa Area), WS-09 TTA (Bravo Area), and C-6 TTA (Delta Area). In the costing workbook, each alternative cost is developed for each of the three TTAs. The costing workbook contains the following spreadsheets:

- Spreadsheet 1: Cost Summary
- Spreadsheet 2: Alternative 1, Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs)
- Spreadsheet 3: Alternative 2a, Enhanced In Situ Bioremediation (EISB), Bedrock Vapor Extraction (BVE), MNA, and LUCs
- Spreadsheet 4: Alternative 2b, BVE, Thermally Enhanced EISB, MNA, and LUCs
- Spreadsheet 5: Alternative 3, Pump and Treat (P&T), BVE, MNA, and LUCs
- Spreadsheets 6: Alternative 4, In Situ Chemical Oxidation (ISCO), BVE, MNA, and LUCs
- Spreadsheet 7: Details for BVE Treatment at ND-136 TTA – rolled into cost estimate for Alternatives 2a, 2b, 3, and 4
- Spreadsheet 8: Groundwater Extraction and Treatment System (GETS) Treatment Costs – NASA's share of GETS costs at system managed by The Boeing Company (Boeing)
- Spreadsheet 9: T-EISB Heating Source Costs – rolled into Spreadsheet 4
- Spreadsheet 10: MNA Network by TTA, List of Wells Assumed for MNA Monitoring Per TTA
- Spreadsheet 11. Laboratory and Data Validation Costs
- Spreadsheet 12. Discount Rate Schedule – used as lookup table for different cost spreadsheets and includes Turner Construction Cost Index factors used for escalation
- Spreadsheet 13. EISB Treatment Reagent Calculations
- Spreadsheet 14. ISCO Treatment Reagent Calculations

- Spreadsheet 15: U.S. Environmental Protection Agency (EPA) Recommendations for Cost Loading Factors, from *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000)

Presentation of Costs

The costs presented in the summary spreadsheet (Spreadsheet 1) were developed in each of the separate costing spreadsheets (Spreadsheets 2 through 15), and are linked to those spreadsheets. For each remedial alternative, Spreadsheet 1 summarizes capital costs, operations and maintenance (O&M) costs, and total costs, based on the details presented in Spreadsheets 2 through 15.

The costs were developed as Class 4 estimates, consistent with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). A Class 4 estimate is considered a conceptual design, with an accuracy range of -30% to +50%. Therefore, the summary spreadsheet (Spreadsheet 1) includes the +50%/-30% cost range based on the total costs for each remedial alternative for each area.

Net Present Value Considerations

The costs are presented as net present value costs. The discount rate applied to calculate the net present value costs is shown on Spreadsheet 1.

The time of remediation (TOR) applied to calculate the net present value costs is included for each of the remedial alternatives. The TOR is presented in the present value analysis by presenting periodic costs for the period evaluated.

The discount factor used to calculate the net present value is based on the discount rate, assumed to be 2%, and the TOR. The discount factors are included in a backup spreadsheet in the workbook (Spreadsheet 12) and are calculated based on changing the discount rate and TOR on the Cost Summary (Spreadsheet 1). The basis for the TOR and discount rate used for cost estimating are presented in Section 6.2.8 of the Phase 1 Groundwater CMS, respectively.

Assumptions

General Assumptions Related to Method of Accomplishment

The method of accomplishment for the site includes an integrating contractor, field subcontractor, and design subcontractor. Factors for design, project management, and construction management were based on guidance from *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). A 25% contingency cost was also included in capital costs.

General Assumptions for all Remedial Alternatives

- Costs are developed based on vendor quotes, costs for construction activities from similar projects, and cost estimating experience.
- Costs were primarily based on the year 2020, with escalation to 2023 using Turner Construction Cost Index factors. Based on the index factors, a 16.57% increase was applied to costs that were not considered current. In the cost spreadsheets, an escalation factor column is included to note where the increases have been applied.
- MNA monitoring includes costs for well sampling, reporting, and analytical costs.
- MNA monitoring will be carried out and reported semiannually, as included in the O&M costs of the individual cost spreadsheets.
- The TTAs and depths of treatment are described in Section 4.2.1 and Appendix D of the Phase 1 Groundwater CMS.
- Applicable alternatives include O&M costs for reconditioning of wells, replacement pumps and other O&M activities as summarized.

Assumptions Specific to Remedial Alternatives

- Alternative 1 – Monitored Natural Attenuation and LUCs (all alternatives; Spreadsheet 2)
  - Development of an MNA work plan and LUC design and implementation plan are included in the capital cost for each alternative.
  - MNA and LUCs also apply to all alternatives and are estimated as outlined in the cost sheets.
  - MNA and LUCs TOR is assumed to be 30 years.
  - Wells included in the monitoring program are defined in Spreadsheet 10.
  - The analytical schedule is defined in Spreadsheet 11.
  - Discount rates used for present value calculations are referenced by the VLOOKUP Excel function and referencing Spreadsheet 12
- Alternative 2a – EISB Treatment (Spreadsheets 3 and 4)
  - EISB is planned for implementation in the vicinity of ND-136, WS-09, and C-6.
  - No capital costs are included for the ND-136 TTA. This treatment system will be installed for the EISB pilot study.
  - Capital costs for the WS-09 and C-6 areas are assumed to be the same for costing purposes.
  - These areas are planned to have seven wells installed (three injection wells, one extraction well, and three monitoring wells). Only six wells are included in the cost estimate, as it is assumed one of the wells located at each TTA will be repurposed as a monitoring, injection, or extraction well.
  - EISB will be delivered using a recirculation approach.
  - Three upgradient injection wells will be used to deliver EISB substrate.
  - An extraction well will be placed on the downgradient side of the TTA.
  - Groundwater extracted from the extraction well (10 to 30 gallons per minute) will be dosed with treatment reagents, as necessary, and gravity drained into the injection wells.
  - EISB TOR is assumed to take 10 years.
  - MNA and LUCs represent costs for a total of 30 years (including 20 years after active treatment).
  - BVE is expected to provide ventilation of interconnected fractures, pathways in the rock matrix used by volatile organic compounds (VOCs) to migrate are treated, and upward pathways for possible surface emission are captured to remove VOCs.
  - BVE would require a new vapor extraction well to be installed at the ND-136 TTA.
  - A vacuum of 70 inches (H_2O) to produce a flow of 125 standard cubic feet per minute (scfm) is assumed for operation.
  - Vapor-phase granular activated carbon (e.g., four 6,000-pound vessels) is planned with periodic recharge of media.
  - Assumed BVE TOR is 5 years.
  - Wells included in the monitoring program are defined in Spreadsheet 10.
  - The analytical schedule is defined in Spreadsheet 11.
  - Discount rates used for present value calculations are referenced by the VLOOKUP Excel function and by referencing Spreadsheet 12.

- EISB dosing calculations are referenced in Spreadsheet 13 and include initial EISB treatment reagent addition and reapplication of treatment reagents in years 4 and 7.
- Capital and O&M costs for BVE elements of this alternative are presented in Spreadsheet 7 (BVE at the ND-136 TTA).

- Alternative 2b – Thermally Enhanced EISB (T-EISB in Spreadsheet 4, Steam Boiler in Spreadsheet 9)
  - All information in Alternative 2a applies to this alternative, with the addition of heating water prior to re-injection to enhance biological activity for contaminant reduction and installation of six additional coreholes to monitor temperature in the TTA.
  - An onsite electric powered steam boiler would be used for heating the water with a goal of heating recirculated water to achieve a 10 degrees Celsius (°C) temperature rise in the TTA. For the purpose of this CMS, it was assumed water would be injected at 145°C.
- Alternative 3 – Pump and Treat (Spreadsheet 5)
  - Estimated extraction rates are presented in Table 6-2 of the Phase 1 Groundwater CMS.
  - Extracted water will be treated at the GETS, which is operated by Boeing.
  - P&T TOR is assumed to be 10 years.
  - MNA and LUCs represent costs for a total of 30 years (including 20 years after active treatment).
  - BVE is expected to provide ventilation of interconnected fractures, pathways in the rock matrix used by VOCs to migrate are treated, and upward pathways for possible surface emission are captured to remove VOCs.
  - BVE would require a new vapor extraction well to be installed at the ND-136 TTA.
  - A vacuum of 70 inches (H_2O) to produce a flow of 125 scfm is assumed for operation.
  - Vapor-phase granular activated carbon (e.g., four 6,000-pound vessels) is planned with periodic recharge of media.
  - Assumed BVE TOR is 5 years.
  - Wells included in the monitoring program are defined in Spreadsheet 10.
  - The analytical schedule is defined in Spreadsheet 11.
  - Discount rates use for present value calculations are referenced by the VLOOKUP Excel function and by referencing Spreadsheet 12.
  - NASA's share of the GETS, which includes the physiochemical treatment of groundwater, is presented in Spreadsheet 8.
  - Capital and O&M costs for BVE elements of this alternative are presented in Spreadsheet 7 (BVE at the ND-136 TTA)
- Alternative 4 – ISCO (Spreadsheet 6)
  - ISCO is planned for implementation in the vicinity of ND-136, WS-09, and C-6.
  - No capital costs are included for ND-136. This treatment system will be installed as part of the EISB pilot study, which is substantially equivalent to that which would be used for ISCO delivery.
  - Capital costs for the WS-09 and C-6 areas are assumed to be the same for costing purposes.
  - These areas are planned to have seven wells installed (three injection wells, one extraction well, and three monitoring wells). Only six wells are included in the cost estimate, as it is assumed one of the wells located at each TTA will be repurposed as a monitoring, injection, or extraction well.

- ISCO will be delivered using a recirculation approach via upgradient inject wells and downgradient recirculation wells.
- Upgradient injection wells will be used to deliver ISCO reagents.
- ISCO TOR is assumed to be 10 years, although MNA and LUCs are expected to extend to 30 years.
- BVE is expected to provide ventilation of interconnected fractures, pathways in the rock matrix used by VOCs to migrate are treated, and upward pathways for possible surface emission are captured to remove VOCs.
- BVE would require a new vapor extraction well to be installed at the ND-136 TTA.
- A vacuum of 70 inches (H_2O) to produce a flow of 125 scfm is assumed for operation.
- Vapor-phase granular activated carbon (e.g., four 6,000-pound vessels) is planned with periodic recharge of media.
- Assumed BVE TOR is 5 years.
- Wells included in the monitoring program are defined in Spreadsheet 10.
- The analytical schedule is defined in Spreadsheet 11.
- Discount rates use for present value calculations are referenced by the VLOOKUP Excel function and referencing Spreadsheet 12.
- ISCO dosing calculations are referenced in Spreadsheet 14 and include annual ISCO injections.
- Capital and O&M costs for BVE elements of this alternative are presented in Spreadsheet 7 (BVE at the ND-136 TTA).

Cost Uncertainty

The range of costs provided (-30%/+50%) is considered sufficient to cover the risk associated with unknowns of each alternative. The cost summary sheet (Spreadsheet 1) provides a cost range based on the confidence of the cost estimate.

Escalation Factors

Some costs were derived from sources such as the RSMeans Estimating Methods catalog (RSMeans 2004). Where current costs were not available, costs were escalated to fourth quarter 2019 costs using the Turner Building Cost Index. Escalation factors were used by dividing the current index by the index for the year of the cost item to derive a current cost. Escalation factors were applied when project experience or RSMeans environmental cost data from previous years were used as the basis for a line item unit cost, as called out in the notes/assumptions column of the individual remedial alternative cost spreadsheets.

References

RSMeans. 2004. *Environmental Remediation Cost Data—Assemblies*. 10th Annual Edition. Kingston, MA.

U.S. Environmental Protection Agency (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*. Interim Final.

U.S. Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. July.

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Appendix G2
Basis of Estimate for Seep Alternatives

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Basis of Estimate for Seep Alternatives

Introduction

This basis of estimate has been developed to support the seep alternative cost estimates associated with the National Aeronautics and Space Administration (NASA) Phase 1 Groundwater Corrective Measures Study (CMS) at the Santa Susana Field Laboratory (SSFL) site. Although the SSFL site work is being conducted under the Resource Conservation and Recovery Act (RCRA), the process is similar to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. Consequently, cost estimates were developed in accordance with the Feasibility Study (FS) process outlined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), which requires cost as one of the primary evaluation criteria between alternatives. The CMS for groundwater remediation at SSFL includes development of costs for seep management primarily as a contingency should site contaminants be detected in seep water in the future.

Cost Estimate Approach

Cost Workbook Overview

The approach taken to complete the cost estimates for the seep management in the CMS at SSFL was to develop costs for each alternative for two separate areas where off-site seep water is expected to be at potential risk being impacted by onsite impacted groundwater. The seep areas include the Southern Seep Area, located in the Burro Flats Fault Zone area, and the Northern Seep Area, which consists of an area north of the Expendable Launch Vehicle (ELV) and another area north of the Building 204 Area. In the costing workbook, each alternative cost is developed for each seep area and presented in its own spreadsheet. The costing workbook contains the following spreadsheets:

- Spreadsheet 16: Cost Summary
- Spreadsheet 17: Alternative SP-1 – Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs) in Northern Seep Area
- Spreadsheet 18: Alternative SP-1 – MNA and LUCs in Southern Seep Area
- Spreadsheet 19: Alternative SP-2 – Hydraulic Control, MNA, and LUCs in Northern Seep Area
- Spreadsheet 20: Alternative SP-2 – Hydraulic Control, MNA, and LUCs in Southern Seep Area
- Spreadsheet 21: Alternative SP-3 – Enhanced In Situ Bioremediation (EISB), MNA, and LUCs in Northern Seep Area
- Spreadsheet 22: Alternative SP3 – EISB, MNA, and LUCs in Northern Seep Area and Southern Seep Area
- Spreadsheet 23: Enhanced Reductive Dechlorination (ERD) Treatment Reagents for Northern Seep Area
- Spreadsheet 24: ERD Treatment Reagents for Southern Seep Area
- Spreadsheet 25: Laboratory Services - Analytical Costs – Monitoring for ERD North System
- Spreadsheet 26: Laboratory Services - Analytical Costs – Monitoring for ERD South System
- Spreadsheet 27: Present Value Schedule – used as lookup table for different cost spreadsheets
- Spreadsheet 28: U.S. Environmental Protection Agency (EPA) Recommendations for Cost Loading Factors, from *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000)

Presentation of Costs

The costs presented in the summary spreadsheet (Spreadsheet 16) were developed in each of the separate costing spreadsheets (Spreadsheets 17 through 28) and are linked to those spreadsheets. For each remedial alternative, Spreadsheet 16 summarizes capital costs, operations and maintenance (O&M) costs, and total costs, based on the details presented in Spreadsheets 17 through 28.

The costs were developed as Class 4 estimates, consistent with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). A Class 4 estimate is considered a conceptual design, with an accuracy range of -30% to +50%. Therefore, the summary spreadsheet (Spreadsheet 16) includes the +50%/-30% cost range based on the total costs for each remedial alternative for each area.

Net Present Value Considerations

The costs are presented as net present value costs. The discount rate applied to calculate the net present value costs is shown on Spreadsheet 1.

The time of remediation (TOR) applied to calculate the net present value costs is included for each of the remedial alternatives. The TOR was estimated to be 10 years for each alternative. The actual TOR will depend on when/if site contaminants are found in the seep water and the effectiveness of groundwater corrective actions. However, using a consistent TOR for the seep alternative costing provides a consistent metric for evaluation costs.

The discount factor used to calculate the net present value is based on the discount rate, assumed to be 2%, and the TOR. The discount factors are included in a backup spreadsheet in the workbook (Spreadsheet 27) and are calculated based on changing the discount rate and TOR on the Cost Summary (Spreadsheet 16). The basis for the TOR and discount rate used for cost estimating are presented in Section 6.2.8 of the Phase 1 Groundwater CMS, respectively.

Assumptions

General Assumptions Related to Method of Accomplishment

The site’s method of accomplishment includes an integrating contractor, field subcontractor, and design subcontractor. Factors for design, project management, and construction management were based on guidance from *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). A 25% contingency cost was also included in capital costs.

General Assumptions for all Remedial Alternatives

- Costs are developed based on vendor quotes, costs for construction activities from similar projects, and cost estimating experience.
- Costs were primarily based on the year 2020, with escalation to 2023 using Turner Construction Cost Index factors. Based on the index factors, a 16.57% increase was applied to costs that were not considered current. In the cost spreadsheets, an escalation factor column is included to note where increases have been applied.
- MNA monitoring includes costs for well sampling, reporting, and analytical costs.
- MNA monitoring will be carried out and reported semiannually, as included in the O&M costs of the individual cost spreadsheets.
- The target treatment areas and depths of treatment are described in Section 4.2.1 and Appendix D of the Phase 1 Groundwater CMS.
- Applicable alternatives include O&M costs for reconditioning of wells, replacement pumps and other O&M activities as summarized.

Assumptions Specific to Remedial Alternatives

- SP-1 – MNA and LUCs (Spreadsheets 17 and 18 for the Northern and Southern Seep Areas, respectively)
  - Development of an MNA work plan and LUC design and implementation plan are included in the capital cost for each alternative.
  - MNA and LUCs also apply to all alternatives and are estimated as outlined in the cost sheets.
  - MNA and LUCs TOR is assumed to be 10 years
  - Wells included in the monitoring program for the Northern and Southern Seep Areas are defined in Spreadsheets 25 and 26, respectively. The analytical schedule for analysis is also presented in these spreadsheets.
  - Discount rates used for present value calculations are referenced by the VLOOKUP Excel function and by referencing Spreadsheet 27.
- SP-2 – Hydraulic Control (Spreadsheets 16 and 19)
  - Monitoring Program (for each seep area)
    - Development of an MNA work plan and LUC design and implementation plan are included in the capital cost for each alternative.
    - MNA and LUCs also apply to all alternatives and are estimated as outlined in the cost sheets.
    - MNA and LUCs TOR is assumed to be 10 years
    - Wells included in the monitoring program for the Northern and Southern Seep Areas are defined in Spreadsheets 25 and 26, respectively. The analytical schedule for analysis is also presented in these spreadsheets.
    - Discount rates used for present value calculations are referenced by the VLOOKUP Excel function and by referencing Spreadsheet 27.
  - Northern Seep Area (Building 204/Expendable Launch Vehicle [B204/ELV] Area of Impacted Groundwater [AIG])
    - Based on the current understanding of the subsurface contamination, a total of three new downgradient wells are assumed.
      - Wells are configured with one extraction well downgradient and near RD-56 (Building 204 Area transect) and two extraction wells downgradient of ND-125 (ELV transect).
      - Wells are planned to be installed as open boreholes to a depth of 450 feet below ground surface (bgs) with solid casing to 100 feet bgs at the Building 204 Area transect and 400 feet bgs with solid casing to 100 feet bgs at the ELV transect.
      - Wells will be connected to the existing groundwater extraction and treatment system (GETS) to manage extracted groundwater.
      - Power to the well heads is available via the existing transformer near the office trailer.
      - New piping will be installed above grade and secured to existing structures or foundations.
      - New pipeline will consist of up to 750 feet of pipe to individual wells with up to 2,450 feet of trunk line.
      - Wells will be connected to the existing GETS telemetry system.
  - Southern Seep Area (Burro Flats Fault Zone Area)

    - Based on pump test results, it is assumed that a single existing extraction well (ND-138 [A or B]) can be used to effectively provide hydraulic control in the Burro Flats Fault Zone Area seeps.
    - Groundwater extraction is currently operating in this area and has been connected to the GETS (conveyance and telemetry systems).

- SP-3 – EISB Treatment Zone (Spreadsheets 19 and 20 for the Northern and Southern Seep Areas, respectively)
  - Monitoring Program (for each seep area)
    - Development of an MNA work plan and LUC design and implementation plan are included in the capital cost for each alternative.
    - MNA and LUCs also apply to all alternatives and are estimated as outlined in the cost sheets.
    - MNA and LUCs TOR is assumed to be 10 years.
    - Wells included in the monitoring program for the Northern and Southern Seep Areas are defined in Spreadsheets 25 and 26, respectively. The analytical schedule for analysis is also presented in these spreadsheets.
    - Discount rates used for present value calculations are referenced by the VLOOKUP Excel function and by referencing Spreadsheet 27.
  - Northern Seep Area (B204/ELV AIG) – 10 years of treatment
    - Based on the current understanding of the subsurface contamination, a total of 10 new downgradient wells are assumed.
      - Wells are configured as two transects downgradient of ND-125 and RD-56 (Building 204 Area transect).
      - Each transect consists of a line of five wells on 50-foot centers (with a radius of influence of 25 feet).
      - Wells are planned to be installed as open boreholes to a depth of 450 feet bgs with solid casing to 100 feet bgs.
      - Annual re-injections are assumed.
      - Emulsified vegetable oil (EVO) is the planned substrate (refer to Spreadsheet 23 for amount applied and basis for amount).
  - Southern Seep Area (Burro Flats Fault Zone Area) – 10 years of treatment
    - Based on pump test results, it is assumed that a single existing injection well (ND-138A) can be used to effectively deliver the required substrate in the Burro Flats Fault Zone Area seeps.
    - EVO is the planned substrate (refer to Spreadsheet 23 for amount applied and basis for amount).

Cost Uncertainty

The range of costs provided (-30%/+50%) is considered sufficient to cover the risk associated with the unknowns of each alternative. The cost summary sheet (Spreadsheet 16) provides a cost range based on the confidence of the cost estimate.

Escalation Factors

Some costs were derived from sources such as the RSMeans Estimating Methods catalog (RSMeans 2004). Where current costs were not available, costs were escalated to fourth quarter 2019 costs using the Turner

Building Cost Index. Escalation factors were used by dividing the current index by the index for the year of the cost item to derive a current cost. Escalation factors were applied when project experience or RSMeans environmental cost data from previous years were used as the basis for a line item unit cost, as called out in the notes/assumptions column of the individual remedial alternative cost spreadsheets.

References

RSMeans. 2004. *Environmental Remediation Cost Data—Assemblies*. 10th Annual Edition. Kingston, MA.

U.S. Environmental Protection Agency (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*.

U.S. Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. July.

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Spreadsheets 1–15

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Spreadsheet 1: Cost Summary for Groundwater Alternatives

Element	Alternative 1: MNA and LUCs	Alternative 2a: EISB, BVE, MNA, and LUCs	Alternative 2b: T-EISB, BVE, MNA, and LUCs	Alternative 3: P&T, BVE, MNA, and LUCs	Alternative 4: ISCO, BVE, MNA, and LUCs
Capital Cost					
MNA & LUCs	$220,000			$220,000	
EISB		$11,039,948			
T-EISB			$14,306,467		
P&T				$943,275	
ISCO					$11,355,571
BVE @ ND-136 TTA		$278,902	$278,902	$278,902	$278,902
Capital SubTotal	$220,000	$11,318,850	$14,585,369	$1,442,177	$11,634,472
PV O&M Costs					
MNA & LUCs (30 yrs)	$7,111,000	$7,111,000	$7,111,000	$7,111,000	$7,111,000
EISB (10 yrs)		$4,451,964			
T-EISB (10 yrs)			$5,161,055		
P&T (10 yrs)				$3,895,000	
ISCO (10 yrs)					$5,082,623
BVE @ ND-136 TTA (5 Yrs)		$7,747,387	$7,747,387	$7,747,387	$7,747,387
PV O&M Subtotal	$7,111,000	$19,310,351	$20,019,443	$18,753,387	$19,941,010
Total Present Value of Alternative (NPV @ 2%) for 30 years	$7,331,000	$30,629,201	$34,604,812	$20,195,564	$31,575,482
+50% NPV Costs for 30 years	$10,996,500	$45,943,802	$51,907,217	$30,293,346	$47,363,223
-30% NPV Costs for 30 years	$5,131,700	$21,440,441	$24,223,368	$14,136,895	$22,102,837

Spreadsheet 2: Alternative 1, Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs)

Cost Worksheet, Opinion of Probable Costs

NASA, SSLF P1 CMS

10/20/2023

CAPITAL COSTS

	DESCRIPTION	QTY	UNIT	COST	Escalation	TOTAL	NOTES
	Land Use Controls						
	LUC Remedial Design and implementation	1	LS	$40,000	16.57%	$46,627	Based on project similar in nature.
	SUBTOTAL					**$46,627**	
	Develop MNA Work Plan						
	Prepare MNA work plan	1	LS	$100,000	16.57%	$116,567	Based on project similar in nature.
	SUBTOTAL					**$116,567**	
	SUBTOTAL Capital Cost					$163,194	
	Contingency	25%		$163,194		$40,798	USEPA 2000 Guide to Developing and documenting Cost Estimates, 10% Scope and 15% Bid
	SUBTOTAL					**$203,992**	
	Project Management	8%		$203,992		$16,319	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	Design	0%		$203,992		$0	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	Construction Management	0%		$203,992		$0	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	SUBTOTAL					$16,319	
	TOTAL CAPITAL COST					**$220,000**	

OPERATIONS AND MAINTENANCE COST - 1 Year Period

	DESCRIPTION	QTY	UNIT	UNIT COST		TOTAL	NOTES
O&M LUC							
	Annual Land Use Monitoring and Reporting	1	EA	$30,000	16.57%	$34,970	Based on recent project similar in nature.
MNA Monitoring							
	Subcontractor Oversight	94	Hours	$196	16.57%	$21,476	E4 staff rate Option Year 1
	Analytical Costs	2	EVENT	$77,955		$155,911	Includes Data Validation
	Annual report	1	LC	$70,000	16.57%	$81,597	Based on recent project similar in nature.
	SUBTOTAL					**$258,984**	
	SUBTOTAL					$293,954	
	Project Management	8%				$23,516	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	Remedial Design	0%				$0	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	Construction Management	0%				$0	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $100K-$500K
	SUBTOTAL					**$23,516**	
	TOTAL O&M					**$317,470**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE
CAPITAL COST	0	$220,000	1.00	$220,000
O&M COST	30	$317,470	22.40	$7,111,000
TOTAL PRESENT VALUE FOR MNA & LUCs - ALT 1				**$7,331,000**

Spreadsheet 3: Alternative 2a, Enhanced In-Situ Bioremediation (EISB), Bedrock Vapor Extraction (BVE [see Spreadsheets 7 and 8]), MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023

Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description		Qty	Unit	Unit Cost	Escalation	Total	Notes
Preconstruction							
	Installation Subcontractor Bond and Submittals	1	LS	$14,154	16.57%	$16,499	Based on recent project similar in nature.
	Well permits	6	EA	$400	16.57%	$2,798	Based on recent project similar in nature.
	Driller Mobilization	1	LS	$20,000	16.57%	$23,313	Based on recent project similar in nature.
	Civil Mobilization	1	LS	$7,500	16.57%	$8,743	Based on recent project similar in nature.
	Utility Locate	2	DY	$2,198	16.57%	$5,123	Based on recent project similar in nature.
	Brush Clearance	8	DY	$3,000	16.57%	$27,976	Based on recent project similar in nature.
	Waste Discharge Permit	1	EA	$40,000	16.57%	$46,627	Based on recent project similar in nature.
	Setup Stockpile Area	1	LS	$5,000	16.57%	$5,828	Based on recent project similar in nature.
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
	C-6 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
ND-136 (ALFA)							
	Drilling Contractor						
	Drill Extraction/Injection/Monitoring Wells (PQ rock core) and develop	2,375	FT	$115	16.57%	$318,374	Based on recent bid average of $115 per foot for bedrock coring/developmet (five 475-foot wells).
	Drill Downgradient Monitoring Well (PQ rock core) and develop	515	FT	$115	16.57%	$69,037	Based on recent bid average of $115 per foot for bedrock coring/developmet (one 515-foot well).
	Well Development	6	EA	$10,000	16.57%	$69,940	Based on recent bid
	Ream PQ rock cores to 6-inch	3	LS	$47,500	16.57%	$166,108	Based on Yellow Jacketbid for air rotary drilling 6-inch boring; $100 per foot (three 475-foot wells injection wells)
	Injection/Monitoring Well Head Completion	6	EA	$2,000	16.57%	$13,988	Allowance for misc. valves/fittings.
	Geophysical Surveys	6	EA	$13,750	16.57%	$96,168	Based on recent quote.
	Packer Testing	6	WL	$24,300	16.57%	$169,955	Based on recent project similar in nature. Assumes 10 packer tests, collect depth discrete GW samples in packered zones at each well.
	FLUTe Well Installation	3	EA	$76,257	16.57%	$266,672	5 port FLUTe wells, two 475-ft and one 515 ft. Costs from recent quote.
	Survey	6	WL	$800	16.57%	$5,595	Based on recent project similar in nature.
	Field Oversight/Travel	6	WL	$70,000	16.57%	$489,582	assumes working 20 days per well, two staff, plus travel
	Site Restoration	1	EA	$8,000	16.57%	$9,325	Based on recent project similar in nature.
	IDW Management - Well Water & Solids	6	WL	$122,080	16.57%	$853,829	Based on recent project similar in nature.
	Waste Characterization	6	LS	$10,000	16.57%	$69,940	Based on historical pricing.
	Misc. Field supplies and shipping	6	WL	$6,000	16.57%	$41,964	Based on recent project similar in nature.
	Geologist - Oversight for operations	80	DY	$1,350	16.57%	$125,892	Unit Rate includes Geologist for 10 hrs/day plus Per Diem-Lodging and Meals, and Rental vehicle
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$2,766,369**	
	C-6 TTA: Assume same at ND-136 TTA Subtotal					**$2,766,369**	

Spreadsheet 3: Alternative 2a, Enhanced In-Situ Bioremediation (EISB), Bedrock Vapor Extraction (BVE [see Spreadsheets 7 and 8]), MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023

Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description	Qty	Unit	Unit Cost	Escalation	Total	Notes
Install Extraction/Recirculation System						
Schedule Updates/Site Preparation	1	LS	$5,500	16.57%	$6,411	Based on recent Subcontractor quote.
Install containment berm, injection manifold pipe rack, and overhead canopy	1	LS	$21,773	16.57%	$25,380	Based on recent Subcontractor quote.
Injection leg conveyance piping, concrete road ramp (Connection at GETS and EW to Iws)	1	LS	$18,230	16.57%	$21,250	Based on recent Subcontractor quote.
Provide and install Electric and Com. Control Panels with Controls Package	1	LS	$65,000	16.57%	$75,769	Based on recent Subcontractor quote.
Provide Valves, Fittings, Transduscors, Flow Meters, Pressure Gauges, Leak Detection Sensors	1	LS	$94,126	16.57%	$109,720	Based on recent Subcontractor quote.
Conduct pressure/leak testing, controls testing, and third-party operations and maintenance training	1	LS	$7,800	16.57%	$9,092	Based on recent Subcontractor quote.
Provide project completion documentation, final deliverables (as-builts, operations and maintenance plan)	1	LS	$8,000	16.57%	$9,325	Based on recent Subcontractor quote.
EISB Startup Support	1	LS	$72,101		$72,101	Actual Cost
Site Restoration	1	LS	$3,000	16.57%	$3,497	Based on recent Subcontractor quote.
3-Month Post-Startup Troubleshooting and Repairs	1	LS	$11,700	16.57%	$13,638	Based on recent Subcontractor quote.
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$346,184**	
C-6 TTA: Assume same at ND-136 TTA Subtotal					**$346,184**	
Injections and Tracer/Substrate Distribution Monitoring						
Mobe	1	EA	$15,000	16.57%	$17,485	Based on recent project similar in nature.
Baseline Groundwater Sampling Analytical Laboratory Costs	1	Event	$25,985	16.57%	$30,290	1/3 of MNA EISB Costs
EISB Substrate, Tracer, and Bioaugmentation Culture	1	LS	$49,415	16.57%	$57,602	EIBSubstrate Worksheet for ND-136
Injections Operator and Field Labor	41	DY	$1,628	16.57%	$77,820	Based on recent quote.
Tracer Test, Tracer/Substrate Distribution Monitoring	1	EA	$102,074	16.57%	$118,985	Based on OUL quote and 3-months monitoring/sampling costs estimate.
As-Built Report and Construction Completion Report	1	EA	$150,000	16.57%	$174,851	Based on recent project similar in nature.
O&M for Extraction wells (Annual 9 HP total at 24 hrs per day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$488,002**	
C-6 TTA: Assume same at ND-136 TTA Subtotal + 2x EISB Reagents and Field Labor					**$623,423**	
EISB Recirculation System Total					**$7,610,345**	
Engineering, PM, CM						
Design	1	LS	$208,476		$208,476	Actual Cost
Project Management	5%		$7,610,345		$380,517	USEPA 2000, p. 5-13, $2MM - $10MM
Construction Management	6%		$7,610,345		$456,621	USEPA 2000, p. 5-13, $2MM - $10MM
Subtotal Engineering					**$1,045,614**	
			Capital Cost Subtotal		**$8,655,959**	
Contingency		**25%**			**$2,163,990**	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $2M-$10M
Capital from MNA Alternative 1 (same for this alternative)					**$220,000**	Including Design, PM, CM, and Contingency
	Total Estimated Capital Cost				**$11,039,948**	

Spreadsheet 3: Alternative 2a, Enhanced In-Situ Bioremediation (EISB), Bedrock Vapor Extraction (BVE [see Spreadsheets 7 and 8]), MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023

Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description		Qty	Unit	Unit Cost	Escalation	Total	Notes
ANNUAL OPERATIONS AND MAINTENANCE COST - 10 YEAR PERIOD ACTIVE TREATMENT AND 30 YEARS MONITORING							
O&M LUC							
	Annual Land Use Monitoring and Reporting	1	EA	$30,000	16.57%	$34,970	Based on recent project similar in nature.
Years 1-10	**EVO OPERATIONS**						
	Quarterly Inspections	4	EA	$1,500	16.57%	$6,994	Quarterly
	O&M for Extraction wells (Annual 9 HP total at 24 hr/day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
	IDW Management	1	LS	$9,795.00		$9,795	Actual costs
	EISB Reporting	1	LS	$168,674.00		$168,674	Actual costs
	Mechanical Repairs	1	LS	$15,000.00	16.57%	$17,485	Based on similar projects
	Labor	1040	Hr	$150.00	16.57%	$181,845	Assume 20 hrs per week at $150/hr for 52 weeks
	Annual Total					**$395,762**	
Years 1-30	**SAMPLING AND ANALYSIS**						
	Semi-Annual Laboratory Analysis	2	EA	$77,955		$155,911	Per MNA_Lab Rates Updated 2023
	Subcontractor Oversight	94	Samples	$196	16.57%	$21,476	Based on subcontractor rate
	ANNUAL Report	1	LS	$70,000	16.57%	$81,597	Assumption
	Annual Total					**$258,984**	
Year 5	Recondition Injection Wells	9	EA	$12,500		$ 112,500.00	Recondition wells At Year 5
Year 5	Pump Replacement	3	EA	$20,000		$60,000.00	One pump replacement at each site at Year 5
Year 4 & Year 7	**EVO REINJECTIONS**						
	EVO	1	LS	$120,525		$120,525	Total of EISB Substate Sheet
	EVO Injection Crew	123	DY	$1,628		$200,244	Assume 1/3 of capital costs annually
	Subtotal EVO					**$320,769**	
	Project Management for Annual Activity	8%		$430,732		**$34,459**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Yr 5 Activity	8%		$172,500		**$13,800**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Year 4 and Year 7 Activity	8%		$25,661.50		**$2,053**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Sampling and Analysis	8%		$293,954		**$23,516**	USEPA 2000, p. 5-13, $100K-$500K
Total O&M Cost						**Variable**	**Total O&M**

PRESENT VALUE ANALYSIS Discount Rate = 2.0%

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (1.5%)	PRESENT VALUE
CAPITAL COST (EISB)	0	$11,039,948	$11,039,948	1.00	$10,819,948
CAPITAL COST (MNA & LUC)	0	$220,000	$220,000	1.00	$220,000
PERIODIC COST EVO OPERATIONS	1	$465,191	Variable	0.98	$456,069
PERIODIC COST EVO OPERATIONS	2	$465,191	Variable	0.96	$447,127
PERIODIC COST EVO OPERATIONS	3	$465,191	Variable	0.94	$438,360
PERIODIC COST EVO OPERATIONS	4	$753,554	Variable	0.92	$696,167
PERIODIC COST EVO OPERATIONS	5	$617,032	Variable	0.91	$558,865
PERIODIC COST EVO OPERATIONS	6	$465,191	Variable	0.89	$413,076
PERIODIC COST EVO OPERATIONS	7	$753,554	Variable	0.87	$656,014
PERIODIC COST EVO OPERATIONS	8	$465,191	Variable	0.85	$397,036
PERIODIC COST EVO OPERATIONS	9	$465,191	Variable	0.84	$389,251
LUC and MNA for 30 Years (Same as Alternative 1)	30	$317,470	Variable	22.40	$7,110,207
TOTAL PV O&M					**$11,562,171**
TOTAL PRESENT VALUE FOR ALT 2a (not including BVE)					**$22,602,120**

Spreadsheet 4: Alternative 2b: T-EISB, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description	Qty	Unit	Unit Cost	Escalation	Total	Notes
Preconstruction						
Installation Subcontractor Bond and Submittals	1	LS	$14,154	16.57%	$16,499	Based on recent project similar in nature.
Well permits	6	EA	$400	16.57%	$2,798	Based on recent project similar in nature.
Driller Mobilization	1	LS	$20,000	16.57%	$23,313	Based on recent project similar in nature.
Civil Mobilization	1	LS	$7,500	16.57%	$8,743	Based on recent project similar in nature.
Utility Locate	2	DY	$2,198	16.57%	$5,123	Based on recent project similar in nature.
Brush Clearance	8	DY	$3,000	16.57%	$27,976	Based on recent project similar in nature.
Waste Discharge Permit	1	EA	$40,000	16.57%	$46,627	Based on recent project similar in nature.
Setup Stockpile Area	1	LS	$5,000	16.57%	$5,828	Based on recent project similar in nature.
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
C-6 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
ND-136 (ALFA)						
Drilling Contractor						
Drill Extraction/Injection/Monitoring Wells (PQ rock core) and develop	2,375	FT	$115	16.57%	$318,374	Based on recent bid average of $115 per foot for bedrock coring/development (five 475-foot wells).
Drill Downgradient Monitoring Well (PQ rock core) and develop	515	FT	$115	16.57%	$69,037	Based on recent bid average of $115 per foot for bedrock coring/development (one 515-foot well).
Drill Temperature Sensing Coreholes	2,850	FT	$115	16.57%	$382,048	Based on recent bid average of $115 per foot for bedrock coring/development (one 515-foot well).
Well Development	6	EA	$10,000	16.57%	$69,940	Based on recent bid
Ream PQ rock cores to 6-inch	3	LS	$47,500	16.57%	$166,108	Based on Yellow Jacketbid for air rotary drilling 6-inch boring; $100 per foot (three 475-foot wells injection wells)
Injection/Monitoring Well Head Completion	6	EA	$2,000	16.57%	$13,988	Allowance for misc. valves/fittings.
Geophysical Surveys	6	EA	$13,750	16.57%	$96,168	Based on recent quote.
Packer Testing	6	WL	$24,300	16.57%	$169,955	Based on recent project similar in nature. Assumes 10 packer tests, collect depth discrete GW samples in packered zones at each well.
FLUTe Well Installation	3	EA	$76,257	16.57%	$266,672	5 port FLUTe wells, two 475-ft and one 515 ft. Costs from recent quote.
Survey	6	WL	$800	16.57%	$5,595	Based on recent project similar in nature.
Field Oversight/Travel	6	WL	$70,000	16.57%	$489,582	assumes working 20 days per well, two staff, plus travel
Site Restoration	1	EA	$8,000	16.57%	$9,325	Based on recent project similar in nature.
IDW Management - Well Water & Solids	6	WL	$122,080	16.57%	$853,829	Based on recent project similar in nature.
Waste Characterization	6	LS	$10,000	16.57%	$69,940	Based on historical pricing.
Misc. Field supplies and shipping	6	WL	$6,000	16.57%	$41,964	Based on recent project similar in nature.
Geologist - Oversight for operations	80	DY	$1,350	16.57%	$125,892	Unit Rate includes Geologist for 10 hrs/day plus Per Diem-Lodging and Meals, and Rental vehicle
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$3,148,418**	
C-6 TTA: Assume same at ND-136 TTA Subtotal					**$3,148,418**	

Spreadsheet 4: Alternative 2b: T-EISB, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description	Qty	Unit	Unit Cost	Escalation	Total	Notes
Install Extraction/Recirculation System						
Schedule Updates/Site Preparation	1	LS	$5,500	16.57%	$6,411	Based on recent Subcontractor quote.
Install containment berm, injection manifold pipe rack, and overhead canopy	1	LS	$21,773	16.57%	$25,380	Based on recent Subcontractor quote.
Injection leg conveyance piping, concrete road ramp (Connection at GETS and EW to Iws)	1	LS	$18,230	16.57%	$21,250	Based on recent Subcontractor quote.
Install Hot Water Boiler	1	LS	$294,144	16.57%	$342,875	See Thermal Worksheet
Provide and install Electric and Com. Control Panels with Controls Package	1	LS	$65,000	16.57%	$75,769	Based on recent Subcontractor quote.
Provide Valves, Fittings, Transducers, Flow Meters, Pressure Gauges, Leak Detection Sensors	1	LS	$94,126	16.57%	$109,720	Based on recent Subcontractor quote.
Optical temperature sensors for saturated thickness	6	EA	$5,320	16.57%	$37,208	Verbal quote from AOMS Tech
Optical data acquisition system	6	EA	$48,000	16.57%	$335,713	Verbal quote from AOMS Tech
Conduct pressure/leak testing, controls testing, and third-party operations and maintenance training	1	LS	$7,800	16.57%	$9,092	Based on recent Subcontractor quote.
Provide project completion documentation, final deliverables (as-builts, operations and maintenance plan)	1	LS	$8,000	16.57%	$9,325	Based on recent Subcontractor quote.
EISB Startup Support	1	LS	$72,101		$72,101	Actual Cost
Site Restoration	1	LS	$3,000	16.57%	$3,497	Based on recent Subcontractor quote.
3-Month Post-Startup Troubleshooting and Repairs	1	LS	$11,700	16.57%	$13,638	Based on recent Subcontractor quote.
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$1,061,980**	
C-6 TTA: Assume same at ND-136 TTA Subtotal					**$1,061,980**	
Injections and Tracer/Substrate Distribution Monitoring						
Mobe	1	EA	$15,000	16.57%	$17,485	Based on recent project similar in nature.
Baseline Groundwater Sampling Analytical Laboratory Costs	1	Event	$25,985	16.57%	$30,290	1/3 of MNA EISB Costs
EISB Substrate, Tracer, and Bioaugmentation Culture	1	LS	$49,415	16.57%	$57,602	EIBSubstrate Worksheet for ND-136
Injections Operator and Field Labor	41	DY	$1,628	16.57%	$77,820	Based on recent quote.
Tracer Test, Tracer/Substrate Distribution Monitoring	1	EA	$102,074	16.57%	$118,985	Based on OUL quote and 3-months monitoring/sampling costs estimate.
As-Built Report and Construction Completion Report	1	EA	$150,000	16.57%	$174,851	Based on recent project similar in nature.
O&M for Extraction wells (Annual 9 HP total at 24 hrs per day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$488,002**	
C-6 TTA: Assume same at ND-136 TTA Subtotal + 2x EISB Reagents and Field Labor					**$623,423**	
EISB Recirculation System Total					**$9,806,034**	

Spreadsheet 4: Alternative 2b: T-EISB, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description		Qty	Unit	Unit Cost	Escalation	Total	Notes
Engineering, PM, CM							
	Design	1	LS	$208,476		$208,476	Actual Cost
	Project Management	5%		$9,806,034		$490,302	USEPA 2000, p. 5-13, $2MM - $10MM
	Construction Management	6%		$9,806,034		$588,362	USEPA 2000, p. 5-13, $2MM - $10MM
	Subtotal Engineering					**$1,287,140**	
				Capital Cost Subtotal		**$11,093,174**	
	Contingency		**25%**			**$2,773,293**	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $2M-$10M
	Capital from MNA Alternative 1 (same for this alternative)					**$220,000**	Including Design, PM, CM, and Contingency
	Total Estimated Capital Cost					**$14,086,467**	
ANNUAL OPERATIONS AND MAINTENANCE COST - 10 YEAR PERIOD ACTIVE TREATMENT AND 30 YEARS MONITORING							
O&M LUC							
	Annual Land Use Monitoring and Reporting	1	EA	$30,000	16.57%	$34,970	Based on recent project similar in nature.
Years 1-10	**EVO OPERATIONS**						
	Quarterly Inspections	4	EA	$1,500	16.57%	$6,994	Quarterly
	O&M for Extraction wells (Annual 9 HP total at 24 hr/day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
	Electricity to operate steam boilers	412,128	KW-Hr	$0.16	16.57%	$76,865	Based on historical pricing.
	Annual License Fee for Optical Temperature Sensors	1	EA	$4,800.00	16.57%	$5,595	Verbal Quote from AOMS Tech
	IDW Management	1	LS	$9,795.00		$9,795	Actual costs
	Reporting	1	LS	$168,674.00		$168,674	Actual costs
	Mechanical Repairs	1	LS	$15,000.00	16.57%	$17,485	Based on similar projects
	Labor	1040	Hr	$150.00	16.57%	$181,845	Assume 20 hrs per week at $150/hr for 52 weeks
	Annual Total					**$478,222**	
Years 1-30	**SAMPLING AND ANALYSIS**						
	Semi-Annual Laboratory Analysis	2	EA	$77,955		$155,911	Per MNA_Lab Rates Updated 2023
	Subcontractor Oversight	94	Samples	$196	16.57%	$21,476	Based on subcontractor rate
	ANNUAL Report	1	LS	$70,000	16.57%	$81,597	Assumption
	Annual Total					**$258,984**	
Year 5	Recondition Injection Wells	9	EA	$12,500		$ 112,500.00	Recondition wells At Year 5
Year 5	Pump Replacement	3	EA	$20,000		$60,000.00	One pump replacement at each site at Year 5
Year 4 & Year 7 EVO REINJECTIONS							
	EVO	1	LS	$120,525		$120,525	Total of EISB Substate Sheet
	EVO Injection Crew	123	DY	$1,628		$200,244	Assume 1/3 of capital costs annually
	Subtotal EVO					**$320,769**	
	Project Management for Annual Activity	8%		$513,192		**$41,055**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Yr 5 Activity	8%		$172,500		**$13,800**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Year 4 and Year 7 Activity	8%		$25,661.50		**$2,053**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Sampling and Analysis	8%		$293,954		**$23,516**	USEPA 2000, p. 5-13, $100K-$500K
Total O&M Cost						**Variable**	**Total O&M**

Spreadsheet 4: Alternative 2b: T-EISB, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description	Qty	Unit	Unit Cost	Escalation	Total	Notes
PRESENT VALUE ANALYSIS		Discount Rate =	2.0%			Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (1.5%)	PRESENT VALUE
CAPITAL COST (EISB)	0	$14,086,467	$14,086,467	1.00	$13,866,467
CAPITAL COST (MNA & LUC)	0	$220,000	$220,000	1.00	$220,000
PERIODIC COST EVO OPERATIONS	1	$554,248	Variable	0.98	$543,380
PERIODIC COST EVO OPERATIONS	2	$554,248	Variable	0.96	$532,725
PERIODIC COST EVO OPERATIONS	3	$554,248	Variable	0.94	$522,280
PERIODIC COST EVO OPERATIONS	4	$836,014	Variable	0.92	$772,348
PERIODIC COST EVO OPERATIONS	5	$699,492	Variable	0.91	$633,552
PERIODIC COST EVO OPERATIONS	6	$554,248	Variable	0.89	$492,156
PERIODIC COST EVO OPERATIONS	7	$836,014	Variable	0.87	$727,800
PERIODIC COST EVO OPERATIONS	8	$554,248	Variable	0.85	$473,045
PERIODIC COST EVO OPERATIONS	9	$554,248	Variable	0.84	$463,770
LUC and MNA for 30 Years (Same as Alternative 1)	30	$317,470	Variable	22.40	$7,110,207
TOTAL PV O&M					**$12,271,263**
TOTAL PRESENT VALUE FOR ALT 2a (not including BVE)					**$26,357,730**

Spreadsheet 5: Alternative 3: P&T Extraction Wells and Conveyance, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSFL P1 CMS
9/25/2023
Site: NASA SSFL — Description: Cost to add a well to GETS, connect that well, then provide annual O&M.
Phase:

WORK STATEMENT
Scope: Pump and Treat Wells and Conveyance

	Description	Qty	Unit	Unit Cost	Total	Notes
Preconstruction						
	Driller Submittals	1	LS	$750.00	$750	Pricing for Driller Submittals is per RSMeans #01 31 13.20 (0120 and 0200).
	Well permits	1	EA	$450.00	$450	Assumes 1 permit per boring. Pricing is per recent project similar in nature.
	Driller Mobilization / Demobilization	1	LS	$7,910.00	$7,910	Pricing is based on RSMeans Crew #B-23B
	Utility Locate	1	DY	$2,290.00	$2,290	Pricing is based on RSMeans Crew #A-6
	Site Survey	1	LS	$2,400.00	$2,400	Pricing is per RSMeans #01 71 23.13 (1200) for a 3 person crew (1 day)
	Subtotal				**$13,800**	
Construction						
	Drilling Contractor					
	Erosion/Site Controls	1	LS	$2,780.00	$2,780	Silt fence @ $4.13/LF + $1,750 for maintenance. 10' x 10' area per well; Pricing is per RSMeans #31 25 14.16 (1000), 20% productivity factor
	Extraction Well Installation					
	Drill Extraction Column - 6" diameter	500	LF	$115.00	$57,500	Based on recent air rotary costs ranging from $110 to $120 per foot
	Well Development	1	EA	$10,800.00	$10,800	Pricing is based on recent project similar in nature
	Extraction Wells - 4" PVC Perforated	0	LF	$50.00	$0	Pricing is based on RSMeans #33 11 13.10 (8340) plus markup for perforated piping
	Extraction Wells - 4" PVC Solid	300	LF	$40.00	$12,000	Pricing is based on RSMeans #33 11 13.10 (8340)
	Sand Pack (Provide and Install)	0	LF	$40.00	$0	Pricing is based on West Coast Drilling BOA and RSMeans #33 11 1310
	Extraction Well Head Completion	1	EA	$115.00	$115	Pricing is based on West Coast Drilling BOA
	Bentonite Seal (Provide and Install)	300	LF	$27.00	$8,100	Pricing is per RSMeans #33 11 13.10 (8400)
	IDW Management - Well Installation Water & Solids	1	EA	$210.00	$210	Pricing is based on West Coast Drilling BOA; Assume 50 gallons/well (solids) and 50 gallons/well (water); Deliver to holding area.
	IDW for water from development	1	EA	$210.00	$210	Pricing is based on West Coast Drilling BOA; Assume 50 gallons/well
	Submersible Pump (~9-26 gpm @ 180' head)	1	EA	$5,400.00	$5,400	Pricing is per RSMeans #33 11 13.10 (1800)
	Site Restoration	100	SF	$2.50	$250	Pricing per RSMeans #32 01 30.10 for the 10'x10' area per well; 20% productivity factor
	Geologist - Oversight for operations	20	DY	$1,480.00	$29,600	Unit Rate includes Geologist for 10 hrs/day plus Per Diem-Lodging and Meals per gsa.gov, and Rental vehicle with fuel
	Subtotal				**$126,965**	
	Pipeline Construction					
	Plans, Submittals, Mobilization, and Demobilization	1	LS	$8,750.00	$8,750	Pricing for Developing Plans (Work Plan, H&S Plan, QA/QC Plan) is per RSMeans #01 31 13.20 (0120 and 0200).
	Mobilization / Demobilization	1	LS	$4,530.00	$4,530	Pricing is per RSMeans Crew #B-1 and Crew #B-22A plus travel
	Baseline Schedule / Weekly Schedule Updates	1	LS	$3,250.00	$3,250	Pricing for Baseline Schedule and Weekly Schedule Updates is per RSMeans #01 31 13.20 (0120 and 0200).
	Site Setup, Prepare Work Areas	1	LS	$3,930.00	$3,930	Pricing is per RSMeans Crew #B-1 and Crew #B-22A
	Installation of Erosion and Sediment Control Measures	1	LS	$3,470.00	$3,470	Pricing is per RSMeans Crew #B-62 plus RSM #31 25 14.16 (1000) for silt fence
	Clear and Grub Pipeline and Well Locations (poison oak mitigation expected)	1	LS	$7,650.00	$7,650	Pricing is per RSMeans Crew #B-7
	Install 4"x8" Double Wall HDPE Pipe	0	LF	$70.00	$0	Pricing is per RSMeans Crew #B-22A plus RSM #33 14 13.35 (0100 & 0300) for HDPE piping
	Install double contained check valve near main trunk line intersection (12" tee, line flange, double contained)	1	EA	$5,330.00	$5,330	Pricing is per RSMeans Crew #Q-13, plus RSM #21 05 23.50 (6860), RSM #33 14 13.35 (2600 & 4160)
	Install Manual Leak Detection Piping	1	EA	$1,250.00	$1,250	Pricing is per RSMeans #28 42 15.50 (0320 and 0510)
	Install Sample Ports	1	EA	$1,340.00	$1,340	Pricing is per RSMeans Crew #B-22A plus pricing from Sample port website for materials
	Install Air Release Valves	1	EA	$4,900.00	$4,900	Pricing is per RSMeans Crew #B-22A, plus RSM #33 14 19.20 (1020) for air release valve
	Install Connection to Existing Boeing Pipeline	1	EA	$5,560.00	$5,560	Pricing is per RSMeans Crew #B-22A plus Grainger for materials
	Trenching and Road Crossings (dirt roads)	3	EA	$1,450.00	$4,350	Pricing is per RSMeans Crew #B-1 and Crew #B-12A
	Installation of transformer for wellhead for the control panel (mounted to backer board)	1	EA	$5,575.00	$5,575	Pricing is per RSMeans #26 22 13.10 (2190)
	Installation of 35' electrical poles to wellheads	1	EA	$13,780.00	$13,780	Pricing is per RSMeans #33 71 16.33 (7200 & 8000), and RSMeans Crew #B-47 for drilling through rock for installation
	Installation of guying	2	EA	$3,290.00	$6,580	Pricing is per RSMeans Crew #R-3 plus RSM #03 21 05.10 (2840) and Grainger for materials
	Installation of wiring and conduit support at wellheads, to wellhead instruments, receptacles and submersible pumps	200	LF	$72.00	$14,400	Pricing is per RSMeans Crew #R-1C, plus electrical materials per RSM #26 05 19.90 (3340) and RSM #26 05 33.13 (9170)
	Install Control Panel, Backer, Switch Gear	1	EA	$24,875.00	$24,875	Pricing is per RSMeans #26 24 16.30 (0550) and RSM #26 13 16.10 (0300)
	Reconstruct above-ground wellhead and concrete Work: Double containment pad (4'x8'x4' with fiberglass lid).	1	LS	$28,380.00	$28,380	Pricing is per RSMeans Crew #C-14H and Crew #R-21, plus RSM #01 54 33 (40-7290)
	Install above ground secondary feeders	500	LF	$68.00	$34,000	Pricing is per RSMeans Crew #R-1C, plus electrical materials per RSM #26 05 19.90 (3340) and RSM #26 05 33.13 (9170)
	Install guides and secure pipeline to guides	140	EA	$185.00	$25,900	Pricing is per RSMeans Crew #B-22A plus Grainger for materials
	Water Management - Truck Water to onsite Treatment Plant	10	HR	$260.00	$2,600	Pricing is per RSMeans Crew #B-9A
	Offsite disposal of approximately 2,000 gallons	2,000	GAL	$3.50	$7,000	Pricing is per recent project similar in nature for off site disposal of liquids.

Spreadsheet 5: Alternative 3: P&T Extraction Wells and Conveyance, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSFL P1 CMS
9/25/2023
Site: NASA SSFL
Description: Cost to add a well to GETS, connect that well, then provide annual O&M.
Phase:

WORK STATEMENT
Scope: Pump and Treat Wells and Conveyance

Description	Qty	Unit	Unit Cost	Total	Notes
Project Completion Documentation	1	LS	$4,430.00	$4,430	Pricing for Wellhead Telemetry Submittals is per RSMeans #01 31 13.20 (0120 and 0200).
Install Pipeline (1x3 individual wells)	800	LF	$37.00	$29,600	Pricing is per RSMeans Crew #B-22A plus RSM #33 14 13.35 (0100 & 0300) for HDPE piping
Install Pipeline (2x4 trunk to existing 4x8)	0	LS	$1,050.00	$0	Pricing is per RSMeans Crew #B-22A
Geologist - Oversight for operations	20	DY	$1,480.00	$29,600	Unit Rate includes Geologist for 10 hrs/day plus Per Diem-Lodging and Meals per gsa.gov, and Rental vehicle with fuel
Subtotal				**$281,030**	
Well Connection					
Plans, Submittals, Mobilization, and Demobilization	1	LS	$12,790.00	$12,790	Pricing for Developing Plans (Work Plan, H&S Plan, QA/QC Plan) is per RSMeans #01 31 13.20 (0120 and 0200).
Install Telemetry	1	LS	$2,670.00	$2,670	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Power to Wellhead	1	LS	$21,780.00	$21,780	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Install wellhead and Connect to Pipeline	1	LS	$69,300.00	$69,300	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Groundwater Management	1	LS	$2,100.00	$2,100	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Transport and Dispose F002 Groundwater	0	GAL	$4.50	$0	Pricing is per recent project similar in nature for T&D of hazardous liquids.
Wellhead Startup and Commissioning	1	LS	$3,500.00	$3,500	Pricing is per RSMeans Crew #R-21
Prepare Submittals (wellhead telemetry)	1	LS	$2,750.00	$2,750	Pricing for Wellhead Telemetry Submittals is per RSMeans #01 31 13.20 (0120 and 0200).
Design and Install Telemetry Addition	1	LS	$10,500.00	$10,500	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Submittals for GETS Controls	1	LS	$7,720.00	$7,720	Pricing for GETS Controls Submittals is per RSMeans #01 31 13.20 (0120 and 0200).
Construct, Program, and Commission Control Panel (GETS)	1	LS	$44,000.00	$44,000	Pricing is per Engineer Estimate based on Jacobs Project Experience at SSFL
Subtotal				**$177,110**	
P&T Wells and Conveyance TSubTotal				**$598,905**	
Remedial Design	12%		$598,905	$71,869	Per USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $500k - $2M
Project Management	6%		$598,905	$35,934	Per USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $500k - $2M
Construction Management	8%		$598,905	$47,912	Per USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $500k - $2M
Subtotal Engineering				**$155,715**	
			Capital Cost Subtotal	**$754,620**	
Contingency		25%		$188,655	Per USEPA 2000 Guide to Developing and documenting Cost Estimates, pp. 5-10 and 5-11 (15% Scope and 10% Bid Contingency)
Total Estimated Capital Cost				**$943,275**	

ANNUAL OPERATIONS AND MAINTENANCE COST - 1 YEAR PERIOD

	Description	Qty	Unit	Unit Cost	Total	Notes
Annual O&M	O&M for Extraction wells (Annual 9 HP total at 24 hrs per day)	58814.64	KW-Hr	$0.175	$10,293	Based on historical pricing.
	Annual GETS treatment Costs	60.00%	Percent of Tota	$579,488	$347,693	Based on 60% of NASA's 50 gpm allocation for GETS, see GETS Operations Worksheet
Total Annual O&M Cost					**$357,985**	**Total O&M**

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	
CAPITAL COST	0	$0	1.00	$943,275	
O&M COST	10	$357,985	8.98	$3,216,000	10 years active treatment assumed
LUC and MNA for 30 Years (Same as Alternative 1)	30	$317,470	22.40	$7,111,000	30 years of LUCs and MNA assumed
TOTAL PRESENT VALUE FOR ALT 3 (not including BVE)				**$11,270,275**	

Spreadsheet 6: Alternative 4, ISCO, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023

Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Enhanced In Situ Biological Reduction ND-136, WS-09, C-6

Description		Qty	Unit	Unit Cost	Escalation	Total	Notes
Preconstruction							
	Installation Subcontractor Bond and Submittals	1	LS	$14,154	16.57%	$16,499	Based on recent project similar in nature.
	Well permits	6	EA	$400	16.57%	$2,798	Based on recent project similar in nature.
	Driller Mobilization	1	LS	$20,000	16.57%	$23,313	Based on recent project similar in nature.
	Civil Mobilization	1	LS	$7,500	16.57%	$8,743	Based on recent project similar in nature.
	Utility Locate	2	DY	$2,198	16.57%	$5,123	Based on recent project similar in nature.
	Brush Clearance	8	DY	$3,000	16.57%	$27,976	Based on recent project similar in nature.
	Waste Discharge Permit	1	EA	$40,000	16.57%	$46,627	Based on recent project similar in nature.
	Setup Stockpile Area	1	LS	$5,000	16.57%	$5,828	Based on recent project similar in nature.
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
	C-6 TTA: Assume same at ND-136 TTA Subtotal					**$136,907**	
ND-136 (ALFA)							
	Drilling Contractor						
	Drill Extraction/Injection/Monitoring Wells (PQ rock core) and develop	2,375	FT	$115	16.57%	$318,374	Based on recent bid average of $115 per foot for bedrock coring/development (five 475-foot wells).
	Drill Downgradient Monitoring Well (PQ rock core) and develop	515	FT	$115	16.57%	$69,037	Based on recent bid average of $115 per foot for bedrock coring/development (one 515-foot well).
	Well Development	6	EA	$10,000	16.57%	$69,940	Based on recent bid
	Ream PQ rock cores to 6-inch	3	LS	$47,500	16.57%	$166,108	Based on Yellow Jacketbid for air rotary drilling 6-inch boring; $100 per foot (three 475-foot wells injection wells)
	Injection/Monitoring Well Head Completion	6	EA	$2,000	16.57%	$13,988	Allowance for misc. valves/fittings.
	Geophysical Surveys	6	EA	$13,750	16.57%	$96,168	Based on recent quote.
	Packer Testing	6	WL	$24,300	16.57%	$169,955	Based on recent project similar in nature. Assumes 10 packer tests, collect depth discrete GW samples in packered zones at each well.
	FLUTe Well Installation	3	EA	$76,257	16.57%	$266,672	5 port FLUTe wells, two 475-ft and one 515 ft. Costs from recent quote.
	Survey	6	WL	$800	16.57%	$5,595	Based on recent project similar in nature.
	Field Oversight/Travel	6	WL	$70,000	16.57%	$489,582	assumes working 20 days per well, two staff, plus travel
	Site Restoration	1	EA	$8,000	16.57%	$9,325	Based on recent project similar in nature.
	IDW Management - Well Water & Solids	6	WL	$122,080	16.57%	$853,829	Based on recent project similar in nature.
	Waste Characterization	6	LS	$10,000	16.57%	$69,940	Based on historical pricing.
	Misc. Field supplies and shipping	6	WL	$6,000	16.57%	$41,964	Based on recent project similar in nature.
	Geologist - Oversight for operations	80	DY	$1,350	16.57%	$125,892	Unit Rate includes Geologist for 10 hrs/day plus Per Diem-Lodging and Meals, and Rental vehicle
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$2,766,369**	
	C-6 TTA: Assume same at ND-136 TTA Subtotal					**$2,766,369**	
Install Extraction/Recirculation System							
	Schedule Updates/Site Preparation	1	LS	$5,500	16.57%	$6,411	Based on recent Subcontractor quote.
	Install containment berm, injection manifold pipe rack, and overhead canopy	1	LS	$21,773	16.57%	$25,380	Based on recent Subcontractor quote.
	Injection leg conveyance piping, concrete road ramp (Connection at GETS and EW to Iws)	1	LS	$18,230	16.57%	$21,250	Based on recent Subcontractor quote.
	Provide and install Electric and Com. Control Panels with Controls Package	1	LS	$65,000	16.57%	$75,769	Based on recent Subcontractor quote.
	Provide Valves, Fittings, Transducers, Flow Meters, Pressure Gauges, Leak Detection Sensors	1	LS	$94,126	16.57%	$109,720	Based on recent Subcontractor quote.
	Conduct pressure/leak testing, controls testing, and third-party operations and maintenance training	1	LS	$7,800	16.57%	$9,092	Based on recent Subcontractor quote.
	Provide project completion documentation, final deliverables (as-builts, operations and maintenance plan)	1	LS	$8,000	16.57%	$9,325	Based on recent Subcontractor quote.
	ISCO Startup Support	1	LS	$72,101		$72,101	Actual Cost
	Site Restoration	1	LS	$3,000	16.57%	$3,497	Based on recent Subcontractor quote.
	3-Month Post-Startup Troubleshooting and Repairs	1	LS	$11,700	16.57%	$13,638	Based on recent Subcontractor quote.
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$346,184**	
	C-6 TTA: Assume same at ND-136 TTA Subtotal					**$346,184**	

Spreadsheet 6: Alternative 4, ISCO, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
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Injections and Tracer/Substrate Distribution Monitoring							
	Mobe	1	EA	$15,000	16.57%	$17,485	Based on recent project similar in nature.
	Baseline Groundwater Sampling Analytical Laboratory Costs	1	Event	$25,985	16.57%	$30,290	1/3 of MNA EISB Costs
	ISCO Reagent ND-136	1	LS	$38,785	16.57%	$45,211	ISCO Worksheet for ND-136
	ISCO Reagent WS-09	1	LS	$37,839	16.57%	$44,108	ISCO Worksheet for WS-09
	ISCO Reagent C-6	1	LS	$75,678	16.57%	$88,216	ISCO Worksheet for C-6
	Injections Operator and Field Labor	41	DY	$1,628	16.57%	$77,820	Based on recent quote.
	Tracer Test, Tracer/Substrate Distribution Monitoring	1	EA	$102,074	16.57%	$118,985	Based on OUL quote and 3-months monitoring/sampling costs estimate.
	As-Built Report and Construction Completion Report	1	EA	$150,000	16.57%	$174,851	Based on recent project similar in nature.
	O&M for Extraction wells (Annual 9 HP total at 24 hrs per day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
	ND-136 TTA Subtotal					**$0**	Installed in 2020, no additional installation costs
	WS-09 TTA: Assume same at ND-136 TTA Subtotal					**$607,935**	WS Worksheet for Assume same at ND-136 TTA Subtotal
	C-6 TTA: Assume same at ND-136 TTA Subtotal + 2x EISB Reagents and Field Labor					**$730,966**	C Worksheet for Assume same at ND-136 TTA Subtotal + 2x EISB Reagents and Field Labor
	EISB Recirculation System Total					**$7,837,820**	
Engineering, PM, CM							
	Design	1	LS	$208,476		$208,476	Actual Cost
	Project Management	5%		$7,837,820		$391,891	USEPA 2000, p. 5-13, $2MM - $10MM
	Construction Management	6%		$7,837,820		$470,269	USEPA 2000, p. 5-13, $2MM - $10MM
	Subtotal Engineering					**$1,070,636**	
				Capital Cost Subtotal		**$8,908,456**	
	Contingency		**25%**			**$2,227,114**	USEPA 2000 Guide to Developing and documenting Cost Estimates, p. 5-13, $2M-$10M
	Capital from MNA Alternative 1 (same for this alternative)					**$220,000**	Including Design, PM, CM, and Contingency
		Total Estimated Capital Cost				**$11,355,571**	
ANNUAL OPERATIONS AND MAINTENANCE COST - 10 YEAR PERIOD ACTIVE TREATMENT AND 30 YEARS MONITORING							
O&M LUC							
	Annual Land Use Monitoring and Reporting	1	EA	$30,000	16.57%	$34,970	Based on recent project similar in nature.
Years 1-10	**EVO OPERATIONS**						
	Quarterly Inspections	4	EA	$1,500	16.57%	$6,994	Quarterly
	O&M for Extraction wells (Annual 9 HP total at 24 hr/day)	58814.64	KW-Hr	$0.16	16.57%	$10,969	Based on historical pricing.
	IDW Management	1	LS	$9,795.00		$9,795	Actual costs
	ISCO Reporting	1	LS	$168,674.00		$168,674	Actual costs
	Mechanical Repairs	1	LS	$15,000.00	16.57%	$17,485	Based on similar projects
	Labor	1040	Hr	$150.00	16.57%	$181,845	Assume 20 hrs per week at $150/hr for 52 weeks
	Annual Total					**$395,762**	
Years 1-30	**SAMPLING AND ANALYSIS**						
	Semi-Annual Laboratory Analysis	2	EA	$77,955		$155,911	Per MNA_Lab Rates Updated 2023
	Subcontractor Oversight	94	Samples	$196	16.57%	$21,476	Based on subcontractor rate
	ANNUAL Report	1	LS	$70,000	16.57%	$81,597	Assumption
	Annual Total					**$258,984**	
Year 5	Recondition Injection Wells	9	EA	$12,500		$ 112,500.00	Recondition wells At Year 5
Year 5	Pump Replacement	3	EA	$20,000		$60,000.00	One pump replacement at each site at Year 5
Year 4 & Year 7 ISCO REINJECTIONS							
	ISCO Reagent	1	LS	$152,303		$152,303	Total of ISCO Sheet
	ISCO Injection Crew	123	DY	$1,628		$200,244	Assume 1/3 of capital costs annually
	Subtotal EVO					**$352,547**	
	Project Management for Annual Activity	8%		$430,732		**$34,459**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Yr 5 Activity	8%		$172,500		**$13,800**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Year 4 and Year 7 Activity	8%		$28,203.75		**$2,256**	USEPA 2000, p. 5-13, $100K-$500K
	Project Management for Sampling and Analysis	8%		$293,954		**$23,516**	USEPA 2000, p. 5-13, $100K-$500K

Spreadsheet 6: Alternative 4, ISCO, BVE [see Spreadsheets 7 and 8], MNA, and LUCs
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
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Total O&M Cost					Variable	Total O&M

PRESENT VALUE ANALYSIS Discount Rate 2.0%

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (1.5%)	PRESENT VALUE
CAPITAL COST (EISB)	0	$11,355,571	$11,355,571	1.00	$11,135,571
CAPITAL COST (MNA & LUC)	0	$220,000	$220,000	1.00	$220,000
PERIODIC COST ISCO OPERATIONS	1	$465,191	Variable	1.00	$465,191
PERIODIC COST ISCO OPERATIONS	2	$465,191	Variable	1.00	$465,191
PERIODIC COST ISCO OPERATIONS	3	$465,191	Variable	1.00	$465,191
PERIODIC COST ISCO OPERATIONS	4	$819,994	Variable	1.00	$819,994
PERIODIC COST ISCO OPERATIONS	5	$651,491	Variable	1.00	$651,491
PERIODIC COST ISCO OPERATIONS	6	$465,191	Variable	1.00	$465,191
PERIODIC COST ISCO OPERATIONS	7	$819,994	Variable	1.00	$819,994
PERIODIC COST ISCO OPERATIONS	8	$465,191	Variable	1.00	$465,191
PERIODIC COST ISCO OPERATIONS	9	$465,191	Variable	1.00	$465,191
LUC and MNA for 30 Years (Same as Alternative 1)	30	$317,470	Variable	22.40	$7,110,207
TOTAL PV O&M					**$12,192,830**
TOTAL PRESENT VALUE FOR ALT 2a (not including BVE)					**$23,548,400**

Spreadsheet 7: Bedrock Vapor Extraction at Alfa ND-136 TTA
Cost Worksheet, Opinion of Probable Costs
NASA, SSLF P1 CMS
10/20/2023

Capital Costs

Engineering		Quoted Cost
	Solar Performance Specification	$45,526
	Install Planning & Oversight (whole syste	$114,964
	SubTotal	**$160,490**
Subcontractor		
	BVE System Construction	$15,001
	Site Prep and Conveyance Pipe	$57,532
	Carbon System Delivery & Setup	$9,396
	Utility and Brush Clearance	$9,299
	IDW Management	$11,691
	Survey	$8,316
	SubTotal	**$111,235**
Expense		
	Field Equipment	$867
	Travel	$6,310
	SubTotal	**$7,177**
Construction Subtotal		**$278,902**

BVE Annual O&M Cost Estimation		**Annual Cost**
Engineering Labor		
	O&M	$200,692.50
	Reporting	$80,041.50
	SubTotal	**$280,734**
Subcontractor		
	Laboratory	$51,200.10
	Site Maintenance	$15,552.00
	BVE System Rental	$58,320.00
	IDW Management (exc spent Carbon)	$19,851.48
	BVE O&M	$252,234.00
	Solar Rental	$448,664.83
	Vapor Sampling	$79,566.30
	Carbon Replacement & Disposal (haz)	$402,732.00
	SubTotal	**$1,328,121**
Expense		
	Permitting	$3,500.00
	Field Equipment	$2,457.00
	Shipping	$3,880.50
	Travel	$24,981.00
	SubTotal	**$34,819**
Annual O&M Subtotal		**$1,643,673**

PRESENT VALUE ANALYSIS Discount Rate = $0.02

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	UNIT COST	DISCOUNT FACTOR (2%)	PRESENT VALUE
CAPITAL COST	0	$278,902	1.00	$278,902
ANNUAL O&M COST - Cap	1 to 5	$1,643,673	4.71	$7,747,387
TOTAL PV O&M				$7,747,387
TOTAL PRESENT VALUE FOR BVE @ ND-136 TTA				**$8,026,289**

Spreadsheet 8: GETS Treatment Costs

Task	Description	NASA Annual Cost
1	System O&M	$ 294,221
2	Media Changeout	$ 37,216
3	Engineering Support	$ 36,133
4	Effluent Sampling	$ 37,788
5	Process Sampling	$ 10,936
6	WDR Groundwater Sampling	$ 38,122
7	Data Management/Reporting	$ 16,593
8	RWQCP Annual Permit Fee	$ 3,840
9	Waste Management	$ 24,000
10	Electricity	$ 80,640
	Total Annual NASA Allocation	$ 579,488
	Cost per gallon (based on 50 gpm, and 70% uptime)	$ 0.0315

Spreadsheet 9: Thermally Enhanced Biological Treatment Heating Source
Cost Worksheet, Opinion of Probable Costs
Site: NASA SSFL
Phase: Thermally Enhanced Biological Treatment

WORK STATEMENT
Scope:

Description	Qty	Unit	Unit Cost	Total	Notes
Preconstruction					
Contractor Submittals	1	LS	$15,000.00	$15,000	Based on recent project similar in nature.
Permits	1	LS	$10,000.00	$10,000	Based on recent project similar in nature.
Driller Mobilization	0	LS	$5,020.00	$0	Pricing based on RSMeans Crew #B-23B
Civil Mobilization	1	LS	$10,000.00	$10,000	Based on recent project similar in nature.
Utility Locate	1	DY	$2,490.00	$2,490	Pricing based on RSMeans Crew #A-7
Surveying	2	DY	$2,100.00	$4,200	Pricing based on RSMeans #01 71 23.13
Subtotal				**$41,690**	
Equipment for Thermally Enhanced Biological Treatment					
Groundwater Extraction Pump	3	EA	$1,500.00	$4,500	Engineer Estimate (0-15 gpm, 500 ft. total dynamic head - 1 Hp)
Groundwater Booster Pump	3	EA	$800.00	$2,400	Engineer Estimate (0-25 gpm, 100 ft. total dynamic head - 0.5 Hp)
Heat Exchanger	3	EA	$3,000.00	$9,000	Engineer Estimate (75-100 square feet, plate and frame style)
Electric Hot Water Boiler	3	EA	$25,000.00	$75,000	Engineer Estimate [estimated 180 kW size, Cleaver-Brooks WB-122-180 (or equiv.)]
Insulated Hot Water Tank	3	EA	$3,000.00	$9,000	Engineer Estimate (250-gallon capacity, Insulated steel tank, 50 psig pressure rating)
Hot Water Circulation Pump	3	EA	$800.00	$2,400	Engineer Estimate (0-25 gpm, 100 ft. total dynamic head - 0.5 Hp)
Hot Water Expansion Tank	3	EA	$1,800.00	$5,400	Engineer Estimate [10-15 gallon capacity, Amtrol ST-30V-C (or equivalent)]
Container for 1 of each component listed above	3	EA	$10,000.00	$30,000	Engineer Estimate [Estimated 40-foot shipping container)
Freight for equipment	3	EA	$3,500.00	$10,500	Engineer Estimate - Shipping of containers
Subtotal				**$148,200**	
Mechanical for Thermally Enhanced Biological Treatment					
Extraction Piping - Installation	1,500	LF	$ 18.00	$27,000	RSMeans Crew #B-22A plus RSMeans #33 14 13.35 (0050) for 1.5" SDR21 HDPE dual wall containment piping
Injection Piping - Installation	1,500	LF	$23.00	$34,500	Pricing based on RSMeans #22 11 13.44 (0600) for 1.5" Sch 40 Carbon Steel piping with stands
Concrete Equipment Pad for Equipment Containers	3	EA	$13,200.00	$39,600	15' x 40' x 12" (22 cy x $600/cy)
Electrical for Thermally Enhanced Biological Treatment					
Electrical Pole - Drill Foundation	2	DY	$2,750.00	$5,500	Drill to 6 ft to set poles
Electrical Pole - 40 ft	5	EA	$2,500.00	$12,500	Based on recent project similar in nature.
Electrical Pole - Guy Wire	1	EA	$2,000.00	$2,000	Based on recent project similar in nature.
OH Conductor	200	FT	$5.00	$1,000	Based on recent project similar in nature.
600 kVA Transformer	1	EA	$34,500.00	$34,500	Pricing per RSMeans #26 12 19.20 (0250)
Secondary Service to each Boiler	1	LS	$10,000.00	$10,000	Based on recent project similar in nature.
Subtotal				**$65,500**	
Engineering, PM, CM					
Design	15%		$65,500	$9,825	USEPA 2000, p. 5-13, $100K - $500K
Project Management	8%		$65,500	$5,240	USEPA 2000, p. 5-13, $100K - $500K
Construction Management	10%		$65,500	$6,550	USEPA 2000, p. 5-13, $100K - $500K
Subtotal Engineering				**$21,615**	
			Capital Cost Subtotal	**$235,315**	
Contingency		25%		$58,829	Per USEPA 2000 Document
	Total Estimated Capital Cost			**$294,144**	

Spreadsheet 9: Thermally Enhanced Biological Treatment Heating Source
Cost Worksheet, Opinion of Probable Costs
Site: NASA SSFL
Phase: Thermally Enhanced Biological Treatment

WORK STATEMENT
Scope:

Description	Qty	Unit	Unit Cost	Total	Notes
ANNUAL OPERATIONS AND MAINTENANCE COST - 5 YEAR PERIOD					
Annual Thermal Costs					
Daily Energy Demand - 3 Boilers (per year)	412,128	kw-hr	$0.48	$197,821	Pricing is average for California (477 kw-hr per boiler per month X 12 months x 3 each)
Operations and Maintenance of Systems (3 each)	1	LS	$7,500.00	$7,500	Crew for maintenance of systems (3 each) - estimated 1 week per year
Annual Total				*$205,321*	

Decommissioning Costs - Year `0

	QTY	UNIT	RATE	TOTAL	
Contractor Mobilization	1	LS	$5,000	$5,000	Based on recent project similar in nature.
Secondary Power Disconnect	1	LS	$5,000	$5,000	Based on recent project similar in nature.
Remove/Dispose Equipment	1	LS	$25,000	$25,000	Based on recent project similar in nature.
Remove/Dispose Concrete Pads	1	LS	$2,500	$2,500	Based on recent project similar in nature.
Abandon Extraction / Injection Wells	0	EA	$7,500	$0	Based on recent project similar in nature.
TOTAL DECOMMISSIONING COST				**$37,500**	

PRESENT VALUE ANALYSIS — Discount Rate 2.0%

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (2%)	PRESENT VALUE
CAPITAL COST	0	$294,144	$294,144	1.00	$294,144
ANNUAL O&M COST - Cap	10	$205,321	$205,321	8.98	$1,844,317
PERIODIC COST	10	$37,500	$37,500	0.82	$30,763
					$2,169,224
TOTAL PRESENT VALUE FOR BVE					**$2,170,000**

Spreadsheet 10: MNA Network by TTA, List of Wells Assumed for MNA Monitoring Per TTA

ND-136 TTA	Sample Intervals	WS-09 TTA	Sample Intervals	C-6 TTA	Sample Intervals
ND-136 Extraction Well	1	WS-09 Extraction Well	1	C-6	1
ND-163 (5 ports)	5	ND-168	5	ND-169	1
ND-165 (5 ports)	5	ND-134 (4 ports)	4	HAR-07	1
ND-167 (5 ports)	5	ND-135 (4 ports)	4	ND-138A	1
C-5 (3- of 6 ports)	3	RD-04	1	ND-138B	1
ND-160	6	ND-132	5	SP-890 Cluster	2
ND-137A	1	ND-133	4	HAR-08	1
ND-137B	1			SP-881 cluster	2
RD-49B	1			SP-882 cluster	1
RD-49C	1			WS-09A	1
PZ-154	1				

Spreadsheet 11: Lab and Data Validation Costs

Analysis/Test	Sample Matrix	Field Samples	Field Duplicates	Equipment Rinsate Blanks	Field Blanks	Trip Blanks	Matrix Spike	Matrix Spike Duplicate	Total Number of Liquid Samples	Total Billable Liquid Samples	Liquid Unit Price	DV Costs	Liquid Subtotal Cost	Total Analytical Cost
Annual Sampling for Alternatives 1, 2a, 2b and 3 (for full 30 years) and Alternative 4 (years 11-30)														
Baseline Sampling														
Groundwater wells														
TCL VOCs by SW846 8260B	GW	66	7	3	1	22	5	5	109	109	$70.00	$21.63	$9,987.67	$9,987.67
1,4-Dioxane	GW	66	7	3	1	22	5	5	109	109	$125.00	$15.00	$15,260.00	$15,260.00
n-Nitrosodimethylamine	GW	24	3	3	1	0	2	2	35	35	$150.00	$15.00	$5,775.00	$5,775.00
Methane, Ethane, Ethene by RSK-175	GW	66	7	3	1	0	4	4	85	85	$70.00	$15.00	$7,225.00	$7,225.00
Nitrate, Nitrite, Sulfate by USEPA 300.0	GW	66	7	3	1	0	4	4	85	85	$80.00	$15.00	$8,075.00	$8,075.00
Dissolved iron and manganese, major cations	GW	66	7	3	1	0	2	2	28	28	$70.00	$15.00	$2,380.00	$2,380.00
Sulfide by USEPA 376.1	GW	66	7	3	0	0	4	4	84	84	$36.00	$15.00	$4,284.00	$4,284.00
qPCR (e.g., QuantArray Chlor)	GW	5	1	3	0	2	0	0	11	11	$765.00	$15.00	$8,580.00	$8,580.00
Volatile Fatty Acids (or metabolic acids)	GW	5	1	3	0	0	0	0	9	9	$92.40	$8.65	$909.45	$909.45
Alkalinity	GW	66	7	3	1	0	4	4	85	85	$20.00	$21.63	$3,538.55	$3,538.55
TDS	GW	66	7	3	1	0	4	4	85	85	$20.00	$21.63	$3,538.55	$3,538.55
CSIA	GW	5	1	3	0	2	0	0	11	11	$602.00	$15.00	$6,787.00	$6,787.00
Total Organic Carbon (TOC) by SW-846 9060 Quadruplicate analysis	GW	33	0	0	0	0	2	2	37	37	$35.00	$8.65	$1,615.05	$1,615.05
													Subtotal	**$77,955.27**

Spreadsheet 12: Discount Rate Schedule

$1 IMO = Interim Measure O&M Cost (Annual)

0.020 DR = Discount Rate (2%)

Time (Year End)	Accumulated Cash Flow (PV)	Annual Cash Flow	
0	$0	$0	
1	$0.980	$0.980	98%
2	$0.961	$1.942	194%
3	$0.942	$2.884	288%
4	$0.924	$3.808	381%
5	$0.906	$4.713	471%
6	$0.888	$5.601	560%
7	$0.871	$6.472	647%
8	$0.853	$7.325	733%
9	$0.837	$8.162	816%
10	$0.820	$8.983	898%
11	$0.804	$9.787	979%
12	$0.788	$10.575	1058%
13	$0.773	$11.348	1135%
14	$0.758	$12.106	1211%
15	$0.743	$12.849	1285%
16	$0.728	$13.578	1358%
17	$0.714	$14.292	1429%
18	$0.700	$14.992	1499%
19	$0.686	$15.678	1568%
20	$0.673	$16.351	1635%
21	$0.660	$17.011	1701%
22	$0.647	$17.658	1766%
23	$0.634	$18.292	1829%
24	$0.622	$18.914	1891%
25	$0.610	$19.523	1952%
26	$0.598	$20.121	2012%
27	$0.586	$20.707	2071%
28	$0.574	$21.281	2128%
29	$0.563	$21.844	2184%
30	$0.552	$22.396	2240%

2020Q3	1171
2023Q2	1365
Escalation	16.57%

from: Turner Building Cost Index

https://www.turnerconstructio

Spreadsheet 13: EISB Treatment Substrate Calculations
Discount Rate (2%)

EISB Treatment Reagent Costs - ND-136 TTA

		ND-136 TTA		
		Value	Unit	Assumptions/Notes
Aquifer Dimensions				
Vertical Injection Interval	*z*	205	ft	Alpha – 307 to 386 ft bgs Bravo – 300 to 375 ft bgs Delta – 50 to 270 ft bgs
Lateral Injection Length	*L*	75	ft	
Lateral Injection Width	*W*	80	ft	
Estimated Mobile Porosity[1]	Φ	0.008		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	73,603	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted EVO Concentration	C_{DIL}	2.0	%	Recommended EVO dilution to 2 - 5%, lower end used due to recirc
Bulk EVO	C_{BULK}	60	%	Typical purchased bulk concentration
EVO Specifications				
Volume Bulk EVO Substrate (as 60% EVO)[2]	V_{BULK}	2,453	gallons	V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}
EVO Approximate Density	ρ_{EVO}	8.00	lbs/gallon	
Mass Bulk EVO Substrate (as 60% EVO)	$m_{EVOtotal}$	19,628	lbs	$m_{EVOtotal}$ = ρ_{EVO} * V_{BULK}
Bioaugmentation Culture Specifications				
Bulk Amendment Concentration	$C_{biobulk}$	1.0E+11	cells/liter	
Final Target Amendment Concentration	C_{bio}	1.0E+06	cells/liter	
Minimum Volume (Total)	$V_{biomintotal}$	2.79	liters	$V_{biomintotal}$ = V_{pre} * C_{bio} / $C_{biobulk}$ * 3.785
Safety Factor	SF_{bio}	10		
Recommended Volume (Total)	$V_{biototal}$	27.9	liters	V_{biotal} = SF_{bio} * $V_{biomintotal}$
Additional Injectate Materials				
Mass of Bicarbonate @ 600 mg/L [3]	m_{CO3}	369	lbs	m_{CO3} = 600 * (3.785/1000/ 453.59) * V_{total}
Mass of Sodium Ascorbate @ 300 mg/L[4]	$V_{biowell}$	184	lbs	$V_{biowell}$ = $V_{biominwell}$ * 1.25
Dilution Water Volume (Total)	$V_{H2Ototal}$	71,150	gallons	$V_{H2Ototal}$ = V_{total} - V_{BULK}

Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk EVO Substrate (as 60% EVO)[5]	17	$/gallon	$ 41,708	Price based on quote for Terra Systems product 60% SRS®-FRL. Includes taxes and shipping.
Cost for Bicarbonate	0.80	$/lb	$ 295	Price based on quote from TerraSystems, plus shipping.
Cost for Bulk Bioaugmentation Culture	147	$/L	$ 4,095	Quote from TerraSystems. Includes taxes and shipping.
Cost for Sodium Ascorbate	18	$/lb	$ 3,317	Quote from TerraSystems. Includes taxes and shipping.
		TOTAL	**$ 49,415**	

Notes:
[1]Fractured bedrock with low open fracture volume
[2]Assumes nutrient package will be added (lactate, vitamin B12, etc.)
[3]Sodium bicarbonate dosage recommended for aquifers with pH 5 to 6
[4]Or similar compound for production of anaerobic chase water
[5]60% SRS®-FRL EVO contains 4% sodium lactate; proprietary nutrient package containing yeast extracts, nitrogen and phosphorus, and Vitamin B12.

EISB Treatment Reagent Costs - WS-09

		WS-09 TTA		
		Value	Unit	Assumptions/Notes
Aquifer Dimensions				
Vertical Injection Interval	*z*	200	ft	Alpha – 307 to 386 ft bgs Bravo – 300 to 375 ft bgs Delta – 50 to 270 ft bgs
Lateral Injection Length	*L*	80	ft	
Lateral Injection Width	*W*	75	ft	
Estimated Mobile Porosity[1]	Φ	0.010		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	89,760	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted EVO Concentration	C_{DIL}	2.0	%	Recommended EVO dilution to 2 - 5%, lower end used due to recirc
Bulk EVO	C_{BULK}	60	%	Typical purchased bulk concentration
EVO Specifications				
Volume Bulk EVO Substrate (as 60% EVO)[2]	V_{BULK}	2,992	gallons	V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}
EVO Approximate Density	ρ_{EVO}	8.00	lbs/gallon	
Mass Bulk EVO Substrate (as 60% EVO)	$m_{EVOtotal}$	23,936	lbs	$m_{EVOtotal}$ = ρ_{EVO} * V_{BULK}
Bioaugmentation Culture Specifications				
Bulk Amendment Concentration	$C_{biobulk}$	1.0E+11	cells/liter	
Final Target Amendment Concentration	C_{bio}	1.0E+06	cells/liter	
Minimum Volume (Total)	$V_{biomintotal}$	3.40	liters	$V_{biomintotal}$ = V_{pre} * C_{bio} / $C_{biobulk}$ * 3.785
Safety Factor	SF_{bio}	10		
Recommended Volume (Total)	$V_{biototal}$	34.0	liters	V_{biotal} = SF_{bio} * $V_{biomintotal}$
Additional Injectate Materials				
Mass of Bicarbonate @ 600 mg/L [3]	m_{CO3}	449	lbs	m_{CO3} = 600 * (3.785/1000/ 453.59) * V_{total}
Mass of Sodium Ascorbate @ 300 mg/L[4]	$V_{biowell}$	225	lbs	$V_{biowell}$ = $V_{biominwell}$ * 1.25
Dilution Water Volume (Total)	$V_{H2Ototal}$	86,768	gallons	$V_{H2Ototal}$ = V_{total} - V_{BULK}

Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk EVO Substrate (as 60% EVO)[5]	17	$/gallon	$ 50,864	Price based on quote for Terra Systems product 60% SRS®-FRL.
Cost for Bicarbonate	0.80	$/lb	$ 360	Price based on quote from TerraSystems, plus shipping.
Cost for Bulk Bioaugmentation Culture	147	$/L	$ 4,994	Quote from TerraSystems
Cost for Sodium Ascorbate	18	$/lb	$ 4,045	Quote from TerraSystems
		TOTAL	**$ 60,262**	

Notes:
[1]Fractured bedrock with low open fracture volume
[2]Assumes nutrient package will be added (lactate, vitamin B12, etc.)
[3]Sodium bicarbonate dosage recommended for aquifers with pH 5 to 6
[4]Or similar compound for production of anaerobic chase water
[5]60% SRS®-FRL EVO contains 4% sodium lactate; proprietary nutrient package containing yeast extracts, nitrogen and phosphorus, and Vitamin B12.

Spreadsheet 13: EISB Treatment Substrate Calculations
Discount Rate (2%)
EISB Treatment Reagent Costs - C-6

		Alfa Area		
		Value	**Unit**	**Assumptions/Notes**
Aquifer Dimensions				
Vertical Injection Interval	*z*	400	ft	Alpha – 307 to 386 ft bgs Bravo – 300 to 375 ft bgs Delta – 50 to 270 ft bgs
Lateral Injection Length	*L*	75	ft	
Lateral Injection Width	*W*	80	ft	
Estimated Mobile Porosity[1]	Φ	0.010		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	179,520	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted EVO Concentration	C_{DIL}	2.0	%	Recommended EVO dilution to 2 - 5%, lower end used due to recirc
Bulk EVO	C_{BULK}	60	%	Typical purchased bulk concentration
EVO Specifications				
Volume Bulk EVO Substrate (as 60% EVO)[2]	V_{BULK}	5,984	gallons	$V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}$
EVO Approximate Density	ρ_{EVO}	8.00	lbs/gallon	
Mass Bulk EVO Substrate (as 60% EVO)	$m_{EVOtotal}$	47,872	lbs	$m_{EVOtotal} = \rho_{EVO} * V_{BULK}$
Bioaugmentation Culture Specifications				
Bulk Amendment Concentration	$C_{biobulk}$	1.0E+11	cells/liter	
Final Target Amendment Concentration	C_{bio}	1.0E+06	cells/liter	
Minimum Volume (Total)	$V_{biomintotal}$	6.79	liters	$V_{biomintotal} = V_{pre} * C_{bio} / C_{biobulk} * 3.785$
Safety Factor	SF_{bio}	10		
Recommended Volume (Total)	$V_{biototal}$	67.9	liters	$V_{biotal} = SF_{bio} * V_{biomintotal}$
Additional Injectate Materials				
Mass of Bicarbonate @ 600 mg/L [3]	m_{CO3}	899	lbs	m_{CO3} = 600 * (3.785/1000/ 453.59) * V_{total}
Mass of Sodium Ascorbate @ 300 mg/L[4]	$V_{biowell}$	449	lbs	$V_{biowell} = V_{biominwell} * 1.25$
Dilution Water Volume (Total)	$V_{H2Ototal}$	173,536	gallons	$V_{H2Ototal} = V_{total} - V_{BULK}$

Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk EVO Substrate (as 60% EVO)[5]	17	$/gallon	$ 101,728	Price based on quote for Terra Systems product 60% SRS®-FRL.
Cost for Bicarbonate	0.80	$/lb	$ 719	Price based on quote from TerraSystems, plus shipping.
Cost for Bulk Bioaugmentation Culture	147	$/L	$ 9,988	Quote from TerraSystems
Cost for Sodium Ascorbate	18	$/lb	$ 8,089	Quote from TerraSystems
		TOTAL	**$ 120,525**	

Notes:
[1]Fractured bedrock with low open fracture volume
[2]Assumes nutrient package will be added (lactate, vitamin B12, etc.)
[3]Sodium bicarbonate dosage recommended for aquifers with pH 5 to 6
[4]Or similar compound for production of anaerobic chase water
[5]60% SRS®-FRL EVO contains 4% sodium lactate; proprietary nutrient package containing yeast extracts, nitrogen and phosphorus, and Vitamin B12.

Spreadsheet 14: ISCO Treatment Reagent Calculations

ISCO Treatment Reagent Costs - ND-136 TTA

		ND-136 TTA		
		Value	Unit	Assumptions/Notes
Aquifer Dimensions				
Vertical Injection Interval	*z*	205	ft	
Lateral Injection Length	*L*	75	ft	
Lateral Injection Width	*W*	80	ft	
Estimated Mobile Porosity[1]	Φ	0.008		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	73,603	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted Oxidant Concentration	C_{DIL}	3	%	Recommended ISCO concentration based on SSFL Pilot
Bulk Oxidant Concentration	C_{BULK}	40	%	Typical purchased bulk concentration
Oxidant Specifications				
Volume Sodium Permanganate (as 40% Sodium Permanganate)[2]	V_{BULK}	5,520	gallons	V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}
ISCO 40% Reagent Density	ρ_{EVO}	11.42	lbs/gallon	
Mass Bulk ISCO Reagent (as 40% Sodium Permanganate)	$m_{EVOtotal}$	63,041	lbs	$m_{EVOtotal}$ = ρ_{EVO} * V_{BULK}
Dilution Water Volume (Total)	$V_{H2Ototal}$	68,083	gallons	$V_{H2Ototal}$ = V_{total} - V_{BULK}
Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk ISCO Reagent (as 40% Sodium Permanganate)	23.42	$/gallon	$ 129,284	Based on recent project quote.
		TOTAL	**$ 38,785**	Assume 30% reagent pore volume

Notes:
[1]Fractured bedrock with low open fracture volume

ISCO Treatment Reagent Costs - WS-09

		WS-09 TTA		
		Value	Unit	Assumptions/Notes
Aquifer Dimensions				
Vertical Injection Interval	*z*	200	ft	
Lateral Injection Length	*L*	75	ft	
Lateral Injection Width	*W*	80	ft	
Estimated Mobile Porosity[1]	Φ	0.008		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	71,808	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted Oxidant Concentration	C_{DIL}	3	%	Recommended ISCO concentration based on SSFL Pilot
Bulk Oxidant Concentration	C_{BULK}	40	%	Typical purchased bulk concentration
Oxidant Specifications				
Volume Sodium Permanganate (as 40% Sodium Permanganate)[2]	V_{BULK}	5,386	gallons	V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}
EVO Approximate Density	ρ_{EVO}	11.42	lbs/gallon	
Mass Bulk ISCO Reagent (as 40% Sodium Permanganate)	$m_{EVOtotal}$	61,504	lbs	$m_{EVOtotal}$ = ρ_{EVO} * V_{BULK}
Dilution Water Volume (Total)	$V_{H2Ototal}$	66,422	gallons	$V_{H2Ototal}$ = V_{total} - V_{BULK}
Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk ISCO Reagent (as 40% Sodium Permanganate)	23.42	$/gallon	$ 126,131	Based on recent project quote.
		TOTAL	**$ 37,839**	Assume 30% pore volume

Notes:
[1]Fractured bedrock with low open fracture volume

ISCO Treatment Reagent Costs - C-6

		C-6 TTA		
		Value	Unit	Assumptions/Notes
Aquifer Dimensions				
Vertical Injection Interval	*z*	400	ft	
Lateral Injection Length	*L*	75	ft	
Lateral Injection Width	*W*	80	ft	
Estimated Mobile Porosity[1]	Φ	0.008		Fractured bedrock
Injectate Volume (Total Pore Volume)	V_{pore}	143,616	gallons	V_{pore} = z * L * W * Φ * 7.48
Substrate Injectate Specifications				
Diluted Oxidant Concentration	C_{DIL}	3	%	Recommended ISCO concentration based on SSFL Pilot
Bulk Oxidant Concentration	C_{BULK}	40	%	Typical purchased bulk concentration
Oxidant Specifications				
Volume Sodium Permanganate (as 40% Sodium Permanganate[2]	V_{BULK}	10,771	gallons	V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}
EVO Approximate Density	ρ_{EVO}	11.42	lbs/gallon	
Mass Bulk ISCO Reagent (as 40% Sodium Permanganate)	$m_{EVOtotal}$	123,007	lbs	$m_{EVOtotal}$ = ρ_{EVO} * V_{BULK}
Dilution Water Volume (Total)	$V_{H2Ototal}$	132,845	gallons	$V_{H2Ototal}$ = V_{total} - V_{BULK}
Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk ISCO Reagent (as 40% Sodium Permanganate)	23.42	$/gallon	$ 252,262	Based on recent project quote.
		TOTAL	**$ 75,678**	Assume 30% pore volume

Notes:
[1]Fractured bedrock with low open fracture volume

Spreadsheet 15: EPA Recommendations for Cost Loading Factors, From EPA 2000 FS Cost Estimating Guide

Capital Cost Element	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	> $10M (%)
Project Management	10%	8%	6%	5%	5%
Remedial Design	20%	15%	12%	8%	6%
Construction Management	15%	10%	8%	6%	6%

Spreadsheets 16–28

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Spreadsheet 16: Cost Summary of Seep Alternatives

Element	Alt SP1 MNA (North)	Alt SP1 MNA (South)	Alt SP2 - Hydraulic Control (North)	Alt SP2 Hydraulic Control (South)	Alt SP3 - EISB TZ (North)	Alt SP3 - EISB TZ (South)
Capital Cost						
MNA & LUCs	$48,090	$48,090	$48,090	$48,090	$48,090	$48,090
Hydraulic Containment			$3,784,750	0 (already in place)		
EISB TZ					$6,391,561	$182,854
Capital Subtotal	$48,090	$48,090	$3,832,840	$48,090	$6,439,651	$230,944
PV O&M Costs (10 Years)						
MNA & LUCs	$1,144,000	$572,000	$1,144,000	$572,000	$1,143,500	$572,000
Hydraulic Containment			$824,000	$1,606,000		
EISB TZ					$1,084,900	$137,000
PV O&M Subtotal	$1,144,000	$572,000	$1,968,000	$2,178,000	$2,228,400	$709,000
Total Present Value of Alternative (NPV @ 2%) for 10 years	$1,192,090	$620,090	$5,800,840	$2,226,090	$8,668,051	$939,944
+50% NPV Costs for 30 years	$1,716,000	$858,000	$2,952,000	$3,267,000	$3,342,600	$1,063,500
-30% NPV Costs for 30 years	$800,800	$400,400	$1,377,600	$1,524,600	$1,559,880	$496,300

Spreadsheet 17: Alternative SP-1 – Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs) in Northern Seep Area

Cost Worksheet, Opinion of Probable Costs

NASA, SSLF P1 CMS

8/21/2020

CAPITAL COSTS

DESCRIPTION		QTY	UNIT	UNIT COST	Escalation	TOTAL	NOTES
Land Use Controls							
LUC Remedial Design and implementation		1	LS	$10,000	16.57%	$11,657	Based on recent project similar in nature
	SUBTOTAL					**$11,657**	
Develop MNA Work Plan							
Prepare MNA work plan		1	LS	$20,000	16.57%	$23,314	Based on recent project similar in nature.
	SUBTOTAL					**$23,314**	
	SUBTOTAL Capital Cost					$34,971	
Contingency		25%		$34,971		$8,743	USEPA 2000 Document - A Guide to Developing and Documenting Cost Estimates, 10% Scope + 15% Bid
	SUBTOTAL					**$43,714**	
Project Management		10%		$43,714		$4,371	USEPA 2000 Document, p. 5-13, < $100K
Design		0%		$43,714		$0	USEPA 2000 Document, p. 5-13, < $100K
Construction Management		0%		$43,714		$0	USEPA 2000 Document, p. 5-13, < $100K
	SUBTOTAL					$4,371	
TOTAL CAPITAL COST						**$48,090**	

OPERATIONS AND MAINTENANCE COST - 1 Year Period

DESCRIPTION		QTY	UNIT	UNIT COST		TOTAL	NOTES
O&M LUC							
Annual Land Use Monitoring and Reporting		1	EA	$10,000	16.57%	$11,657	Based on recent project similar in nature.
	SUBTOTAL					**$11,657**	
MNA Monitoring							
Labor, per diem Travel		44	Samples	$196	16.57%	$10,053	Based on current site rates
Analytical Costs and Data Validation		2	EVENT	$35,349		$70,698	Includes DV, see ERDNorthMonitor Worksheet
Annual Report		1	EA	$20,000	16.57%	$23,314	Based on recent project similar in nature.
SUBTOTAL						**$104,065**	
Subcontractor Direct SubTotal						$115,722	
Integrating Contractor							
Project Management		10%				$11,572	USEPA 2000 Document, p. 5-13, < $100K
Remedial Design		0%				$0	USEPA 2000 Document, p. 5-13, < $100K
Construction Management		0%				$0	USEPA 2000 Document, p. 5-13, < $100K
SUBTOTAL						**$11,572**	
TOTAL ANNUAL O&M						**$127,295**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE
CAPITAL COST	0	$48,090	1.00	$48,090
O&M COST	10	$127,295	8.98	$1,144,000
TOTAL PRESENT VALUE FOR HYDRAULIC CONTROL				**$1,192,090**

Spreadsheet 18: Alternative SP-1 – Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs) in Southern Seep Area

Cost Worksheet, Opinion of Probable Costs

NASA, SSLF P1 CMS

8/21/2020

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	Escalation	TOTAL	NOTES
Land Use Controls						
LUC Remedial Design and implementation	1	LS	$10,000	16.57%	$11,657	Based on recent project similar in nature
SUBTOTAL					**$11,657**	
Develop MNA Work Plan						
Prepare MNA work plan	1	LS	$20,000	16.57%	$23,314	Based on recent project similar in nature
SUBTOTAL					**$23,314**	
SUBTOTAL Capital Cost					$34,971	
Contingency	25%		$34,971		$8,743	USEPA 2000 Document - A Guide to Developing and Documenting Cost Estimates, 10% Scope + 15% Bid
SUBTOTAL					**$43,714**	
Project Management	10%		$43,714		$4,371	USEPA 2000, p. 5-13, < $100K
Design	0%		$43,714		$0	USEPA 2000, p. 5-13, < $100K
Construction Management	0%		$43,714		$0	USEPA 2000, p. 5-13, < $100K
SUBTOTAL					$4,371	
TOTAL CAPITAL COST					**$48,090**	

OPERATIONS AND MAINTENANCE COST - 1 Year Period

DESCRIPTION	QTY	UNIT	UNIT COST		TOTAL	NOTES
O&M LUC						
Annual Land Use Monitoring and Reporting	1	EA	$5,000	16.57%	$5,829	Based on recent project similar in nature.
MNA Monitoring						
Labor, per diem Travel	22	Samples	$196	16.57%	$5,026	Based on current site rates
Analytical Costs and Data Validation	2	EVENT	$17,675		$35,349	Includes DV, See ERD South Monitor Worksheet
Annual Report	1	EA	$10,000	16.57%	$11,657	Based on recent project similar in nature.
SUBTOTAL					**$52,033**	
SUBTOTAL - ALL TASKS - O & M						
Subcontractor Direct SubTotal					$57,861	
Integrating Contractor						
Project Management	10%				$5,786	USEPA 2000, p. 5-13, < $100K
Remedial Design	0%				$0	USEPA 2000, p. 5-13, < $100K
Construction Management	0%				$0	USEPA 2000, p. 5-13, < $100K
SUBTOTAL					**$5,786**	
TOTAL ANNUAL O&M					**$63,647**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE
CAPITAL COST	0	$48,090	1.00	$48,090
O&M COST	10	$63,647	8.98	$572,000
TOTAL PRESENT VALUE FOR HYDRAULIC CONTROL				**$620,090**

Spreadsheet 19: Alternative SP-2 - Hydraulic Control, MNA, and LUCs in Northern Seep Area
Alternative Cost Estimates
SSFL

Site: SSFL, North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Hydraulic Control (North)

	Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
CAPITAL COSTS							
FIELD SUBCONTRACTOR							
Preconstruction							
	Installation Subcontractor Bond and Submittals	1	LS	$14,150	16.57%	$16,495	Based on recent project similar in nature.
	Well permits	3	EA	$400	16.57%	$1,399	Based on recent project similar in nature.
	Driller Mobilization	1	LS	$20,000	16.57%	$23,314	Based on recent project similar in nature.
	Utility Locate	2	DY	$2,198	16.57%	$5,123	Based on recent project similar in nature.
	Brush Clearance	8	DY	$3,000	16.57%	$27,977	Based on recent project similar in nature.
	Waste Discharge Permit	1	EA	$40,000	16.57%	$46,628	Based on recent project similar in nature.
	Setup Stockpile Area	1	LS	$5,000	16.57%	$5,829	Based on recent project similar in nature.
	Subtotal					**$126,764**	
Construction							
	Drilling Contractor						
	Extraction Well Installation						
	Drill Extraction Column - 6" dia	1,250	LF	$115.00	16.57%	$167,569	2 wells @ 400 ft in ELV transect, one 450 ft well for B204 transect
	Ream PQ rock cores to 6-inch	1,250	LS	$115	16.57%	$167,569	2 wells @ 400 ft in ELV transect, one 450 ft well for B204 transect
	Well Development	3	EA	$10,000	16.57%	$34,971	Based on recent project similar in nature.
	Injection/Monitoring Well Head Completion	3	EA	$2,000	16.57%	$6,994	Allowance for misc. valves/fittings.
	Survey	2	WL	$800	16.57%	$1,865	Based on recent project similar in nature.
	Field Oversight/Travel	3	WL	$70,000	16.57%	$244,797	assumes working 20 days per well, two staff, plus travel
	Site Restoration	3	EA	$8,000	16.57%	$27,977	Based on recent project similar in nature.
	IDW Management - Well Water & Solids	3	WL	$122,080	16.57%	$426,925	Based on recent project similar in nature.
	Waste Characterization	3	LS	$10,000	16.57%	$34,971	Based on historical pricing.
	Misc. Field supplies and shipping	3	WL	$6,000	16.57%	$20,983	Based on recent project similar in nature.
	Submersible Pump (~9-26 gpm @ 180' head)	3	EA	$4,610.00	16.57%	$16,122	RS Means, 2002, escalated to 2019 per the Turner Cost Index, 33 23 0502
	Subtotal					**$1,150,743**	
	Pipeline Construction						
	Plans, Submittals, Mobilization, and Demobilization	1	LS	$8,145.00	16.57%	$9,495	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Mobilize/Demobilization	1	LS	$3,054.00	16.57%	$3,560	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Baseline Schedule / Weekly Schedule Updates	1	LS	$3,054.00	16.57%	$3,560	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Site Setup, Prepare Work Areas	3	LS	$3,564.00	16.57%	$12,464	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Installation of Erosion and Sediment Control Measures	3	LS	$3,054.00	16.57%	$10,680	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Clear and Grub Pipeline and Well Locations (poison oak mitigation expected)	1	LS	$7,010.00	16.57%	$8,172	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Install 4"x8" Double Wall HDPE Pipe	3,200	LF	$62.00	16.57%	$231,275	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Install double contained check valve near main trunk line intersection (12" tee, line flange, double contained)	1	EA	$4,073.00	16.57%	$4,748	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Install Manual Leak Detection Piping	3	EA	$1,039.00	16.57%	$3,633	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Install Sample Ports	3	EA	$1,181.00	16.57%	$4,130	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Install Air Release Valves	3	EA	$4,434.00	16.57%	$15,506	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)

Spreadsheet 19: Alternative SP-2 - Hydraulic Control, MNA, and LUCs in Northern Seep Area
Alternative Cost Estimates
SSFL

Site: SSFL, North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Hydraulic Control (North)

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
Install Connection to Existing Boeing Pipeline	1	EA	$5,091.00	16.57%	$5,935	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Trenching and Road Crossings (dirt roads)	3	EA	$815.00	16.57%	$2,850	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Installation of transformer for wellhead for the control panel (mounted to backer board)	3	EA	$3,054.00	16.57%	$10,680	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Installation of 35' electrical poles to wellheads	3	EA	$11,801.00	16.57%	$41,269	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Installation of guying	6	EA	$3,024.00	16.57%	$21,150	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Installation of wiring and conduit support at wellheads, to wellhead instruments, receptacles and submersible	200	LF	$66.00	16.57%	$15,387	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Install Control Panel, Backer, Switch Gears	3	EA	$12,569.00	16.57%	$43,955	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Reconstruct above-ground wellhead and concrete Work: Double containment pad (4'x8'x4' with fiberglass lid).	3	LS	$22,781.00	16.57%	$79,667	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Install above ground secondary feeders	500	LF	$61.00	16.57%	$35,554	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Attach Pipeline to Existing Guide	140	EA	$76.00	16.57%	$12,403	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Water Management - Truck Water to onsite Treatment Plant	10	HR	$234.00	16.57%	$2,728	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Offsite disposal of approximately 2,000 gallons	2,000	GAL	$3.00	16.57%	$6,994	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Project Completion Documentation	1	LS	$4,073.00	16.57%	$4,748	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Install Pipeline (1x3 individual wells)	750	LS	$33.00	16.57%	$28,851	Engineer Estimate based on Jacobs Project Experience at SSFL scaled using RS MEANS (33 26 0512/33 26 0514)(escalated using the Turner Building Cost Index)
Install Pipeline (2x4 trunk to existing 4x8)	2,450	LS	$47.00	16.57%	$134,230	Engineer Estimate based on Jacobs Project Experience at SSFL scaled using RS MEANS (33 26 0622/33 26 0624)(escalated using the Turner Building Cost Index)
Subtotal					**$753,625**	
Well Connection						
Plans, Submittals, Mobilization, and Demobilization	1	LS	$12,177.00	16.57%	$14,195	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Install Telemetry	1	LS	$2,474.00	16.57%	$2,884	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Power to Wellhead	3	LS	$20,160.00	16.57%	$70,502	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Install wellhead and Connect to Pipeline	3	LS	$64,134.00	16.57%	$224,283	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Groundwater Management	3	LS	$1,935.00	16.57%	$6,767	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Transport and Dispose F002 Groundwater	0	GAL	$4.00	16.57%	$0	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
Wellhead Startup and Commissioning	3	LS	$2,785.00	16.57%	$9,739	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)

Spreadsheet 19: Alternative SP-2 - Hydraulic Control, MNA, and LUCs in Northern Seep Area
Alternative Cost Estimates
SSFL

Site: SSFL, North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Hydraulic Control (North)

	Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
	Prepare Submittals (wellhead telemetry)	1	LS	$2,545.00	16.57%	$2,967	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Design and Install Telemetry Addition	1	LS	$9,723.00	16.57%	$11,334	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Submittals for GETS Controls	1	LS	$7,254.00	16.57%	$8,456	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Construct, Program, and Commission Control Panel (GETS)	1	LS	$40,727.00	16.57%	$47,475	Engineer Estimate based on Jacobs Project Experience at SSFL (escalated using the Turner Building Cost Index)
	Subtotal					**$398,602**	
O&M LUC							
	Annual Land Use Monitoring and Reporting	1	EA	$10,000		$10,000	Based on recent project similar in nature.
	SUBTOTAL					**$10,000**	
SAMPLING AND REPORTING							
	Labor, per diem Travel	44	Samples	$196	16.57%	$10,053	Based on per sample rate
	Analytical Costs and Data Validation	2	EVENT	$35,349		$70,698	See ERD Monitor North WS
	Annual Report	1	EVENT	$20,000	16.57%	$23,314	Based on project similar in nature
	Sampling and Reporting Subtotal					**$104,065**	
	Subcontractor Direct Subtotal					**$2,543,800**	
	Contingencies	25%		$2,543,799.64		**$635,950**	USEPA 2000 Document - A Guide to Developing and Documenting Cost Estimates, 10% Scope + 15% Bid
	Subcontractor Total					**$3,179,750**	
INTEGRATING CONTRACTOR							
	Remedial Design	8%		$3,179,750		$254,380	USEPA 2000 Document, $2-10 Million
	Project Management	5%		$3,179,750		$158,987	USEPA 2000 Document, $2-10 Million
	Construction Management	6%		$3,179,750		$190,785	USEPA 2000 Document, $2-10 Million
	Integrating Contractor Total					**$605,000**	
Total Estimated Capital Cost for MNA and LUCs (Same as MNA & LUCs for Northern Seep Area)						**$48,090**	(includes PM, Design, CM)
Total Estimated Capital Cost for Hydraulic Control						**$3,784,750**	$48,090

Spreadsheet 19: Alternative SP-2 - Hydraulic Control, MNA, and LUCs in Northern Seep Area
Alternative Cost Estimates
SSFL

Site: SSFL, North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Hydraulic Control (North)

	Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
ANNUAL OPERATIONS AND MAINTENANCE COST							
FIELD SUBCONTRACTOR							
	Annual Land Use Monitoring and Reporting	1	EA	$10,000	16.57%	$11,657	Based on project similar in nature
SAMPLING AND REPORTING							
	Labor, per diem Travel	44	Samples	$196	16.57%	$10,053	Based on current sub rates
	Analytical Costs and Data Validation	2	EVENT	$35,349		$70,698	See ERD Monitor North WS
	Annual Report	1	EVENT	$20,000	16.57%	$23,314	Based on project similar in nature
	Sampling and Reporting Subtotal					**$104,065**	
GETS OPERATIONS							
	O&M for Extraction wells	58,815	KW-hr/yr	$0.16	16.57%	$10,970	(3 hp each well X 3 wells), 24 hr/day, 365 day/year
	Annual GETS treatment Costs	6.40%	Percent of Total	$579,488	16.57%	$43,233	Based on 6.4% of total NASA Cost Allocation for Boeing GETS
	General Inspections and O&M	1	LS	$25,000	16.57%	$29,143	Engineers Estimate
	Subcontractor Direct Subtotal					**$83,345**	
	Subcontractor Total					**$199,067**	
INTEGRATING CONTRACTOR							
	Project Management (Hydraulic Control)	10%		$83,345		$8,334	USEPA 2000 Document, < $100K
	Project Management (MNA & LUCs)	10%		$115,722		$11,572	USEPA 2000 Document, < $100K
Total O&M Costs - Hydraulic Containment						**$91,679**	
Total O&M Cost - MNA & LUCs						**$127,295**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	
CAPITAL COST (HYDRAULIC CONTROL)	0	$3,784,750	1.00	$3,784,750	
CAPITAL COST (MNA & LUCs)	0	$48,090	1.00	$48,090	
O&M COST (HYDRAULIC CONTROL)	10	$91,679	8.98	$824,000	10 years active treatment assumed
O&M COST (MNA & LUCs)	10	$127,295	8.98	$1,144,000	
TOTAL PRESENT VALUE FOR HYDRAULIC CONTROL				**$5,800,840**	

Spreadsheet 20: Alternative SP-2 - Hydraulic Control, MNA, and LUCs in Southern Seep Are
Alternative Cost Estimates
SSFL
Site: SSFL, South Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope: Hydraulic Control (South)

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
CAPITAL COSTS - NONE, SYSTEM CONSTRUCTED						
FIELD SUBCONTRACTOR						
MNA and LUCs Plans (Same and Alternative SP-1 for Southern Area)					**$48,090**	**(includes design, CM, PM, and contingency)**
ANNUAL OPERATIONS AND MAINTENANCE COST						
FIELD SUBCONTRACTOR						
Annual Land Use Monitoring and Reporting	1	EA	$5,000	16.57%	$5,829	Based on project similar in nature.
SAMPLING AND REPORTING						
Labor, per diem Travel	22	Samples	$196	16.57%	$5,026	Based on current sub rates
Analytical Costs and Data Validation	2	EVENT	$17,675		$35,349	See ERD Monitor South WS
Annual Report	1	EVENT	$10,000	16.57%	$11,657	Based on project similar in nature.
Sampling and Reporting Subtotal					**$52,033**	
GETS Operations						
O&M for Extraction wells	6,535	KW-hr/yr	$0.16	16.57%	$1,219	(3 hp each well X 1 wells), 24 hr/day, 365 day/year
Annual GETS treatment Costs	20%	Percent of Total	$579,488	16.57%	$135,102	Based on 20% of total NASA Cost Allocation for Boeing GETS
General Inspections and O&M	1	LS	$25,000	16.57%	$29,143	Engineers Estimate
	Subcontractor Direct Subtotal				**$165,463**	
	Subcontractor Total				**$223,324**	
INTEGRATING CONTRACTOR						
Project Management (hydraulic control)	8%		$165,463		$13,237.06	USEPA 2000 Document, $100K - $500K
Project Management (MNA & LUCs)	10%		$57,861		$5,786.12	USEPA 2000 Document, < $100K
	Integrating Contractor Total				**$20,000**	
Total O&M Cost					**$243,324**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	Period	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	
CAPITAL COST (MNA & LUCs)	0	$48,090	1.00	$48,090	
O&M COST (MNA & LUCs)	10	$63,647	8.98	$572,000	This assumes 10 years active treatment
O&M COST (Hydraulic Control)	10	$178,700	8.98	$1,606,000	
TOTAL PRESENT VALUE FOR HYDRAULIC CONTROL				**$2,226,090**	

Spreadsheet 21: Alternative SP-3 - Enhanced In-Situ Bioremediation (EISB), MNA, and LUCs in Northern Seep Area
Alternative Cost Estimate
SSFL

Site: North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope:

Enhanced In Situ Biological Reduction of Groundwater Upgradient of Seeps

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
CAPITAL COSTS						
FIELD SUBCONTRACTOR						
Preconstruction						
Installation Subcontractor Bond and Submittals	1	LS	$14,150	16.57%	$16,495	EISB Pilot Study Construction Costs
Well permits	3	EA	$400	16.57%	$1,399	Based on recent project similar in nature.
Driller Mobilization	1	LS	$20,000	16.57%	$23,314	Based on recent project similar in nature.
Utility Locate	2	DY	$2,198	16.57%	$5,123	EISB Pilot Study Construction Costs
Brush Clearance	8	DY	$3,000	16.57%	$27,977	EISB Pilot Study Construction Costs
Setup Stockpile Area	1	LS	$5,000	16.57%	$5,829	Based on recent project similar in nature.
Subtotal					**$80,136.0**	
Construction						
Drilling Contractor						
Erosion/Site Controls	2	LS	$2,496.00	16.57%	$5,819	Silt fence @ $2.00/LF + $2,000 for maintenance. 10' x 10' area per well; RS Means, 2019. Section
Injection Well Installation						
Drill Extraction/Injection/Monitoring Wells (PQ rock core) and develop	4,250	FT	$115	16.57%	$569,736	5 wells at 450 Ft for B204 transect, 5 wells at 400 ft for ELV transect
Well Development	10	EA	$10,000	16.57%	$116,570	Based on recent bid
Injection Well Head Completion	10	EA	$2,000	16.57%	$23,314	Allowance for misc. valves/fittings.
Geophysical Surveys	10	EA	$13,750	16.57%	$160,284	Based on recent quote.
Packer Testing	10	WL	$24,300	16.57%	$283,265	Based on recent project similar in nature. Assumes 10 packer tests, collect depth discrete GW
Survey	10	WL	$800	16.57%	$9,326	Based on recent project similar in nature.
Field Oversight/Travel	10	WL	$70,000	16.57%	$815,990	assumes working 20 days per well, two staff, plus travel
Site Restoration	2	EA	$8,000	16.57%	$18,651	Based on recent project similar in nature.
IDW Management - Well Water & Solids	10	WL	$122,080	16.57%	$1,423,084	Based on recent project similar in nature.
Waste Characterization	10	LS	$10,000	16.57%	$116,570	Based on historical pricing.
Misc. Field supplies and shipping	10	WL	$6,000	16.57%	$69,942	Based on recent project similar in nature.
Subtotal					**$3,612,551.2**	
EVO Injection Costs						
Injection Trailer	1	EA	$16,463	16.57%	$19,190	Engineer Estimate based on Jacobs Project Experience. 9.75% Sales Tax
ERD Treatment Reagents	1	LS	$105,264	16.57%	$122,706	From ERDTreatReagNorth Worksheet
Operator - Labor and Travel	60	days	$1,628	16.57%	$113,866	Based on recent quote for ND-136 pilot
Tracer Testing	2	LS	$102,074	16.57%	$237,975	Based on OUL quote and 3-months monitoring/sampling costs estimate.
Tracer Testing Analysis (OUL)	100	EA	$85	16.57%	$9,908	Based on OUL quote
Subtotal					**$503,646**	
Subcontractor Direct Subtotal					**$4,196,333**	
SAMPLING AND REPORTING						
Labor, per diem Travel	44	Samples	$119	16.57%	$6,104	Based on per sample rate
Analytical Costs and Data Validation	2	EVENT	$35,349		$70,698	See ERD Monitor North WS
Annual Report	1	EVENT	$20,000	16.57%	$23,314	Based on project similar in nature.
Sampling and Reporting Subtotal					**$100,116**	
Capital SubTotal					**$4,296,449**	

Spreadsheet 21: Alternative SP-3 - Enhanced In-Situ Bioremediation (EISB), MNA, and LUCs in Northern Seep Area
Alternative Cost Estimate
SSFL
Site: North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope:
Enhanced In Situ Biological Reduction of Groundwater Upgradient of Seeps

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
Contingency	25%		$4,296,448.75		**$1,074,112**	USEPA 2000 Document - A Guide to Developing and Documenting Cost Estimates, 10% Scope + 15% Bid
	Subcontractor Total				**$5,370,561**	
INTEGRATING CONTRACTOR						
Design	8%		$5,370,561		$429,645	USEPA 2000 Document, $2-10 Million
Project Management	5%		$5,370,561		$268,528	USEPA 2000 Document, $2-10 Million
Construction Management	6%		$5,370,561		$322,234	USEPA 2000 Document, $2-10 Million
	Integrating Contractor Total				**$1,021,000**	
Total Estimated Capital Cost - EISB Treatment Zone					**$6,391,561**	
Total Estimated Capital Cost for MNA and LUCs (Same as MNA & LUCs for Northern Seep Area)					**$48,090**	(includes PM, Design, CM)
ANNUAL OPERATIONS AND MAINTENANCE COST						
FIELD SUBCONTRACTOR						
Annual Land Use Monitoring and Reporting	1	EA	$10,000	16.57%	$11,657	Based on project similar in nature
SAMPLING AND REPORTING						
Labor, per diem Travel	44	Samples	$196	16.57%	$10,053	Based on current sub rates
Analytical Costs and Data Validation	2	EVENT	$35,349		$70,698	See ERD Monitor North WS
Annual Report	1	EVENT	$20,000	16.57%	$23,314	Based on similar project
SUBTOTAL INSPECTION AND SAMPLING					**$115,722**	Based on ERDSouthMonit Worksheet
Recondition Injection Wells	10	EA	$1,200	16.57%	$13,988	Assumes 5 year reconditioning schedule. Engineer Estimate based on Jacobs project experience. 20% productivity factor. Adjusted to annual cost.
ERD Treatment Reagents	1	LS	$35,088	16.57%	$40,902	From ERDTreatReagNorth Worksheet - assume one-third required annually
EVO Injection Crew	30	days	$1,628	16.57%	$56,933	Self Perform: 3 operators, 10 hours/day, $125/hr; assumes annual reinjections
SUBTOTAL INJECTIONS					**$111,823**	
	Subcontractor Subtotal				**$227,545**	
INTEGRATING CONTRACTOR						
Project Management (EISB Treatment Zone)	8%		$111,823		$8,946	USEPA, 2000 $100K - $500K
Project Management (MNA & LUCs)	10%		$115,722		$11,572	USEPA, 2000 < $100K
	Integrating Contractor Total				**$20,518**	
Total Annual O&M Cost					**$248,064**	

Spreadsheet 21: Alternative SP-3 - Enhanced In-Situ Bioremediation (EISB), MNA, and LUCs in Northern Seep Area
Alternative Cost Estimate
SSFL

Site: North Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope:

Enhanced In Situ Biological Reduction of Groundwater Upgradient of Seeps

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	TOR	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	
CAPITAL COST (MNA & LUCs)	0	$48,090	1.00	$48,090	
CAPITAL COST (EISB TREATMENT ZONE)	0	$6,391,561	1.00	$6,391,561	
O&M COST (MNA & LUCs)	10	$127,295	8.98	$1,143,500	10 years MNA & LUCs
O&M COST (EISB TREATMENT ZONE)	10	$120,769	8.98	$1,084,900	10 years active treatment assumed
TOTAL PRESENT VALUE FOR EVO				**$8,668,051**	

Spreadsheet 22: Alternative SP-3 - Enhanced In-Situ Bioremediation (EISB), MNA, and LUCs in Southern Seep Area
Alternative Cost Estimates
SSFL
Site: SSFL, South Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope:
Enhanced In Situ Biological Reduction of Groundwater Upgradient of Seeps

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
CAPITAL COSTS - UTILIZES EXISTING WELLS						
FIELD SUBCONTRACTOR						
EVO Injection Costs - Initial						
Injection Trailer	1	EA	$16,460.00	16.57%	$19,187	Engineer Estimate based on Jacobs Project Experience. 9.75% Sales Tax
ERD Treatment Reagents	1	LS	$1,280.23	16.57%	$1,492	From ERDTreatReagSouth Worksheet
Operator	5	days	$1,628.00	16.57%	$9,489	Based on ND-136 EISB Pilot Quote
Subtotal					**$30,169**	
SAMPLING AND REPORTING						
Labor, per diem Travel	22	Samples	$119	16.57%	$3,052	Based on per sample rate
Analytical Costs and Data Validation	2	EVENT	$17,675		$35,349	Includes Data Validation, See ERD South Monitor Worksheet
Annual Report	1	EVENT	$20,000	16.57%	$23,314	Based on project similar in nature
Sampling and Reporting Subtotal					**$61,715**	
Capital SubTotal					**$91,884**	
Contingency	25%		$91,884		**$22,971**	USEPA 2000 Document - A Guide to Developing and Documenting Cost Estimates, 10% Scope + 15% Bid
Subcontractor Total					**$114,854**	
INTEGRATING CONTRACTOR						
Permitting	1	LS	$25,000	16.57%	$29,143	Assumed (includes WDR)
Project Management	8%		$114,854		$9,190	USEPA, 2000, $100K - $500K
Construction Management	10%		$114,854		$11,490	USEPA, 2000, $100K - $500K
Integrating Contractor Total					**$50,000**	
DESIGN CONTRACTOR						
Design	15%		$114,854		$17,228.17	USEPA 2000, p. 5-13, < $100K
Design Contractor Total					**$18,000**	
Total Estimated Capital Cost					**$182,854**	
MNA and LUCs Plans (Same and Alternative SP-1 for Southern Area)					**$48,090**	**(includes design, CM, PM, and contingency)**

Spreadsheet 22: Alternative SP-3 - Enhanced In-Situ Bioremediation (EISB), MNA, and LUCs in Southern Seep Area

Alternative Cost Estimates
SSFL

Site: SSFL, South Seep Area
Phase: Concept Screening Level Costs (AACE Level 5, Accuracy -30% / +50%)

WORK STATEMENT
Scope:
Enhanced In Situ Biological Reduction of Groundwater Upgradient of Seeps

Description	Qty	Unit	Unit Cost	Escalation	Total	Assumptions/Notes
ANNUAL OPERATIONS AND MAINTENANCE COST						
FIELD SUBCONTRACTOR						
Annual Land Use Monitoring and Reporting	1	EA	$5,000	16.57%	$5,829	Based on project similar in nature.
SAMPLING AND REPORTING						
Labor, per diem Travel	22	Samples	$196	16.57%	$5,026	Based on current sub rates
Analytical Costs and Data Validation	2	EVENT	$17,675		$35,349	Includes Data Validation, See ERD South Monitor Worksheet
Annual Report	1	EVENT	$10,000	16.57%	$11,657	Based on project similar in nature
SUBTOTAL INSPECTION AND SAMPLING					**$57,861**	Based on ERDSouthMonit Worksheet
Recondition Injection Wells	2	EA	$1,200	16.57%	$2,798	Assumes 5 year reconditioning schedule. Engineer Estimate based on Jacobs project experience. 20% productivity factor. Adjusted to annual cost.
ERD Treatment Reagents	1	LS	$1,280	16.57%	$1,492	From ERDTreatReagSouth Worksheet
EVO Injection Crew	5	days	$1,628	16.57%	$9,489	Self Perform: 3 operators, 12 hours/day, $125/hr; assumes annual reinjections.
SUBTOTAL INJECTIONS					**$13,779**	
	Subcontractor Total				**$71,640**	
INTEGRATING CONTRACTOR						
Project Management (EISB Treatment Zone)	10%		$13,779		$1,378	USEPA 2000 Document, p. 5-13, < $100K
Project Management (MNA & LUCs)	10%		$57,861		$5,786	USEPA 2000 Document, p. 5-13, < $100K
	Integrating Contractor Total				**$2,000**	
Total Annual O&M Cost					**$73,640.01**	

PRESENT VALUE ANALYSIS

Discount Rate 2%

COST TYPE	TOR	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	
CAPITAL COST (ERD Treatment Zone)	0	$182,854	1.00	$182,854	
Capital Cost (MNA & LUCs)	0	$48,090	1.00	$48,090	
O&M COST (EISB Treatment Zone)	10	$15,157	8.98	$137,000	10 years active treatment assumed
O&M COST (MNA & LUCs)	10	$63,647	8.98	$572,000	10 years MNA & LUCs
TOTAL PRESENT VALUE FOR EVO				**$939,944**	

Spreadsheet 23: ERD Treatment Reagents for Northern Seep Area

		Northern Seep Area		
		Value	Unit	Notes/Assumptions
Aquifer Dimensions				
Vertical Injection Interval	*z*	185	ft	Average of 220 ft (ELV transect) and 150 ft (B204 transect)
Lateral Injection Length	*L*	50	ft	Per well, ROI assumed to be 25 ft
Lateral Injection Width	*W*	50	ft	
Estimated Mobile Porosity[1]	Φ	0.008		Fractured bedrock (Appendix C, GW CMS)
Injectate Volume (Total Pore Volume)	V_{pore}	6,919	gallons	$V_{pore} = z \times pr^2 \times \Phi * 7.48$
Number of Injection wells	#	10	wells	Number of Injection Wells
Substrate Injectate Specifications				
Diluted EVO Concentration	C_{DIL}	5	%	Recommended EVO dilution to 2 - 5%, higher for direct injection
Bulk EVO	C_{BULK}	60	%	Typical purchased bulk concentration
EVO Specifications				
Volume Bulk EVO Substrate (as 60% EVO)[2]	V_{BULK}	5,766	gallons	$V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}$
EVO Approximate Density	ρ_{EVO}	8.00	lbs/gallon	
Mass Bulk EVO Substrate (as 60% EVO)	$m_{EVOtotal}$	46,127	lbs	$m_{EVOtotal} = \rho_{EVO} * V_{BULK}$
Bioaugmentation Culture Specifications				
Bulk Amendment Concentration	$C_{biobulk}$	1.0E+11	cells/liter	
Final Target Amendment Concentration	C_{bio}	1.0E+06	cells/liter	
Minimum Volume (Total)	$V_{biomintotal}$	2.62	liters	$V_{biomintotal} = V_{pre} * C_{bio} / C_{biobulk} * 3.785$
Safety Factor	SF_{bio}	10		
Recommended Volume (Total)	$V_{biototal}$	26.2	liters	$V_{biotal} = SF_{bio} * V_{biomintotal}$
Anaerobic Chase Water Volume (Total)		5,000	gallons	
Anaerobic Chase Water Volume (Per Injection Well)		500	gallons	
Mass of Sodium Ascorbate @300 mg/L[d]	$V_{biowell}$	12.5	lbs	$V_{biowell} = V_{biominwell} * 1.25$
Mass of Sodium Ascorbate @300 mg/L[d] (Per Injection W		1.3	lbs	
Additional Injectate Materials				
Mass of Bicarbonate @ 600 mg/L[3]	m_{CO3}	346	lbs	$m_{CO3} = 600 * (3.785/1000/ 453.59) * V_{total}$
Mass of Sodium Ascorbate @ 300 mg/L[4]	$V_{biowell}$	173	lbs	$V_{biowell} = V_{biominwell} * 1.25$
Dilution Water Volume (Total)	$V_{H2Ototal}$	63,424	gallons	$V_{H2Ototal} = V_{total} - V_{BULK}$

Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk EVO Substrate (as 60% EVO)[5]	17	$/gallon	$ 98,019	Price based on quote for Terra Systems product 60% SRS®-FRL, plus shipping.
Cost for Bicarbonate	0.80	$/lb	$ 277	Price based on quote from TerraSystems, plus shipping.
Cost for Bulk Bioaugmentation Culture	147	$/L	$ 3,850	Quote from TerraSystems, plus shipping.
Cost for Sodium Ascorbate	18	$/lb	$ 3,118	Quote from TerraSystems, plus shipping.
		TOTAL A:	$ 105,264	

Total Substrate Cost:
$ 105,264

Notes:

[1]Fractured bedrock with low open fracture volume

[2]Assumes nutrient package will be added (lactate, vitamin B12, etc.)

[3]Sodium bicarbonate dosage recommended for aquifers with pH 5 to 6

[4]Or similar compound for production of anaerobic chase water

[5]60% SRS®-FRL EVO contains 4% sodium lactate; proprietary nutrient package containing yeast extracts, nitrogen and phosphorus, and Vitamin B12.

Spreadsheet 24: ERD Treatment Reagents for Southern Seep Area

		Southern Seep Area		
		Value	**Unit**	Notes/Assumptions
Aquifer Dimensions				
Vertical Injection Interval	*z*	25	ft	Depth 20 to 45
Lateral Injection Length	*L*	30	ft	Per well, ROI assumed to be 15 ft
Lateral Injection Width	*W*	30	ft	
Estimated Mobile Porosity[1]	Φ	0.020		Fractured bedrock (Appendix C, GW CMS)
Injectate Volume (Total Pore Volume)	V_{pore}	842	gallons	V_{pore} = z x pr^2 x Φ * 7.48
Number of Injection Wells	#	1	wells	ROI = 25 ft
Substrate Injectate Specifications				
Diluted EVO Concentration	C_{DIL}	5	%	Recommended EVO dilution to 2 - 5%, higher for direct injection
Bulk EVO	C_{BULK}	60	%	Typical purchased bulk concentration
EVO Specifications				
Volume Bulk EVO Substrate (as 60% EVO)[2]	V_{BULK}	70	gallons	$V_{BULK} = C_{DIL} * V_{pore} / C_{BULK}$
EVO Approximate Density	ρ_{EVO}	8.00	lbs/gallon	
Mass Bulk EVO Substrate (as 60% EVO)	$m_{EVOtotal}$	561	lbs	$m_{EVOtotal} = \rho_{EVO} * V_{BULK}$
Bioaugmentation Culture Specifications				
Bulk Amendment Concentration	$C_{biobulk}$	1.0E+11	cells/liter	
Final Target Amendment Concentration	C_{bio}	1.0E+06	cells/liter	
Minimum Volume (Total)	$V_{biomintotal}$	0.03	liters	$V_{biomintotal} = V_{pre} * C_{bio} / C_{biobulk} * 3.785$
Safety Factor	SF_{bio}	10		
Recommended Volume (Total)	$V_{biototal}$	0.3	liters	$V_{biotal} = SF_{bio} * V_{biomintotal}$
Additional Injectate Materials				
Mass of Bicarbonate @ 600 mg/L[3]	m_{CO3}	4	lbs	m_{CO3} = 600 * (3.785/1000/ 453.59) * V_{total}
Mass of Sodium Ascorbate @ 300 mg/L[4]	$V_{biowell}$	2	lbs	$V_{biowell} = V_{biominwell} * 1.25$
Dilution Water Volume (Total)	$V_{H2Ototal}$	771	gallons	$V_{H2Ototal} = V_{total} - V_{BULK}$

Estimated Substrate Cost	**Unit Cost**	**Unit**	**Cost**	**Comments**
Cost for Bulk EVO Substrate (as 60% EVO)[5]	17	$/gallon	$ 1,192	Price based on quote for Terra Systems product 60% SRS®-FRL, plus shipping.
Cost for Bicarbonate	0.8	$/lb	$ 3	Price based on quote from TerraSystems, plus shipping.
Cost for Bulk Bioaugmentation Culture	147	$/L	$ 47	Quote from TerraSystems, plus shipping.
Cost for Sodium Ascorbate	18	$/lb	$ 38	Quote from TerraSystems, plus shipping.
		TOTAL A:	**$ 1,280**	

Total Substrate Cost:	
$	**1,280**

Notes:

[1]Fractured bedrock with low open fracture volume

[2]Assumes nutrient package will be added (lactate, vitamin B12, etc.)

[3]Sodium bicarbonate dosage recommended for aquifers with pH 5 to 6

[4]Or similar compound for production of anaerobic chase water

[5]60% SRS®-FRL EVO contains 4% sodium lactate; proprietary nutrient package containing yeast extracts, nitrogen and phosphorus, and Vitamin B12.

Spreadsheet 25: Laboratory Services - Analytical Costs - Monitoring for ERD North System

Analysis	Sample Counts 1 (Per Semiannual Event)	# of Events	Method	Unit Cost	Data Validation	Estimated Costs	Notes
VOCs	22		SW8260B	$70	$22	$2,016	Total Samples in below + 2 TB, 1FD, 1 MS/MSD
1,4-D	22			$125	$15	$3,080	
NDMA	22			$150	$15	$3,630	
Anions (Nitrate, Sulfate)	22		300	$80	$15	$2,090	
Alkalinity as	22		SM2320B	$20	$15	$770	
Manganese (dissolved)	22		SW6010B or 6020	$70	$15	$1,870	
Iron (dissolved) - with MN	22		SM3500Fe-D	$0	$15	$330	
Sulfide	22		376.2	$36	$15	$1,122	
Total Organic Carbon	22		SW9060 or SM5310	$35	$15	$1,100	
Methane, Ethane, Ethene	22		RSK-175	$70	$15	$1,870	
TDS	22			$20	$15	$770	
CSIA	11		in house	$602	$9	$6,721	
Volatile Fatty acids (or metabolic acids)	11		In house	$125	$9	$1,470	Assume annual
QuantArray-Chlor (DNA)	11		In house	$765	$9	$8,510	Assume annual
Total for ERD						**$35,349**	
Total for Hydraulic Control						**$4216**	Includes only VOC, Mn, and Fe

Samples assumed:	Samples	
ND-123	4	ports
ND-127	1	
PZ-144	1	
ND-56A	2	ports
ND-122 (port 2)	1	
ND-124 (port 4)	1	
SP29 (A, B, C)	3	
SP33 (A, B, C)	3	
RD-68A/B	2	
Total Samples	**18**	

Spreadsheet 26: Laboratory Services - Analytical Costs - Monitoring for ERD South System

Analysis	Sample Counts 1 (Per Semiannual Event)	# of Events	Method	Unit Cost	Data Validation	Estimated Cost	Notes
VOCs	11		SW8260B	$70	$22	$1,008	Total Samples in below + 1 TB, 1FD, 1 MS/MSD
1,4-D	11			$125	$15	$1,540	
NDMA	11			$150	$15	$1,815	
Anions (Nitrate, Sulfate)	11		300	$80	$15	$1,045	
Alkalinity as	11		SM2320B	$20	$15	$385	
Manganese (dissolved)	11		SW6010B or 6020	$70	$15	$935	
Iron (dissolved) - with MN	11		SM3500Fe-D	$0	$15	$165	
Sulfide	11		376.2	$36	$15	$561	
Total Organic Carbon	11		SW9060 or SM5310	$35	$15	$550	
Methane, Ethane, Ethene	11		RSK-175	$70	$15	$935	
TDS	11			$20	$15	$385	
CSIA	6		in house	$602	$9	$3,361	
Volatile Fatty acids (or metabolic acids)	6		In house	$125	$9	$735	assume annual
QuantArray-Chlor (DNA)	6		In house	$765	$9	$4,255	assume annual
Total For ERD						**$17,675**	
Total for Hydraulic Control						**$2108**	Includes only VOC, Mn, and Fe

Field Monitoring Labor

Samples assumed:	Samples
ND-138A	1
ND-138B	1
Sp-882	1
Sp-881C	1
SP-881G	1
SP-890C	1
SP-890G	1
WS-09A	1
Total Samples	**8**

Spreadsheet 27: Present Value Schedule

Discount rate 2%

Years	NPV ($1)	Total
0	0	
1	0.980392157	0.980392157
2	0.961168781	1.941560938
3	0.942322335	2.883883273
4	0.923845426	3.807728699
5	0.90573081	4.713459509
6	0.887971382	5.601430891
7	0.870560179	6.471991069
8	0.853490371	7.32548144
9	0.836755266	8.162236706
10	0.8203483	8.982585006
11	0.804263039	9.786848045
12	0.788493176	10.57534122
13	0.773032525	11.34837375
14	0.757875025	12.10624877
15	0.74301473	12.8492635
16	0.728445814	13.57770931
17	0.714162562	14.29187188
18	0.700159375	14.99203125
19	0.68643076	15.67846201
20	0.672971333	16.35143334
21	0.659775817	17.01120916
22	0.646839036	17.6580482
23	0.634155918	18.29220412
24	0.621721488	18.9139256
25	0.609530871	19.52345647
26	0.597579285	20.12103576
27	0.585862044	20.7068978
28	0.574374553	21.28127236
29	0.563112307	21.84438466
30	0.552070889	22.39645555

2020Q3	1171
2023Q2	1365
Escalation	16.57%

from: Turner Building Cost Index

https://www.turnerconstruction.com/cost-index

Spreadsheet 28: EPA Recommendations for Cost Loading Factors, From EPA 2000 FS Cost Estimating Guide

Capital Cost Element	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	> $10M (%)
Project Management	10%	8%	6%	5%	5%
Remedial Design	20%	15%	12%	8%	6%
Construction Management	15%	10%	8%	6%	6%

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Appendix H
ND-138A Optimization Modeling Analysis

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Memorandum

Subject	**ND-138A Optimization Modeling Analysis**
Project Name	Santa Susana Field Laboratory (SSFL), Ventura County, California
Attention	Peter Zorba National Aeronautics and Space Administration (NASA)
From	CH2M HILL, Inc.
Date	November 21, 2022

1. Introduction

The purpose of this technical memorandum is to document the approach to and results of a numerical modeling analysis performed to provide guidance on operation of well ND-138A with regard to seep management. NASA and The Boeing Company (Boeing) are required to manage contaminated groundwater discharging to seep pools within the Southwestern Drainage (also known as Bell Canyon) (Figure 1). Seep management activities generally are performed during the spring and summer when standing water is present in the seep pools, but flow in the stream is low enough that the pools are discontinuous features (not included in the overall main stream flow). Seep management activities performed by NASA and Boeing on alternating months consist of manually dewatering the FDP-881, FDP-882, and FDP-890 seep pools (as necessary) via vacuum truck and offsite disposal. The California Department of Toxic Substances Control (DTSC) has indicated to NASA and Boeing that pumping ND-138A can serve as the method of interim seep control, such that direct manual pumping of the seep pools is not needed (DTSC 2020).

To optimize future ND-138A operations for seep control, the NASA team plans to perform an optimization pilot study of ND-138A associated with the Groundwater Extraction and Treatment System (GETS) seep-control pumping effort, as documented in *ND-138A Optimization Testing Plan* (NASA 2022a). The objective of the optimization pilot study is to identify the lowest effective pumping rate that would achieve hydraulic capture of groundwater in the vicinity of the SP-890 seep well cluster. The ND-138A optimization in-field pilot testing has been postponed because of the following factors related to recent climatic conditions:

- The severe nature of the drought conditions in 2021 and 2022 has precluded groundwater pumping in the Southwestern Drainage to avoid impacts to critical vegetation and ecosystems.
- The occurrence of the drought conditions in 2021 and 2022 has eliminated the need for seep control based on a lack of seep discharges.

This technical memorandum documents the analysis of the existing ND-138A GETS operational data to improve the understanding of ND-138A operations on groundwater conditions in the Southwestern Drainage in the southern seep area. The following sections describe the numerical groundwater flow and particle tracking analyses that were performed in support of the optimization analysis. The numerical model used for this analysis was the Coca/Delta Flow and Transport Model (CDFTM) (NASA 2022c). The purpose of this analysis is to identify the lowest pumping rate at ND-138A that achieves the objectives listed in Table 1.

Table 1. Summary of Objectives for the ND-138A Optimization Analysis

Objective	How Achievement of the Objective was Assessed
Influence groundwater levels in SP-890A through SP-890G.	Graphically evaluating whether particles starting in the SP-890 target capture area discharge to ND-138A using the CDFTM
Minimize discharge of contaminated groundwater to surface water features in the Southwestern Drainage (that is, the FDP-881, FDP-882, and FDP-890 seep pools).	Use the CDFTM to quantify the percentage of particles started in the 2020 TCE plume footprint that discharge to the Southwestern Drainage
Minimize capture of groundwater from the Delta Skim Pond in NASA Area II.	Graphically evaluating whether particles started in the Delta Skim Pond area discharge to ND-138A using the CDFTM
Minimize capture of groundwater from the Boeing STL-IV Area.	Graphically evaluating whether particles started in the STL-IV High TCE Concentration Area discharge to ND-138A using the CDFTM

CDFTM = Coca/Delta Flow and Transport Model
TCE = trichloroethene

2. ND-138A Startup Data Analysis

Intermittent pumping of ND-138A was initiated in June 2020 and continued through early October 2020 (NASA 2021). During this period, ND-138A was pumped at rates of up to 13 gallons per minute (gpm) between 5:00 a.m. and 3:00 p.m. on nonholiday weekdays. During this time, ND-138A operation was limited by Boeing GETS operation, which included operational downtime for upgrades, repairs, and troubleshooting work. In January 2021 and May through June 2021, ND-138A was operated nearly continuously (NASA 2022b). ND-138A was pumped at rates of up to 12 gpm in January and 7 to 9 gpm in May and June. Groundwater levels in a network of surrounding monitoring wells were monitored during both the ND-138A intermittent and continuous pumping periods as part of GETS startup activities (NASA 2021, 2022b). Analysis of the data sets concluded that groundwater levels in wells SP-890B through SP-890G, WS-09A, ND-138B, C-6, and RD-05A exhibited drawdown in groundwater levels in response to pumping at ND-138A. Figure 2 presents plots of groundwater elevations versus time for these locations, as well as the cumulative volume of groundwater extracted from ND-138A.

2.1 Numerical Model Setup for ND-138A Startup Analysis

The ND-138A optimization analysis was performed using the CDFTM. This model is a fully integrated, three-dimensional numerical groundwater flow and solute transport model developed to provide insight into the relevant subsurface parameters and processes that control the persistence and movement of TCE associated with the Coca/Delta Area of Impacted Groundwater. The CDFTM domain includes an area of 787 acres (1.2 square miles) in the southern portion of NASA Area II (Figure 3). The CDFTM was constructed to simulate groundwater flow and solute transport using the MODFLOW-USG code (Panday et al. 2013; Panday 2021). The mesh consists of 6,952 Voronoi cells in each of the 37 model layers. Details regarding the construction, calibration, and application of the CDFTM are presented in *Numerical Groundwater Model Documentation for the Coca/Delta Area of Impacted Groundwater* (NASA 2022c).

The CDFTM base model is calibrated to steady-state 2016 hydraulic conditions. The first step in the ND-138A startup analysis was to modify the CDFTM from a steady state to a transient simulation. Based on nearly continuous operation of ND-138A in 2021, a transient simulation period of January 7 through December 1, 2021, was selected. The transient simulation period was discretized into 16 stress periods based on the measured ND-138A pumping rates and operational schedule. Table 2 presents the start and end dates, the number of time steps, and the ND-138A pumping rate for each stress period. The pumping rates included in Table 2 represent the average pumping rate measured during each stress period.

Table 2. Summary of Transient Simulation of ND-138A Startup

Stress Period	Start Date	End Date	Number of Time Steps	Pumping Rate (gpm)	Pumping Rate (m^3/day)
1	1/7/2021	1/18/2021	11	11.5	62.7
2	1/18/2021	1/21/2021	3	0.0	0.0
3	1/21/2021	2/3/2021	13	11.1	60.5
4	2/3/2021	4/20/2021	77	0.0	0.0
5	4/20/2021	4/22/2021	1	9.9	53.9
6	4/22/2021	5/3/2021	11	0.0	0.0
7	5/3/2021	5/27/2021	24	9.9	54.2
8	5/27/2021	6/7/2021	12	6.0	32.5
9	6/7/2021	6/10/2021	3	9.2	50.0
10	6/10/2021	6/14/2021	3	0.0	0.0
11	6/14/2021	6/18/2021	5	6.7	36.4
12	6/18/2021	6/21/2021	2	0.0	0.0
13	6/21/2021	6/23/2021	2	5.7	30.9
14	6/23/2021	6/25/2021	2	0.0	0.0
15	6/25/2021	7/1/2021	6	6.2	33.7
16	7/1/2021	12/1/2021	153	0.0	0.0

gpm = gallon(s) per minute
m^3/day = cubic meter(s) per day

The measured pumping rates were assigned to the CDFTM Voronoi cell associated with the ND-138A well location. Long-screen or long-open borehole wells that cross multiple CDFTM layers are simulated using the connected linear network (CLN) MODFLOW package (NASA 2022c). In the case of the pumping rate, the CLN package allows the simulation to automatically scale the pumping rate (if necessary) to account for partial penetration effects as the simulated pumping water levels in the CLN decline or if model layers become dewatered.

2.2 Approach to Transient Calibration

Model calibration is a process of tuning a numerical model to simulate observed subsurface flow conditions in the field (as described with measured data) to within a reasonable degree of accuracy. The first step in the calibration process was to select calibration targets. The observed drawdown and recovery responses in monitoring wells that were identified as responding to ND-138A pumping were used in the analysis as calibration targets for the ND-138A startup simulation.

As previously discussed, well locations identified as responding to ND-138A startup pumping include C-6, ND-138B, RD-05A, SP-890B through SP-890G, and WS-09A. Although well ND-138B showed response to ND-138A pumping, it is located within the same Voronoi cell as WS-09A; therefore, the duplicitous data were excluded as calibration targets. Additionally, wells SP-890B through SP-890D are located in the same Voronoi cell and CDFTM model layer; therefore, only SP-890D data were used in the current analysis. As shown on the hydrographs plotted on Figure 2, there was an antecedent decline in groundwater levels during the startup monitoring period. Series SEE software (USGS 2012) was used to remove the antecedent groundwater-level trends and responses to barometric fluctuations from the groundwater-level data sets. This processing was intended to improve the signal-to-noise ratio in the calibration data sets such that the primary stressor resulting in the observed groundwater-level responses was pumping at ND-138A. Additional calibration targets for select locations identified as not responding to ND-138A pumping were included as "one-sided targets." That is, they were assigned as observations of zero drawdown throughout the simulation period. These include ND-117, RD-05B, SP-881C, SP-881G, SP-882C, and SP-882G. These locations were selected for inclusion in the calibration effort because they are located in key areas near the seep pools on the southern side of the Burro Flats Fault Zone (SP-881 and SP-882 wells) and are located relatively close to ND-138A but showed no response (ND-117) and are located in a well cluster where another location responded to pumping (RD-05B). Drawdown targets were assigned spatially to the Voronoi cell associated with each monitoring well and vertically to the model layer encompassing the screen or open borehole interval of the well. For wells where the screen or open interval crossed multiple layers, the target was simulated using the CLN package. The modeled drawdown at CLNs represents a resolved drawdown inside the CLN (that is, in the well) calculated based on simulated heads and flow interactions with the model layers over which the well is screened or open.

A manual calibration approach was implemented whereby aquifer parameter values were adjusted within ranges the technical team deemed reasonable, until there was adequate consistency between modeled and target drawdown values. Model parameters adjusted during model calibration include horizontal and vertical hydraulic conductivity, specific storage, and specific yield. Calibration generally proceeded as follows:

- The transient simulation was performed at the ND-138A pumping rates listed in Table 2.
- The simulated water budget was evaluated to confirm that the assigned ND-138A pumping rates were achieved given the distribution of model parameters.
- The modeled drawdown values for the simulation were plotted against the measured data and were qualitatively evaluated based on the ability of the model to replicate the timing and magnitude of drawdown responses.
- If improvements to the simulated drawdown responses were deemed necessary, based on professional judgement, a new suite of aquifer parameters were developed, and the next transient simulation was performed.

Because the CDFTM was previously calibrated to steady-state conditions, aquifer storage properties were not part of the model construction and calibration. Because the steady-state calibration of the CDFTM was deemed appropriate, priority was given to adjusting simulated storage properties rather than hydraulic conductivity, where possible. The iterative calibration process continued until adequate agreement between modeled and observed drawdown responses was achieved.

2.3 Calibration Results

Figures 4a and 4b present the final modeled and observed change in groundwater-level responses for the ND-138A startup simulation. Change in groundwater levels were computed as each measured or modeled groundwater elevation value minus the static groundwater elevation prior to the onset of ND-138A pumping. As such, negative values on Figures 4a and 4b represent modeled or measured groundwater elevations that are lower than the static groundwater elevation, whereas positive values on Figures 4a and 4b represent modeled or measured groundwater elevations that are higher than the initial groundwater elevation. As indicated by the similarity between the simulated and measured drawdown data, the CDFTM is able to replicate both the timing and magnitude of drawdown responses at C-6. The plots on Figure 4a indicate that the CDFTM is able to replicate the timing and magnitude of the drawdown in response to January and May-June pumping periods at WS-09A, SP-890D, and SP-890G; however, the fit to the recovery data was slightly poorer (that is, the measured groundwater levels recovered more quickly and there was a larger-magnitude recovery than simulated). Better fits to both the drawdown and recovery data at these wells were possible assuming lower hydraulic conductivity values in the Burro Flats Fault Zone; however, these less-permeable values resulted in ND-138A not being able to produce the measured pumping rates. Because that simulation was not able to replicate a key piece of the ND-138A startup data set (the measured pumping rate), this suite of model parameters was not retained. The CDFTM simulates the general decline in groundwater at RD-05A, but is not able to replicate the observed drawdown and recovery responses between ND-138A pumping periods. The measured response at RD-05A is somewhat anomalous, given its distance from ND-138A (approximately 2,100 feet). It is hypothesized that its anomalous behavior results from geologic structures that exist at a scale finer than can be simulated with the CDFTM. The plots on Figures 4a and 4b demonstrate that the CDFTM also is able to adequately replicate the one-sided (that is, zero drawdown) targets at ND-117, RD-05B, SP-881C, SP-881G, SP-882C, and SP-882G.

The final modeled drawdown responses were achieved through adjustment to the aquifer storage properties with no change to the original CDFTM hydraulic conductivity distribution. Figure 5 presents plan-view maps of the existing horizontal hydraulic conductivity distributions for model layers corresponding to the SP-890B through SP-890D depths (Model Layer 2), the mid-plume depth in the Southwestern Drainage area (that is, mid-depth between the SP-890A through SP-890D and SP-890G screen intervals, Model Layer 10), and the model layer corresponding to the SP-890G depth (Model Layer 20). A more comprehensive and three-dimensional representation of the horizontal and vertical distribution of hydraulic conductivity in the CDFTM can be found in *Numerical Groundwater Model Documentation for the Coca/Delta Area of Impacted Groundwater* (NASA 2022c). Figure 6 presents the final distribution of specific yield and specific storage. Because the model layers in the CDFTM are "convertible" (that is, the transmissivity and storage properties vary with saturated thickness as simulated groundwater levels rise or fall), specific yield and specific storage values require assignment in each model layer. Two specific yield zones were assigned to the model layers associated with the SP-890A through SP-890G well screens (Model Layers 1 through 20). A zone of 2% specific yield was assigned to the damaged zone between the north and south traces of the Burro Flats Fault (coincident with the higher horizontal hydraulic conductivity zone shown on Figure 5). The remainder of the model domain, as well as the deeper model layers, were assigned specific yield of 1%. As shown on Figure 6, a specific storage value of 5×10^{-7} per meter (m^{-1}) was assigned to the entire model domain.

The distribution of final hydraulic parameters and the fits between simulated and measured groundwater drawdown and recovery responses presented on Figures 4 through 6 were considered adequate for the ND-138A optimization analysis.

3. ND-138A Optimization Analysis

Following transient calibration of the CDFTM to ND-138A startup conditions, a series of projection model simulations were performed to evaluate the lowest pumping rate at which ND-138A could be operated to achieve the objectives listed in Table 1.

3.1 Numerical Model Setup for ND-138A Optimization Analysis

The approach to the optimization analysis was to simulate ND-138A pumping at a range of flow rates for a period of 6 months and evaluate the model-generated output at the end of the simulation against the optimization objectives in Table 1. A 6-month simulation period (as opposed to a longer-term or steady-state simulation) was considered appropriate, because ND-138A operates seasonally (as needed) for seep management in the Southwestern Drainage. Constant pumping rates ranging from 1 to 10 gpm were assigned to the Voronoi cell corresponding to the ND-138A well location and a 6-month transient CDFTM simulation was performed using the specific yield and specific storage distributions described in Section 2.3. The upper end of the optimization pumping rates (10 gpm) was selected because it represents the approximate limit of the ND-138A pipeline conveyance capacity.

The objectives listed in Table 1 were evaluated using particle tracking analysis for each pumping rate simulation. Particles were started at the center (laterally and vertically) of each Voronoi cell within the inferred 2020 TCE plume footprint at three depth zones: the interval corresponding to the SP-890B through SP-890D screen depths (Model Layer 2), the mid-plume depth (representing the mid-depth between the SP-890B through SP-890D and SP-890G screen intervals, Model Layer 10), and the SP-890G depth interval (Model Layer 20). Particles were started at the beginning of the simulation period and tracked forward to their respective discharge location or for a maximum travel time of 6 months, whichever occurred first. Particle tracking was performed using the mod-PATH3DU code (SSPA 2017), assuming an effective porosity of 1%. Previous studies at SSFL have reported a total porosity of approximately 14% and a fracture porosity of 0.01% (MWH 2009). The effective porosity of 1% was considered a reasonable value because it is between these two end-member porosities (total porosity and fracture porosity) and because, given the heavily sheared nature of the Burro Flats Fault Zone, it is unlikely that advective flow will be restricted to the fracture network or be able to flow effectively through all of the pore space in the bedrock matrix.

3.2 ND-138A Optimization Analysis Results

The ability of ND-138A operations to achieve the objectives listed in Table 1 was evaluated through particle tracking analysis as follows:

- The ability of ND-138A to capture groundwater in the SP-890 well cluster was assessed by graphically evaluating whether particles started in the SP-890 target capture area discharge to ND-138A.
- Minimizing discharge of contaminated groundwater to surface water features in the Southwestern Drainage was evaluated by quantifying the percentage of particles started in the 2020 TCE plume footprint (that is, contaminated groundwater) that discharge to the Southwestern Drainage.
- Minimizing capture of groundwater from the Delta Skim Pond was assessed by graphically evaluating whether particles started in the Delta Skim Pond area discharge to ND-138A.
- Minimizing capture of groundwater from the STL-IV Area was assessed by graphically evaluating whether particles started in STL-IV High TCE Concentration Area discharge to ND-138A. This represents the northern portion of the STL-IV area where TCE concentrations in groundwater are generally higher than 500 micrograms per liter.

Figures 7 through 9 present the 6-month ND-138A capture zones for the 2 gpm, 5 gpm, and 10 gpm optimization simulations, respectively. These simulations were selected because they provide a reasonable range of results. Each figure presents the SP-890 target capture area (green rectangle within the Burro Flats Fault Zone), the Delta Skim Pond (blue and brown hatched RCRA-regulated unit), the STL-IV High TCE Concentration Area (dark blue polygon in the northern portion of STL-IV in SSFL Area III), and the simulated extent of ND-138A capture (magenta circles). As previously described, particles were started at all Voronoi cells within the 2020 TCE plume footprint in Model Layers 2, 10, and 20 and tracked forward in time. The starting locations of particles that ultimately discharge to (are captured by) ND-138A are symbolized as the magenta circles. Other particle starting locations within the plume footprint (not shown on Figures 7 through 9) discharge to other CDFTM boundary conditions (such as the specified-head boundary cells along the model perimeter or the Southwestern Drainage boundary) or were still in transit and had not yet discharged to their final locations by the end of the 6-month simulation period.

As shown on Figure 7, none of the particles started in the SP-890 target capture area discharged to ND-138A at a pumping rate of 2 gpm. The 5-gpm simulation indicates that there is limited capture of the SP-890 target capture area in the shallow portion of the aquifer system (that is, there are a few particles within the target capture rectangle that discharge to ND-138A) (Figure 8). The extent of capture improves for the mid-plume and SP-890G depth intervals with most particles started in the SP-890 target capture area discharging to ND-138A. There is a slightly larger extent of capture of the SP-890 target capture area with a simulated ND-138A pumping rate of 10 gpm, primarily in the shallower portion of the aquifer (Figure 9). The percentage of particles started in the SP-890 target capture area that ultimately discharge to ND-138A under the various pumping rates is summarized in Table 3. These data confirm the graphical analyses described previously whereby there is no capture of the target area under the 2-gpm simulation and a similar degree of capture under the 5- and 10-gpm simulations.

Table 3. Summary of Particle Tracking Analyses

Simulated Pumping Rate (gpm)	Percentage of Particles Started in Target Areas that are Captured by ND-138A			Percentage of Particles Discharging to the Southwestern Drainage
	SP-890 Target Capture Area	Delta Skim Pond	STL-IV High TCE Concentration Area	
0	0	0	0	22
2	0	0	3	6
5	83	0	12	0.1
10	87	0	44	0

gpm = gallon(s) per minute
TCE = trichloroethene

As shown graphically on Figures 7 through 9 and summarized in Table 3, none of the particles started in the Delta Skim Pond discharge to ND-138A over the range of pumping rates evaluated. Although particles started in the Delta Skim Pond are not captured by ND-138A within the 6-month simulation period, operation of ND-138A may induce additional migration of contaminated groundwater from the area by increasing hydraulic gradients toward the Southwestern Drainage.

As shown graphically on Figures 7 through 9, the extent of capture of particles started in the STL-IV High TCE Concentration Area increases with increasing pumping rate (that is, there are an increasing number of magenta circles in the STL-IV Area between the 2-, 5-, and 10-gpm simulations). This graphical analysis is supported by the data presented in Table 3, where the percentage of particles started in STL-IV that are captured by ND-138A increases from 3% in the 2-gpm simulation to 44% in the 10-gpm simulation. Results of the particle tracking analysis further suggest that a subset of the particles started in the STL-IV High TCE Concentration Area enter the WS-09A borehole and move downward, suggesting that WS-09A acts as a conduit for vertical migration.

The final objective of minimizing the discharge of contaminated groundwater to surface water features in the Southwestern Drainage was evaluated by quantifying the percentage of particles started within the plume footprint that discharge to the Southwestern Drainage under a nonpumping scenario, as compared to the pumping simulations. As shown in Table 3, 22% of the particles started within the plume footprint discharge to the Southwestern Drainage surface water features under the nonpumping scenario. This percentage decreases to 6% with ND-138A pumping at 2 gpm and 0.1% with a pumping rate of 5 gpm. Under the 10-gpm simulation, none of the particles started within the plume footprint discharge to the Southwestern Drainage.

4. Summary and Recommendations

The ND-138A optimization pilot test (NASA 2022a) has been delayed because of extreme drought conditions in California. Collection of groundwater-level monitoring data during ND-138A startup and the recent completion of the construction and calibration of the CDFTM provided an opportunity to perform an analysis of ND-138A pumping rate optimization with existing data and numerical tools. This technical memorandum describes the ND-138A pumping optimization analyses. Groundwater-level and pumping rate data collected during continuous operation of ND-138A in 2021 were used to perform a transient calibration of the existing CDFTM. The recalibrated, transient version of the CDFTM was used to evaluate the lowest pumping rate at ND-138A that best balances the objectives listed in Table 1. It is recommended that, if seep management in the Southwestern Drainage becomes necessary, ND-138A be operated at a pumping rate of 5 gpm, based on the following logic:

- This pumping rate would provide an estimated capture of 83% of the SP-890 target capture area. Doubling the pumping rate to 10 gpm may only provide minimal improvement in capture effectiveness.
- Capture of contaminated groundwater from the Delta Skim Pond with ND-138A pumping 5 gpm is not expected to occur within a 6-month pumping period.
- Although there is a limited extent of capture of contaminated groundwater from the STL-IV High TCE Concentration Area, according to the CDFTM, the extent is less than that estimated at the 10-gpm level. Further, while the 2-gpm pumping rate has a lesser degree of capture of the STL-IV High TCE Concentration Area, it provides no estimated capture of groundwater from the SP-890 area.
- There is minimal estimated discharge of contaminated groundwater to the Southwestern Drainage surface water features at 5 gpm.

Additionally, when climatic conditions are improved such that the ND-138A optimization pilot study can be performed, it is recommended that the testing be performed with ND-138A pumping rates of 2 gpm, 5 gpm, and 10 gpm.

5. References

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Figures

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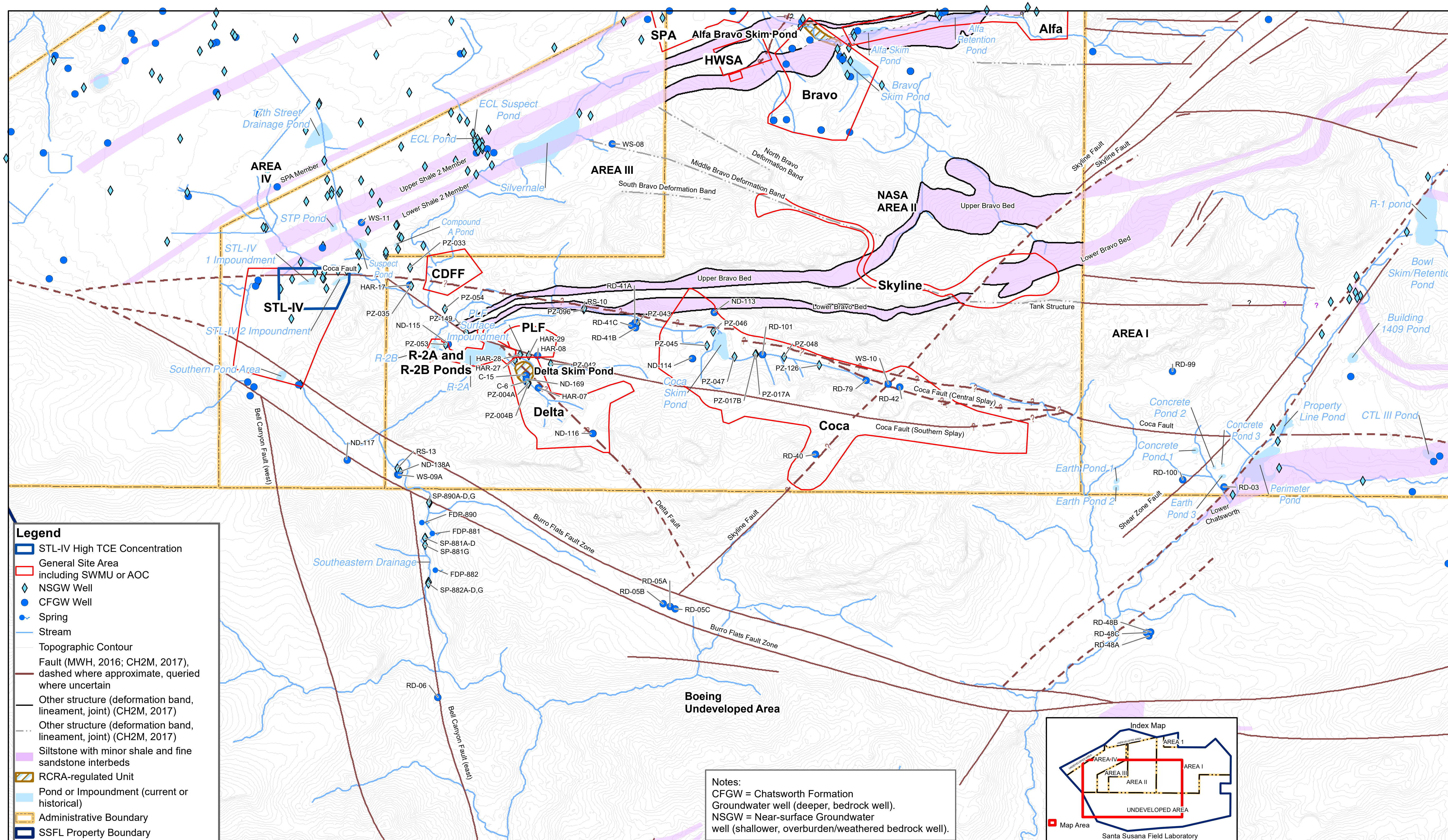
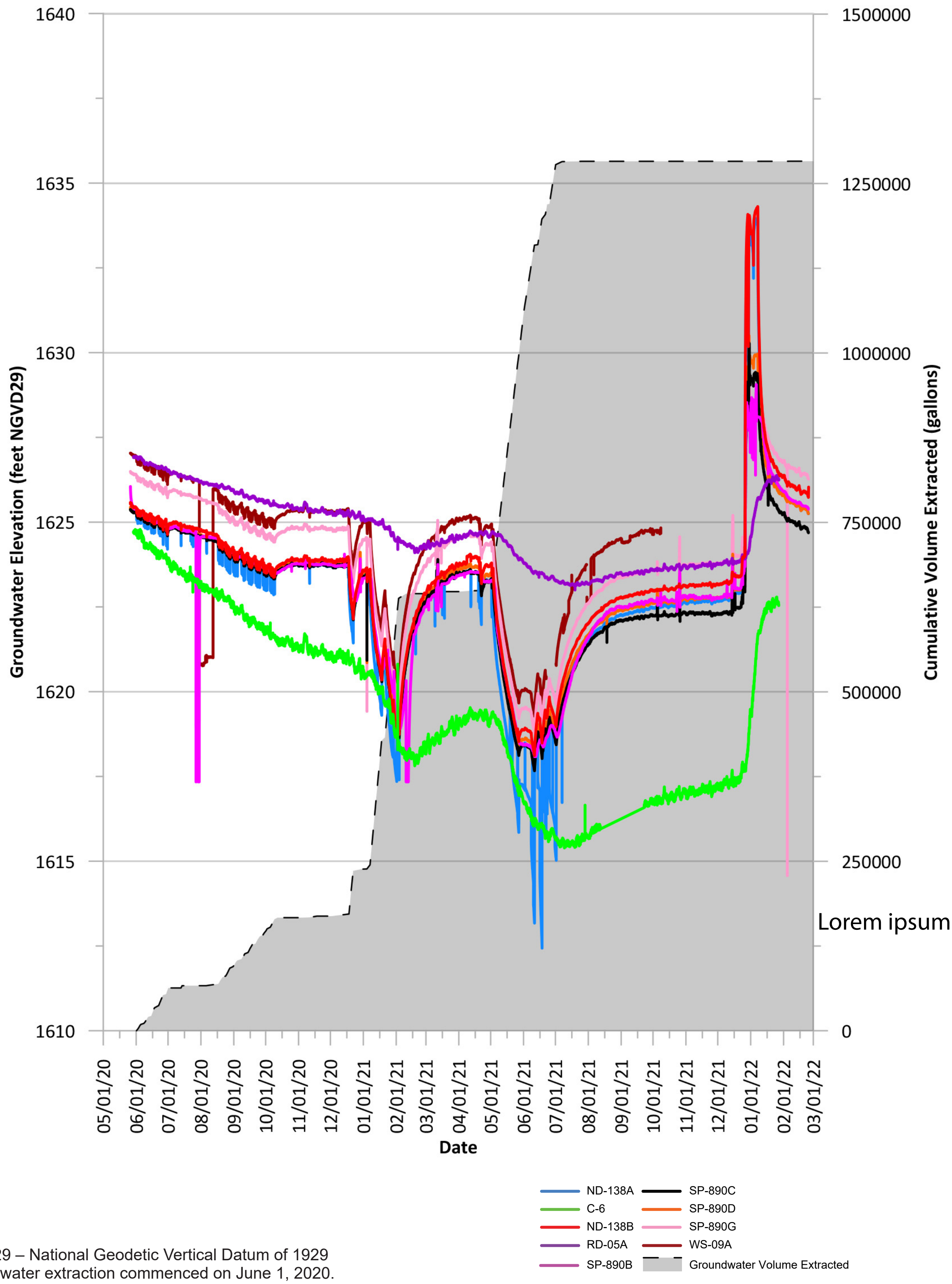


0 250 500 1,000 Feet
0 75 150 300 Meters

15-Nov-2022
Drawn By:
Erin Eppling

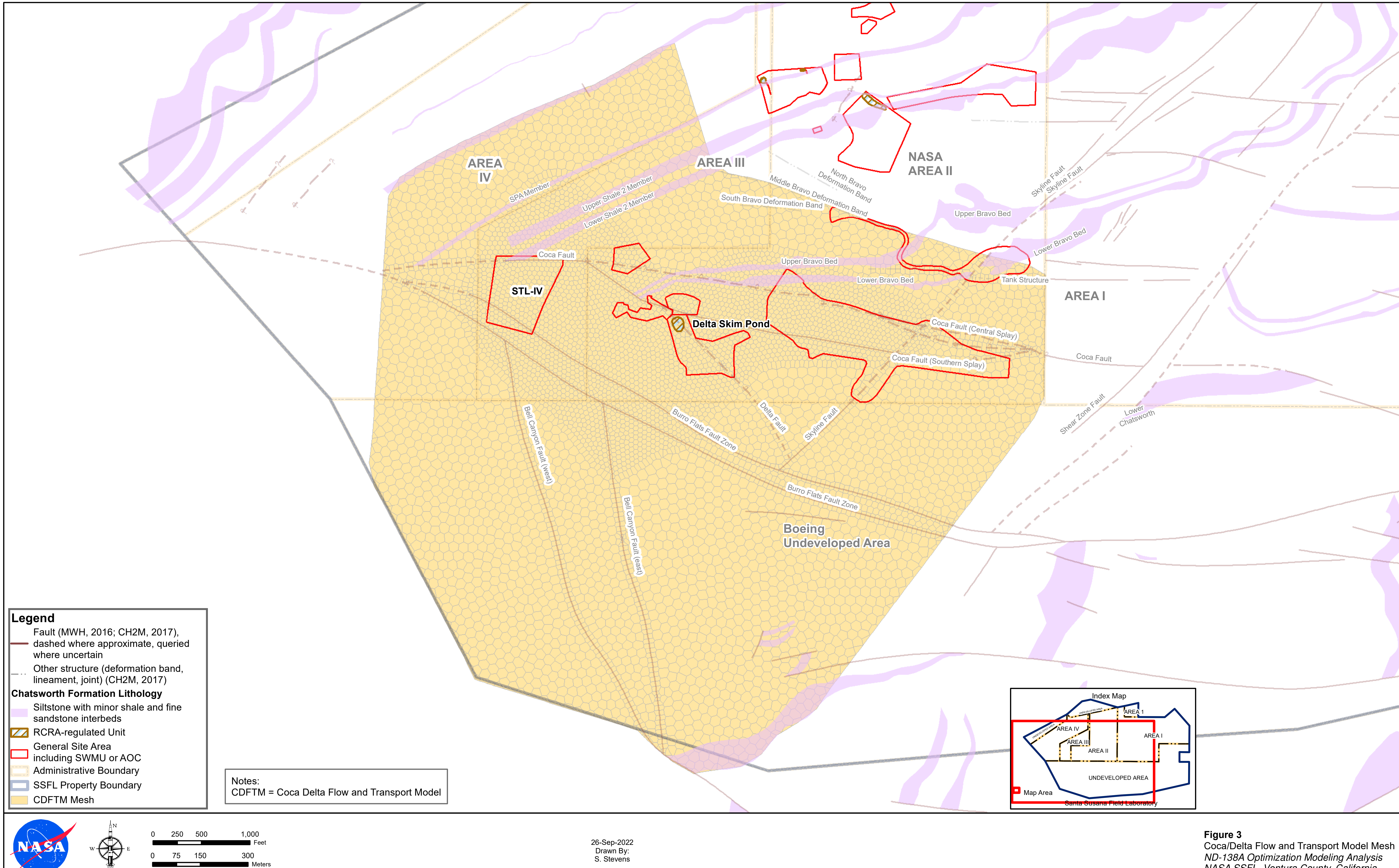
Figure 1
Coca/Delta Area Location Map
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\ND-138A_model\Figure-01_ND-138A_OM_Analysis.mxd



NGVD29 – National Geodetic Vertical Datum of 1929
Groundwater extraction commenced on June 1, 2020.

FIGURE 2
Groundwater Level Responses to Extraction at ND-138A
NASA SSFL ND-138A Optimization Modeling Analysis
Santa Susana Field Laboratory, Ventura County, California



26-Sep-2022
Drawn By:
S. Stevens

Figure 3
Coca/Delta Flow and Transport Model Mesh
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\ND-138A_model\CDFTMmesh.mxd

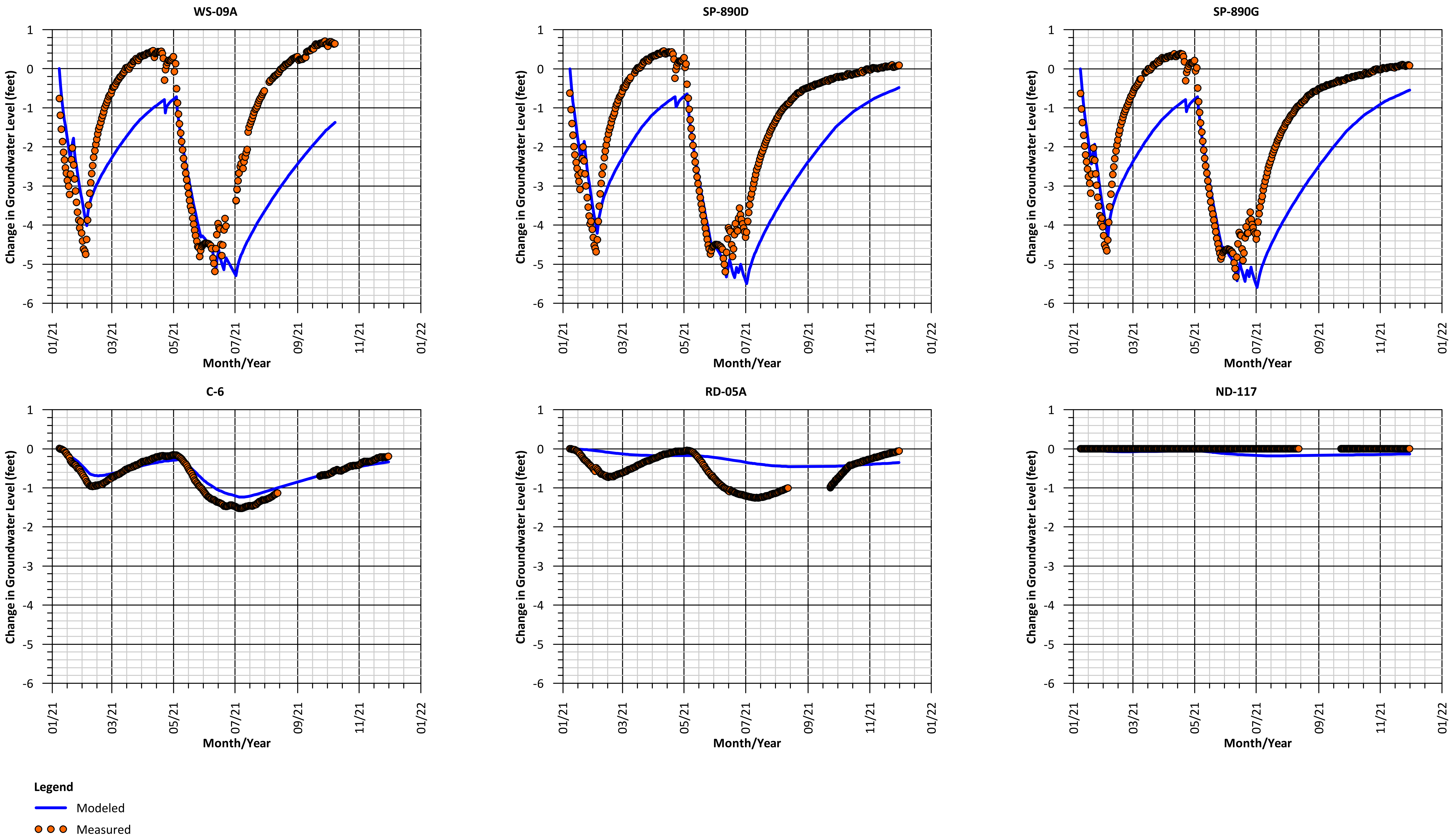


FIGURE 4a

Modeled and Measured Change in Groundwater Level versus Time

NASA SSFL ND-138A Optimization Modeling Analysis

Santa Susana Field Laboratory, Ventura County, California

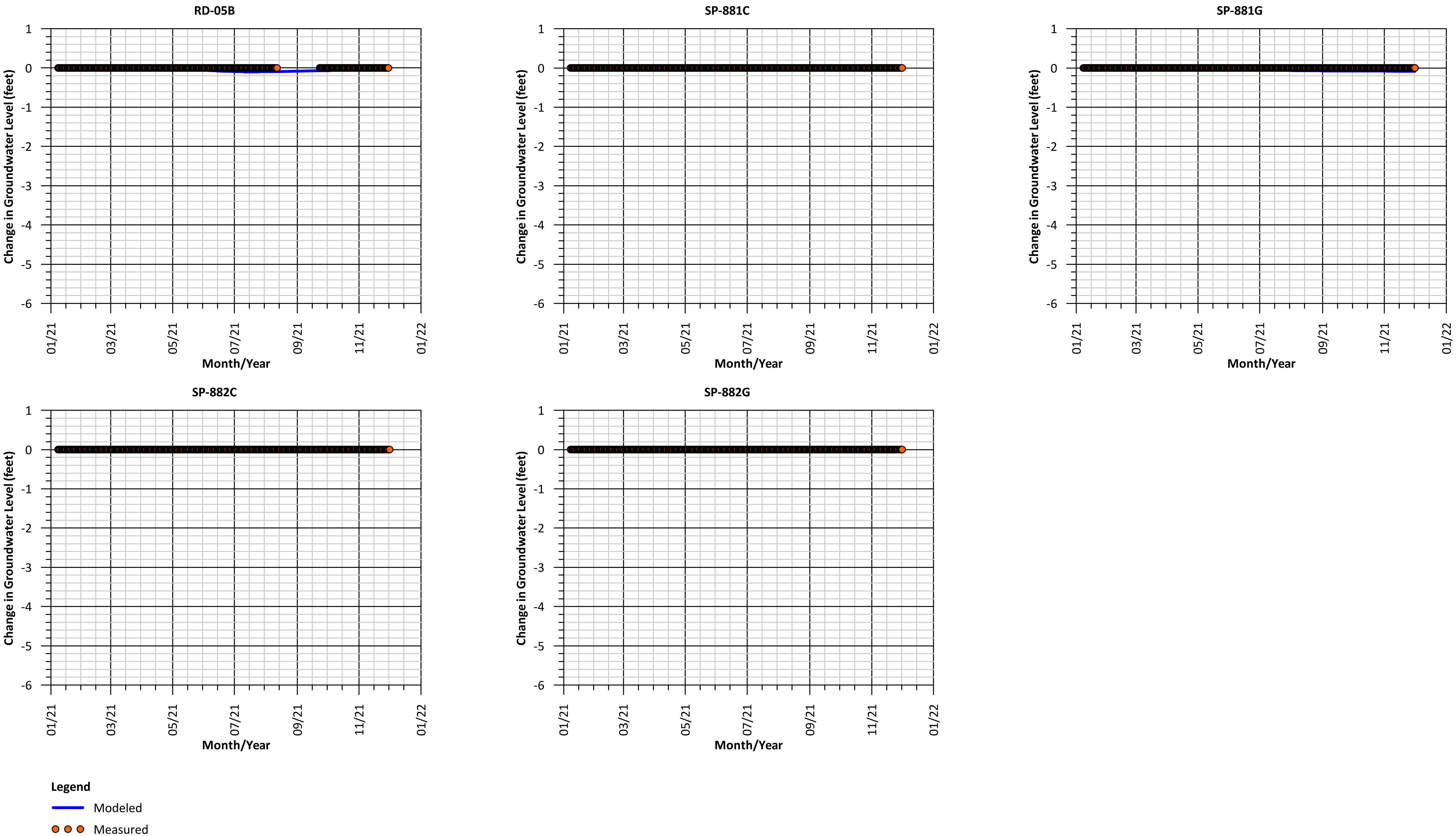
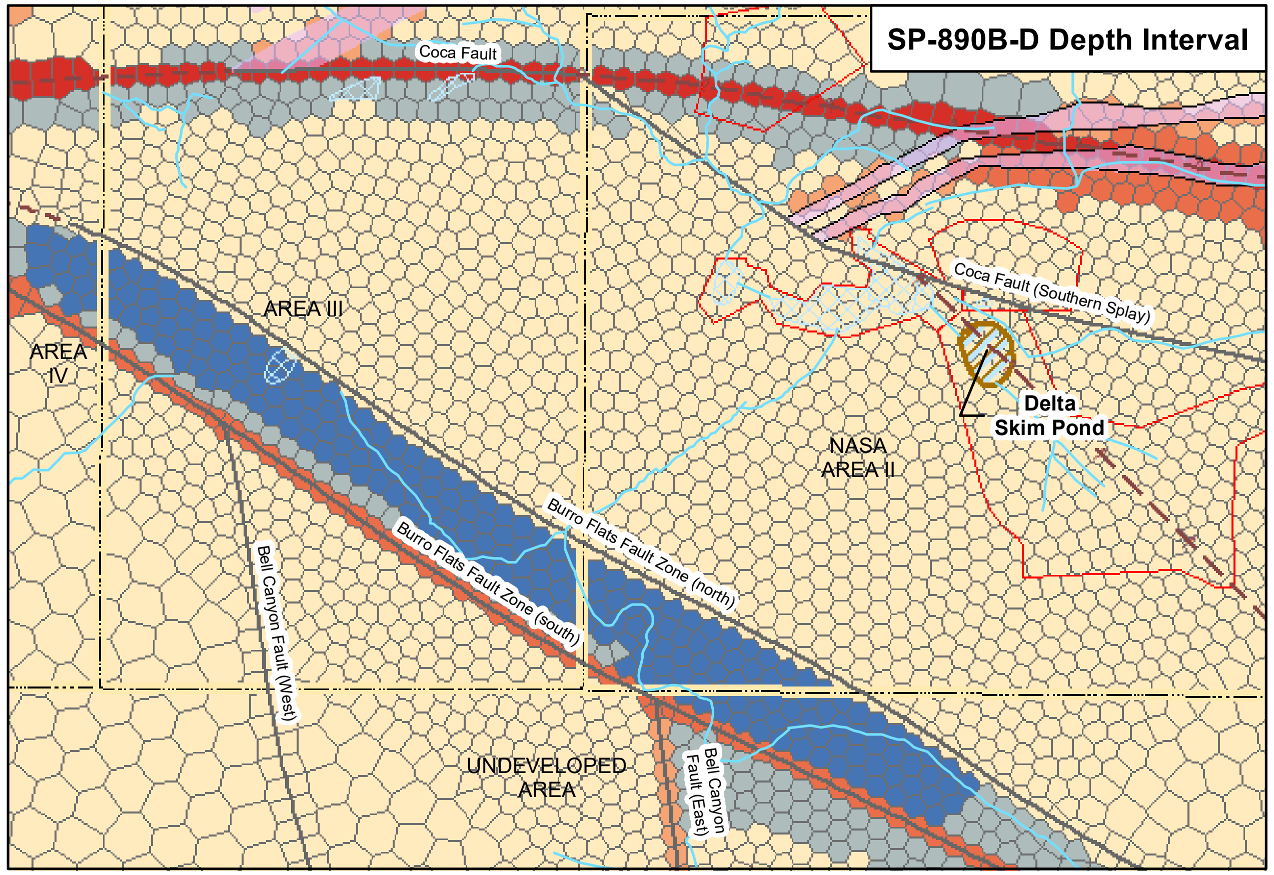
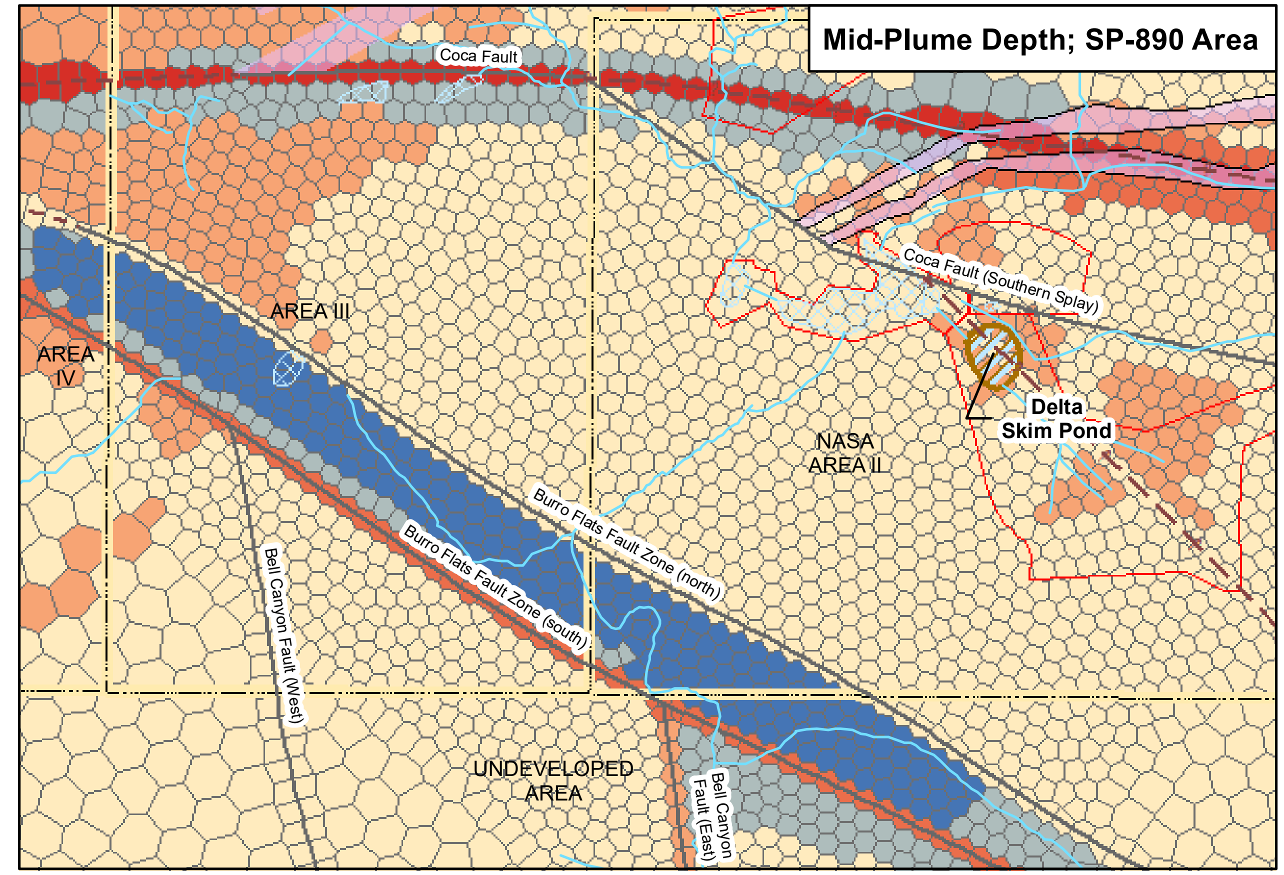
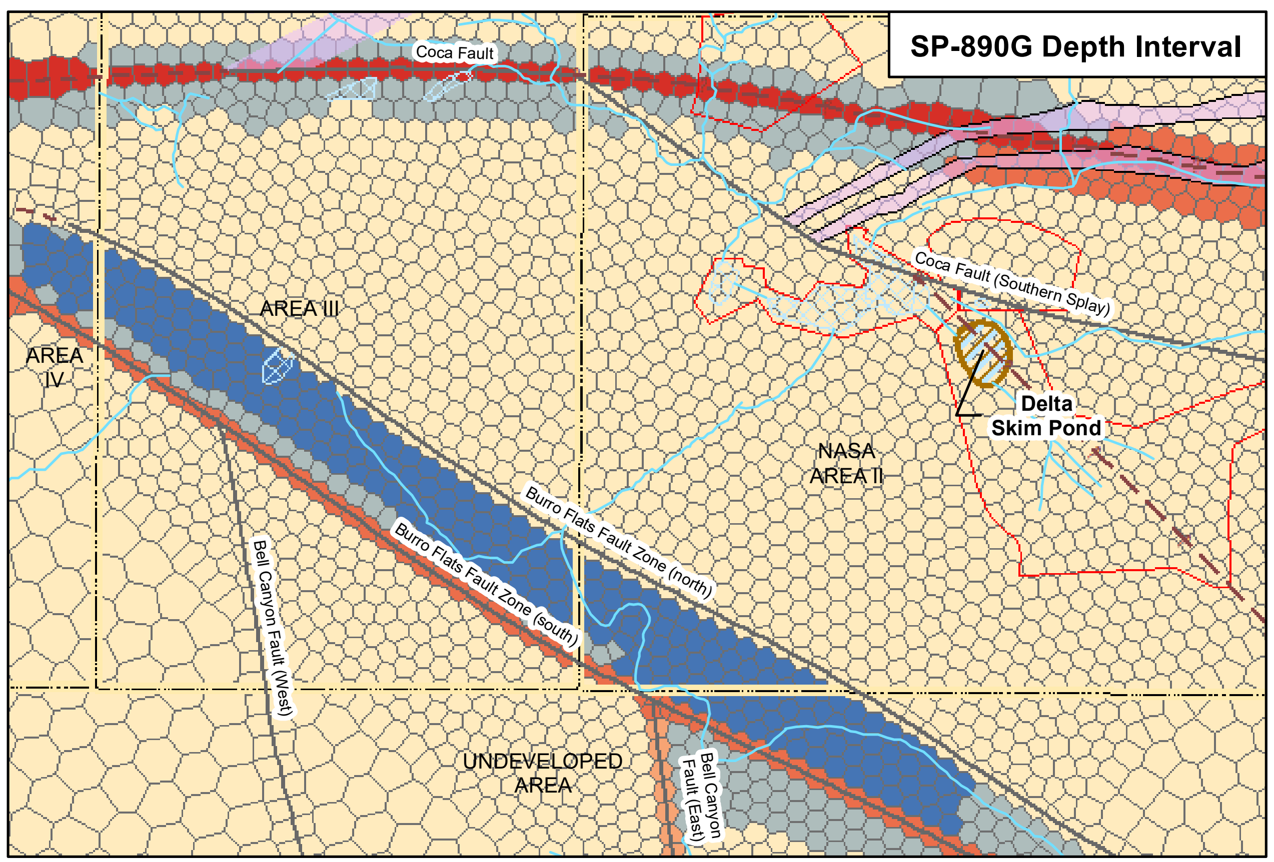
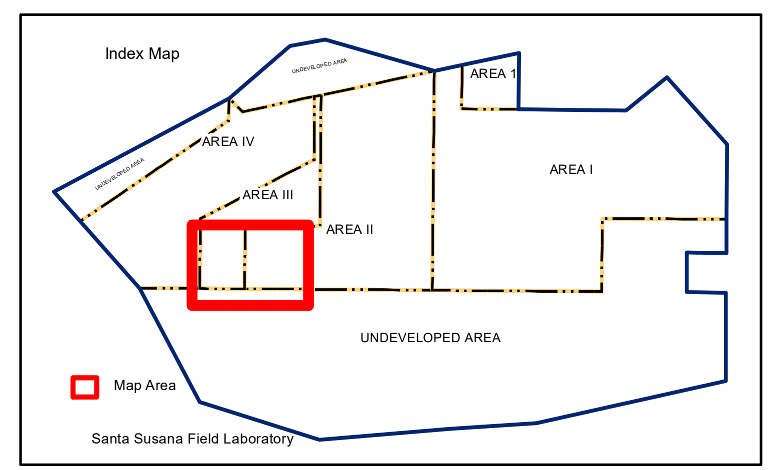


FIGURE 4b
Modeled and Measured Change in Groundwater Level versus Time
NASA SSFL ND-138A Optimization Modeling Analysis
Santa Susana Field Laboratory, Ventura County, California









Legend

Modeled Hydraulic Conductivity (cm/s)

- 1.1e-02 to 1.0e-01
- 1.1e-03 to 1.0e-02
- 1.1e-04 to 1.0e-03
- 1.1e-05 to 1.0e-04
- 1.1e-06 to 1.0e-05
- 1.1e-07 to 1.0e-06
- 1.1e-08 to 1.0e-07
- 9.3e-09 to 1.0e-08
- Stream
- RCRA-regulated Unit
- Pond or Impoundment (current or historic)
- General Site Area Including SWMU or AOC
- Administrative Boundary

Notes:
1. cm/s = centimeters per second
2. See NASA, 2022b for full details regarding the Coca/Delta Flow and Transport Model construction and calibration.

0 225 450 900 Feet

26-Sep-2022

Figure 5
Modeled Hydraulic Conductivity Distribution
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

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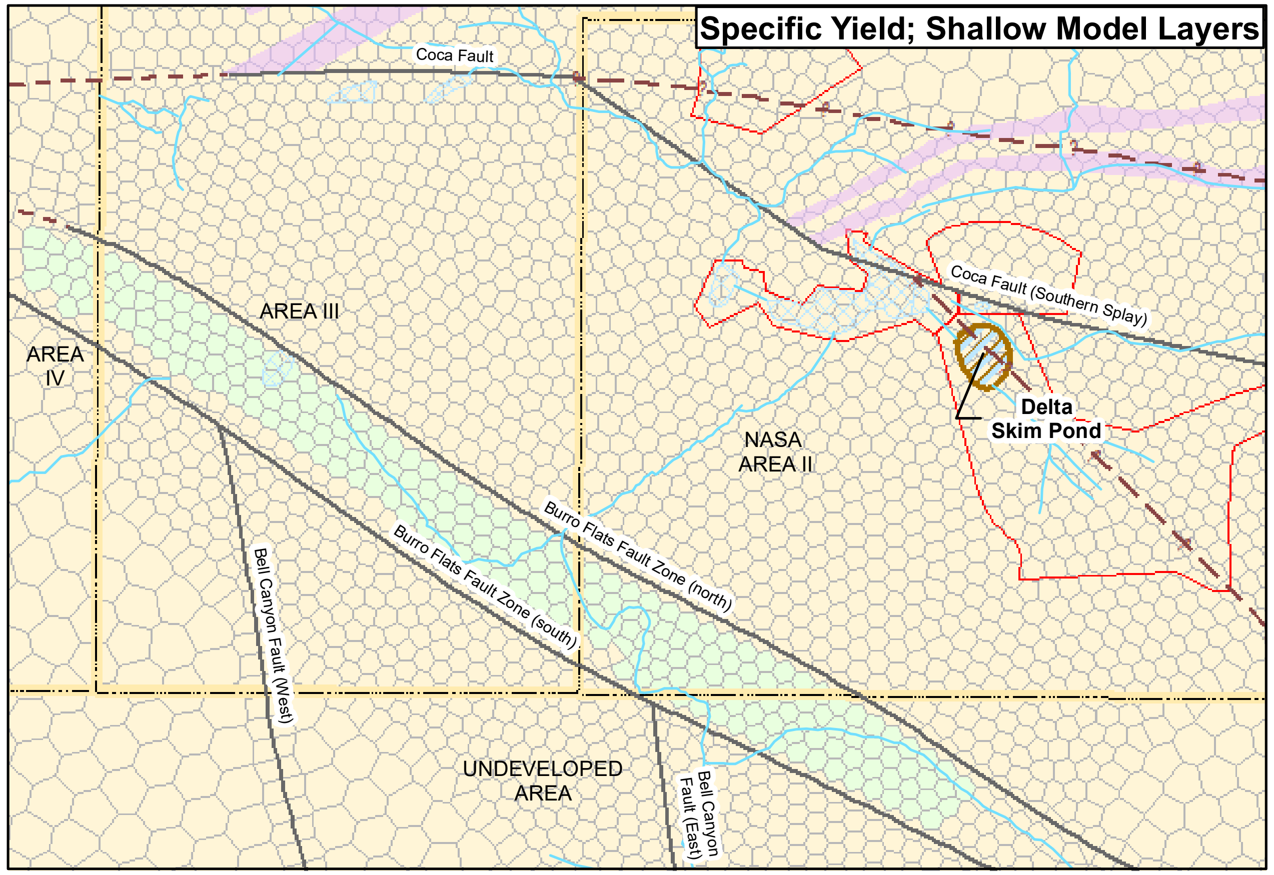
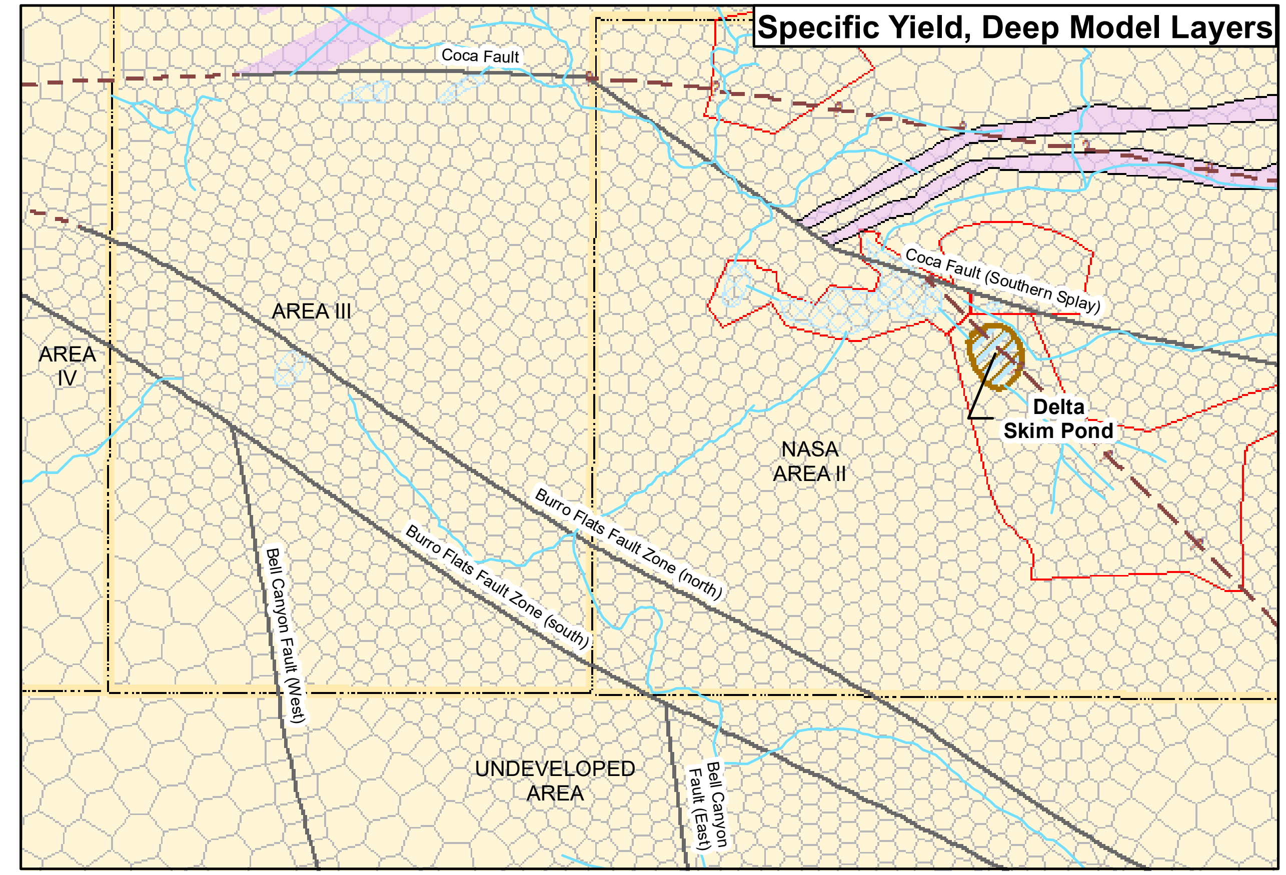
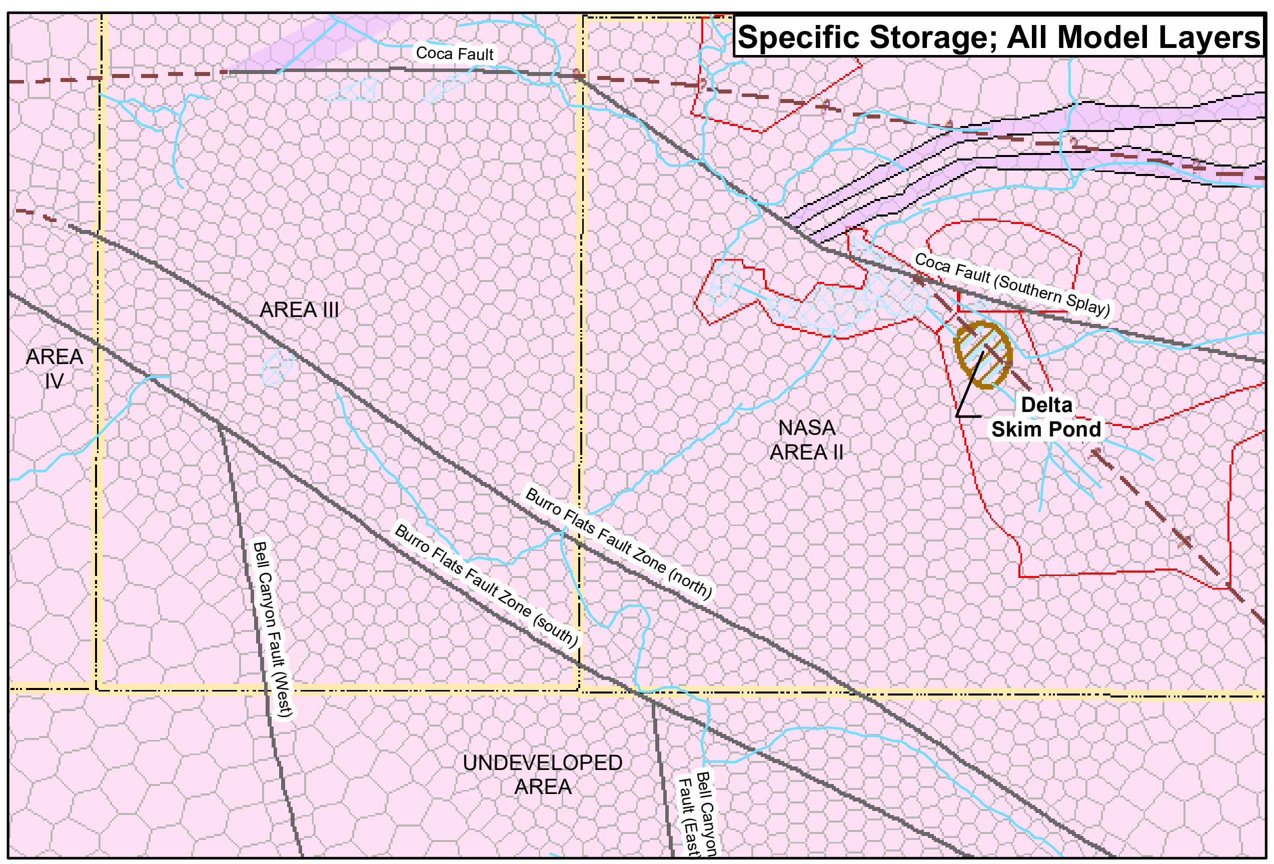
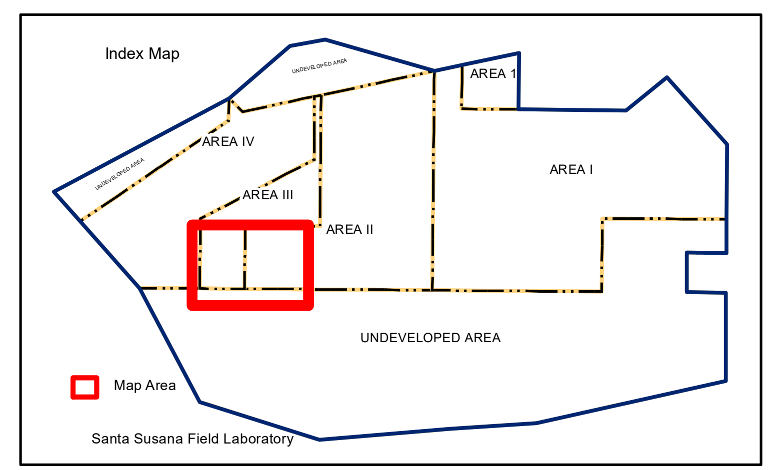








Legend

Modeled Specific Yield
- 1 Percent
- 2 Percent

Modeled Specific Storage (per meter)
- 5.0e-07
- Stream
- RCRA-regulated Unit
- Pond or Impoundment (current or historic)
- General Site Area Including SWMU or AOC
- Administrative Boundary

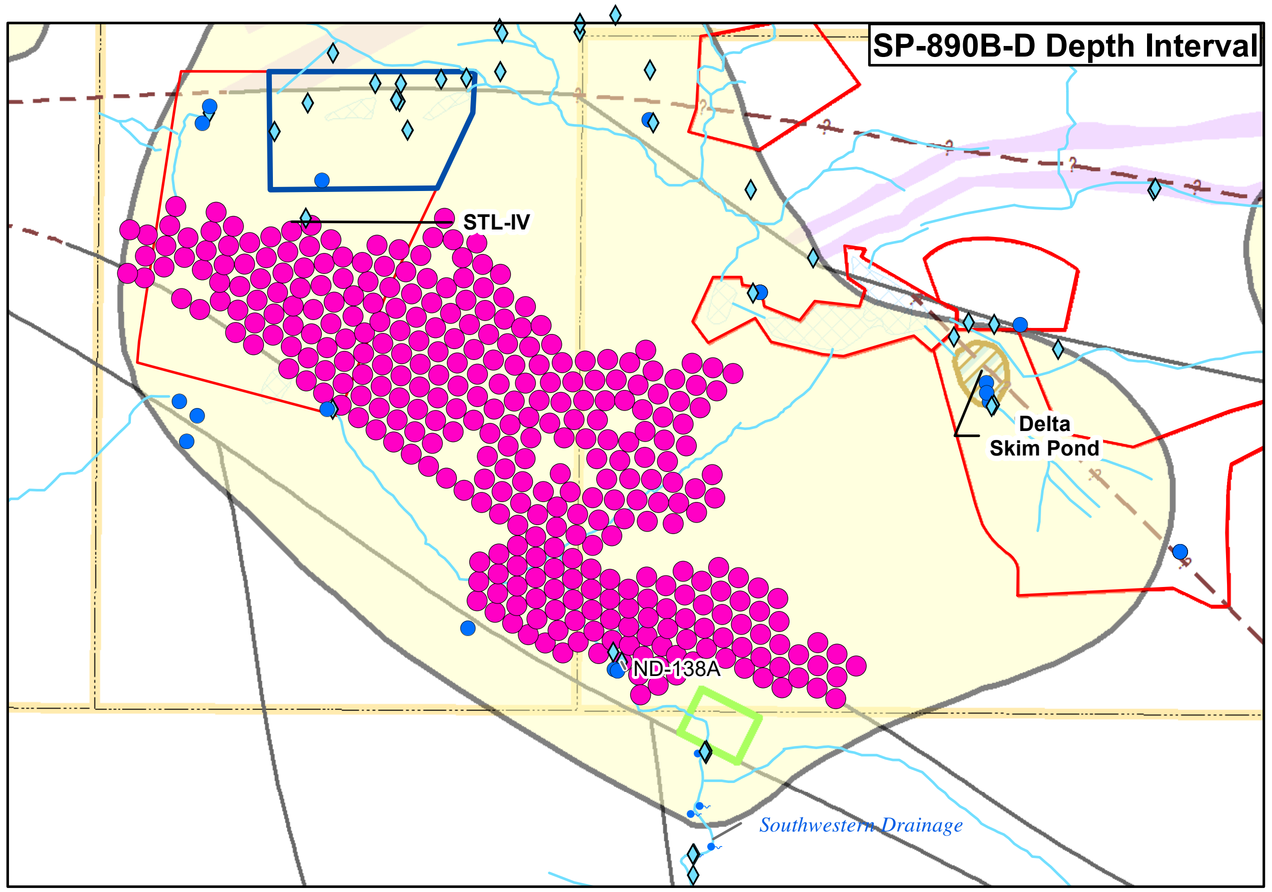
Notes:
1. cm/s = centimeters per second
2. See CH2M, 2022 for full details regarding the Coca/Delta Flow and Transport Model construction and calibration.

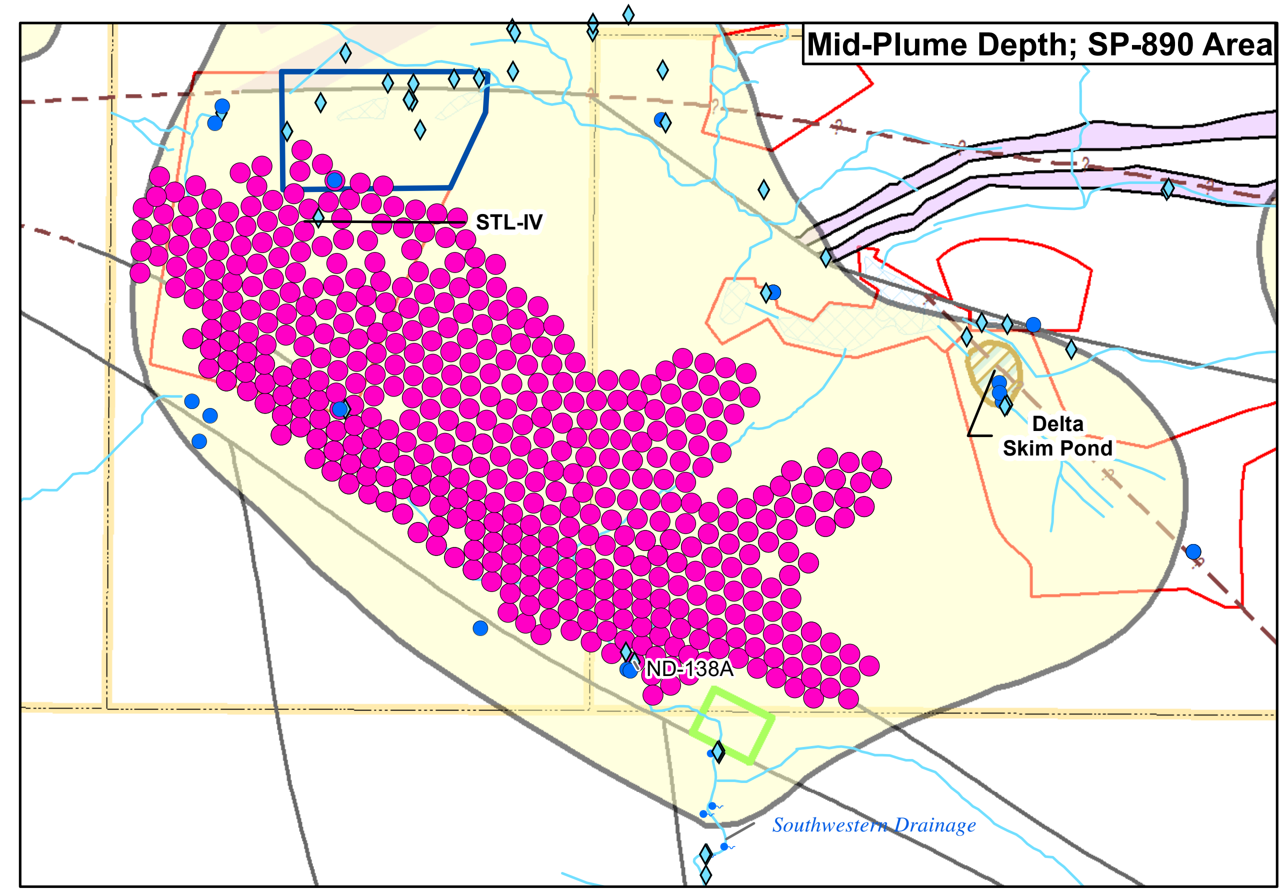
0 225 450 900 Feet

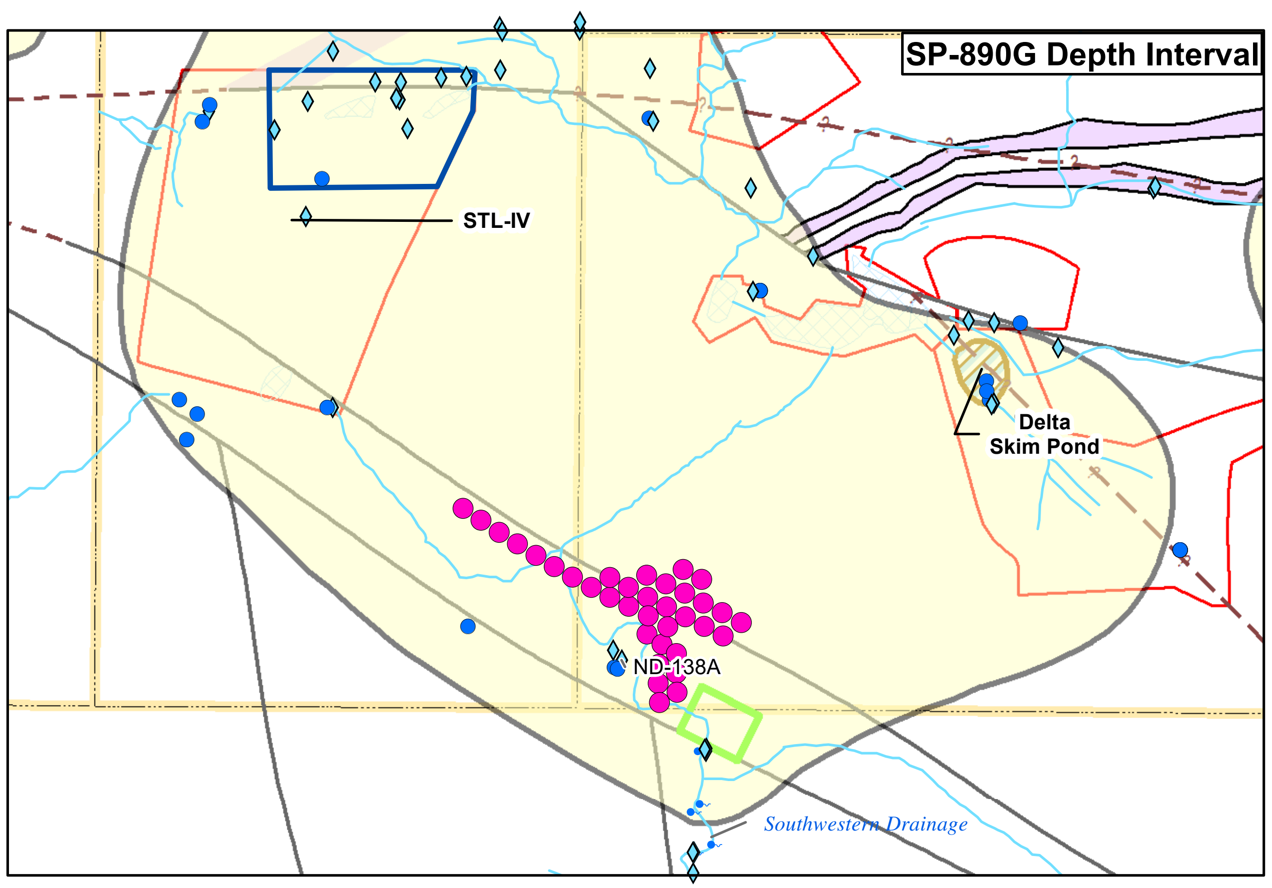
26-Sep-2022

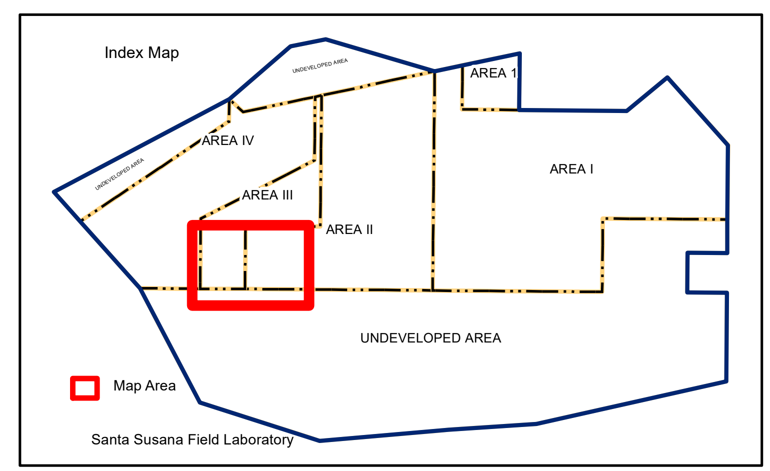
Figure 6
Modeled Storage Distribution
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

Document Path: O:\NASA\SSFL\maps\Groundwater\ND-138A_model\Figure-06_Storage.mxd









Legend

- Particle Captured by ND-138A
- NSGW Well
- CFGW Well
- Seep/Spring
- SP-890 Target Capture Area
- Approximate Extent of TCE in Groundwater Exceeding 5 µg/L, 2020
- Stream
- Fault (MWH, 2016; CH2M, 2017), dashed where approximate, queried where uncertain
- Siltstone with minor shale and fine sandstone interbeds
- RCRA-regulated Unit
- Pond or Impoundment (current or historic)
- General Site Area Including SWMU or AOC
- Administrative Boundary
- STL-IV High TCE Concentration Area

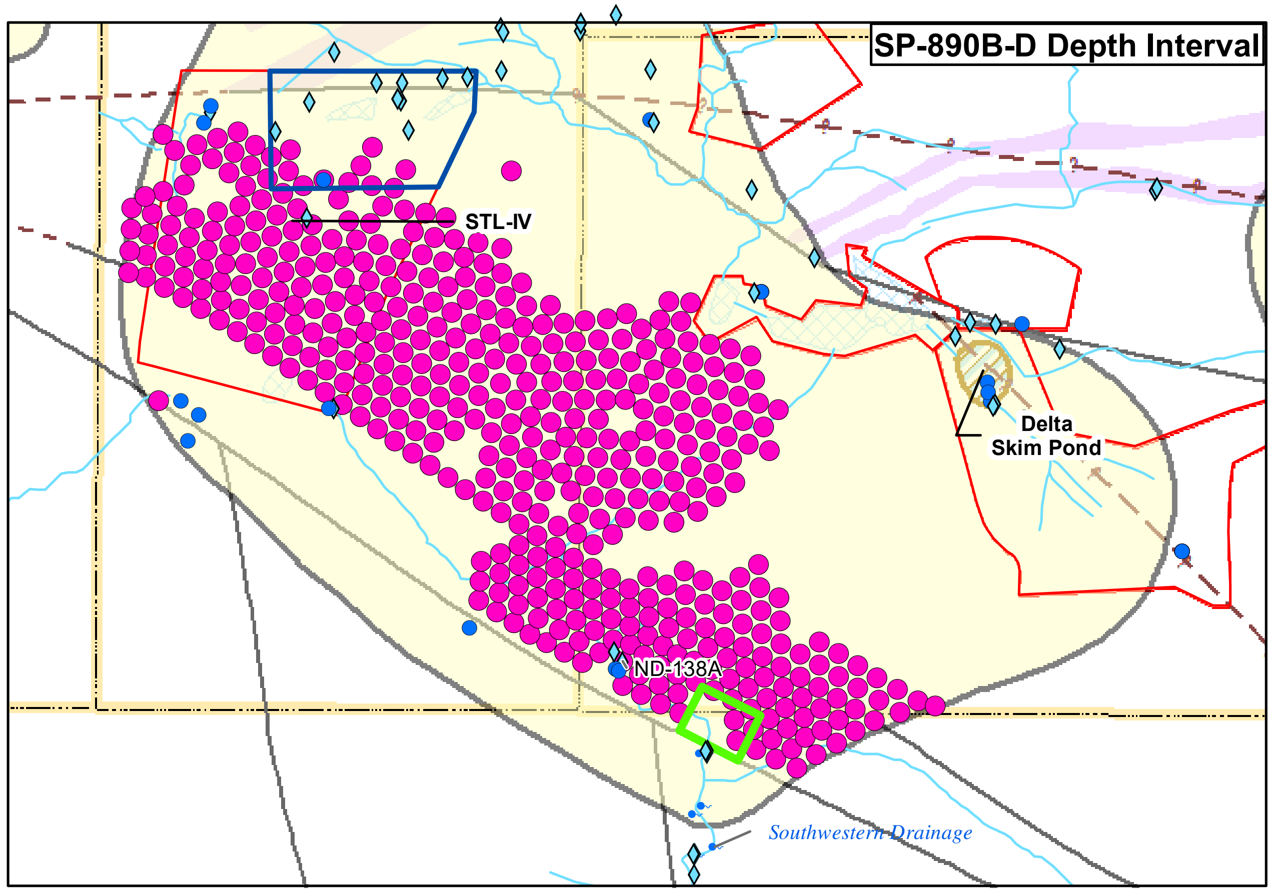
Notes:
1. Particles were started in model layers 2, 10, and 20 and tracked forward in time to their repspective discharge location or a maximum travel time of 180 days (whichever was shorter).
2. Effective porosity = 1 percent.

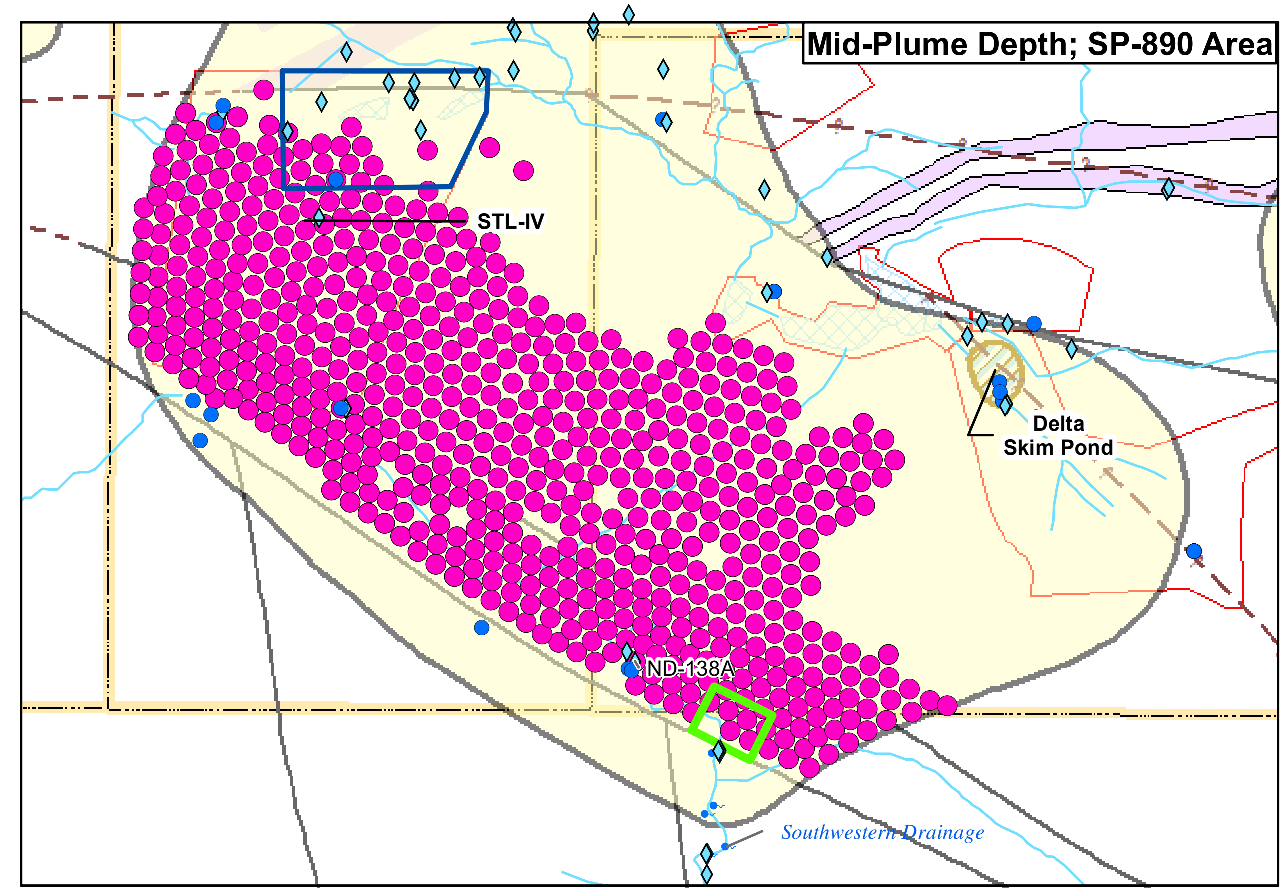
0 225 450 900 Feet

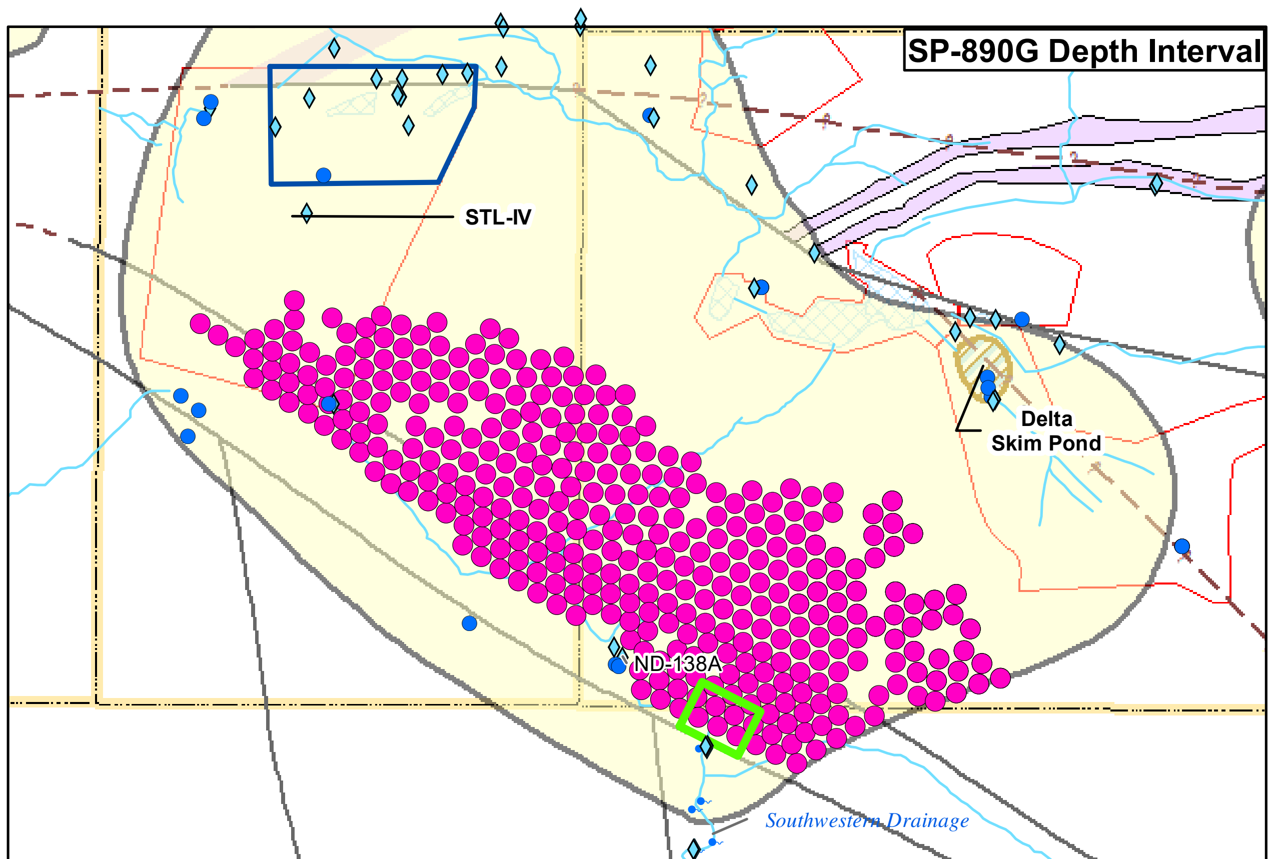
15-Nov-2022
Drawn By:
Erin Eppling

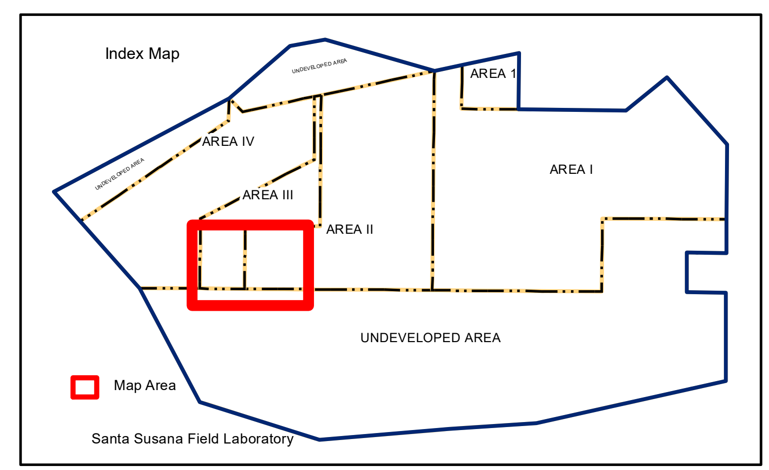
Figure 7
Simulated Extent Capture, 2 gpm
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

Document Path: O:\NASA\SSFL\maps\Groundwater\ND-138A_model\Figure-07_2gpmCapture.mxd









Legend

- Particle Captured by ND-138A
- NSGW Well
- CFGW Well
- Seep/Spring
- SP-890 Target Capture
- Approximate Extent of TCE in Groundwater Exceeding 5 µg/L, 2020
- Stream
- Fault (MWH, 2016; CH2M, 2017), dashed where approximate, queried where uncertain
- Siltstone with minor shale and fine sandstone interbeds
- RCRA-regulated Unit
- Pond or Impoundment (current or historic)
- General Site Area Including SWMU or AOC
- Administrative Boundary
- STL-IV High TCE Concentration Area

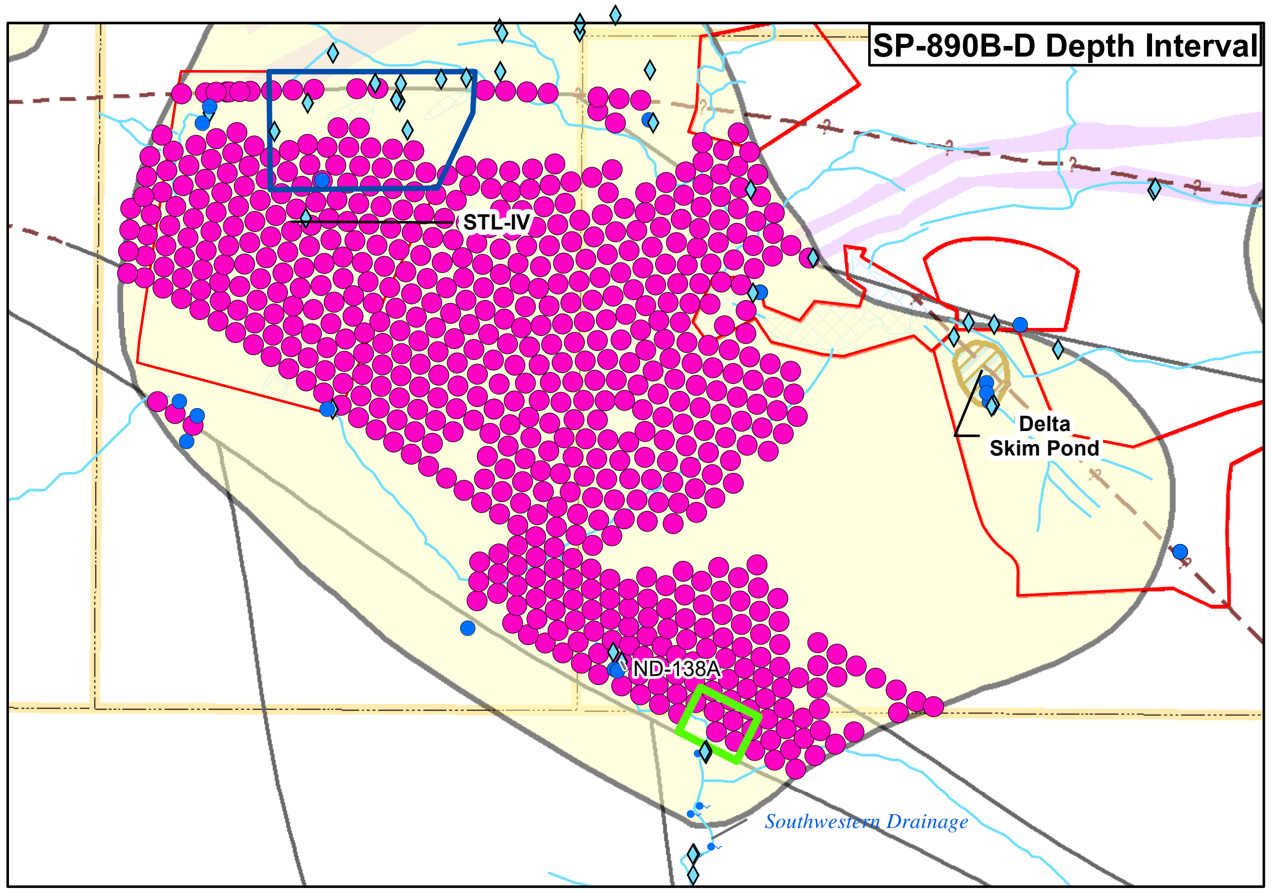
Notes:
1. Particles were started in model layers 2, 10, and 20 and tracked forward in time to their repspective discharge location or a maximum travel time of 180 days (whichever was shorter).
2. Effective porosity = 1 percent.

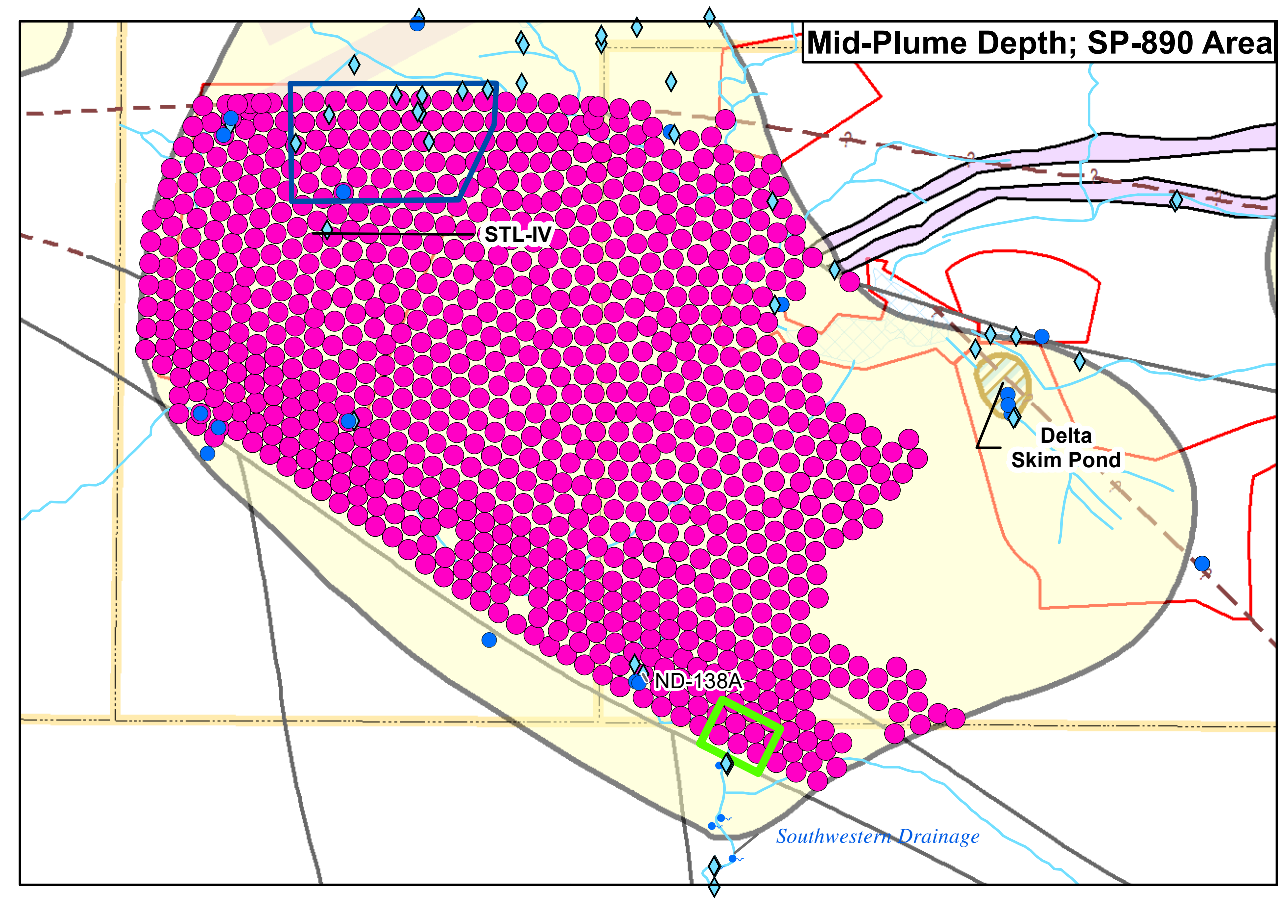
0 225 450 900 Feet

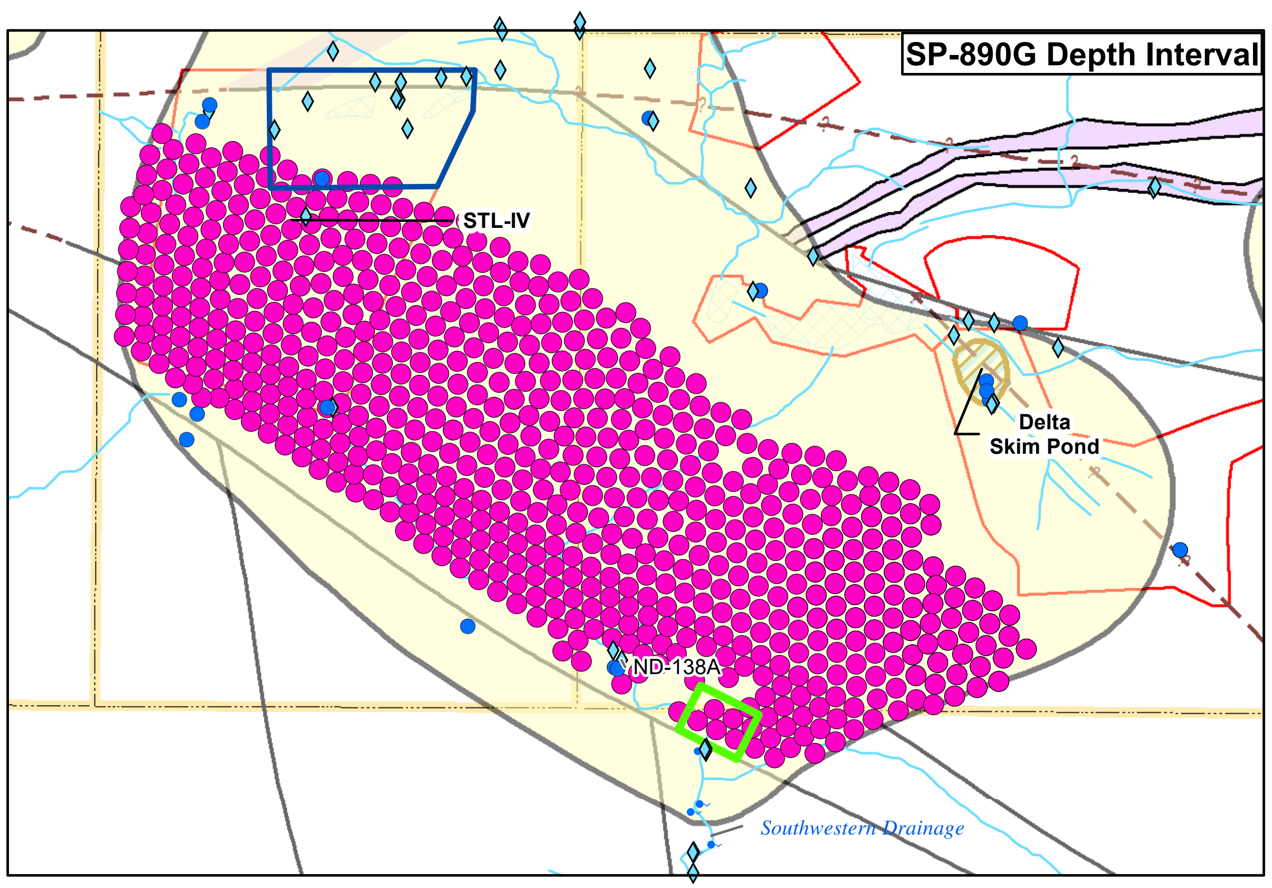
15-Nov-2022
Drawn By:
Erin Eppling

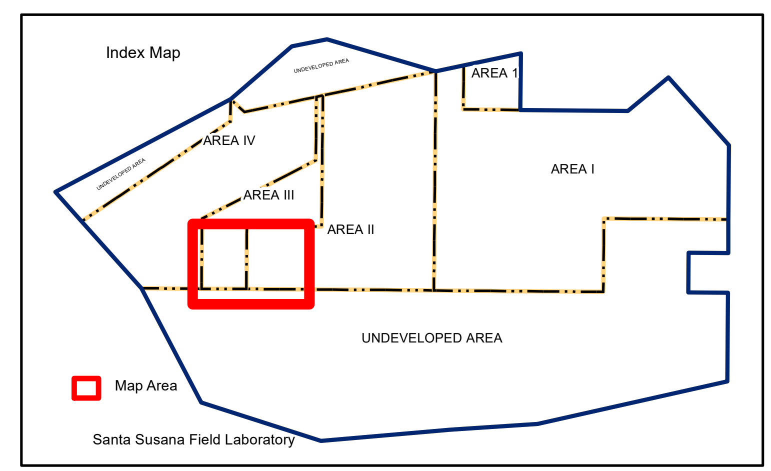
Figure 8
Simulated Extent Capture, 5 gpm
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

Document Path: O:\NASA\SSFL\maps\Groundwater\ND-138A_model\Figure-08_5gpmCapture.mxd









Legend

- Particle Captured by ND-138A
- NSGW Well
- CFGW Well
- Seep/Spring
- SP-890 Target Capture
- Approximate Extent of TCE in Groundwater Exceeding 5 µg/L, 2020
- Stream
- Fault (MWH, 2016; CH2M, 2017), dashed where approximate, queried where uncertain
- Siltstone with minor shale and fine sandstone interbeds
- RCRA-regulated Unit
- Pond or Impoundment (current or historic)
- General Site Area Including SWMU or AOC
- Administrative Boundary
- STL-IV High TCE Concentration Area

Notes:
1. Particles were started in model layers 2, 10, and 20 and tracked forward in time to their repspective discharge location or a maximum travel time of 180 days (whichever was shorter).
2. Effective porosity = 1 percent.

Feet
0 225 450 900

15-Nov-2022
Drawn By:
Erin Eppling

Figure 9
Simulated Extent Capture, 10 gpm
ND-138A Optimization Modeling Analysis
NASA SSFL, Ventura County, California

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Appendix I
Matrix-diffusion Modeling Assessment

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Memorandum

Subject	**Matrix Diffusion Modeling Assessment for the Santa Susana Field Laboratory Using REMChlor-MD**
Project Name	Santa Susana Field Laboratory, Ventura County, California Contract No. 80MSFC18D0003, Task Order No. CJ046A1
Attention	Peter Zorba National Aeronautics Space Administration (NASA)
From	CH2M HILL, Inc. (CH2M)
Date	December 2022

1. Introduction

This technical memorandum presents the results of a matrix diffusion literature search and modeling assessment for chlorinated volatile organic compounds (CVOCs) in groundwater at the NASA Santa Susana Field Laboratory (SSFL) in Ventura County, California. The focus of this effort was the use of a semi-analytical fate and transport model to evaluate the influence of matrix diffusion on contaminant plume dynamics within a fractured bedrock system, building from existing matrix diffusion information at SSFL (Yu et al. 2018, 2020; Darlington et al. 2013). This matrix diffusion assessment will be used to support Corrective Measures Study (CMS) decisions at NASA SSFL.

2. Matrix Diffusion Assessment Objectives

Matrix diffusion is a process in which groundwater contaminants diffuse between higher permeability and lower permeability zones within an aquifer. After contaminant release, contaminants will diffuse from high permeability aquifer zones into low-permeability zones, during what is often referred to as a "loading period" or "forward diffusion." This process may slow, or retard, the rate of contaminant migration within the higher permeability aquifer zones. Afterwards, contaminants can diffuse back out of the low-permeability zones into the higher permeability zones, in what is referred to as "back diffusion" or the "release period." This back diffusion process can hinder the effectiveness of remedial actions by causing rebounding of plume concentrations even after remediation is complete and elongate the time of remediation. Matrix diffusion effects are often greater in fractured bedrock environments or unconsolidated environments with substantial silt or clay layers.

The NASA SSFL matrix diffusion modeling effort was conducted in an attempt to answer the following questions at NASA SSFL:

- How quickly will back diffusion occur if the dissolved contamination is artificially removed from the more permeable fracture zones (the artificial removal of contamination is detailed in Section 5.1)?
- If dissolved contamination in the fractures is idealistically treated for an extended period of time, then how much are matrix diffusion effects potentially lowered?
- If volatile organic compounds (VOCs) within the fractures are remediated over the area with the highest concentrations, then what is the reduction in contaminant mass in the bedrock matrix and concentrations in the bedrock fractures compared to natural attenuation alone, given the back diffusion effects at the site?

3. Model Description

The matrix diffusion assessment for CVOCs in groundwater at SSFL was conducted using the Remediation Evaluation Model with Matrix Diffusion for Chlorinated Solvents (REMChlor-MD) model. This is a semi-analytical fate and transport model that can simulate source and plume remediation of groundwater contaminants, natural attenuation processes, and matrix diffusion effects in low-permeability aquitards or bedrock with parallel fractures (Muskus and Falta, 2018). Supporting information is found in the tables, figures, and charts included after the text.

The REMChlor-MD model includes separate source and dissolved plume model components. The source component serves as a mass flux boundary condition that releases contaminant mass over time to the plume until the source mass is depleted or removed. A gamma factor, in addition to the source concentration and groundwater flow, is used to help control the rate that contaminants are released from the source into the dissolved plume. The plume component is a semi-analytical model, which simulates matrix diffusion at the local scale, based on the thermal conduction approximation developed by Vinsome and Westerveld (1980). Contaminant degradation is incorporated into the model as a first-order decay rate. This decay rate can be used to simulate degradation associated with natural biodegradation, natural abiotic degradation, or enhanced degradation (or remediation). Regarding biodegradation, the model also incorporates a yield factor that simulates the production of a daughter product as a parent compound is degraded, such as the reductive dechlorination of trichloroethene (TCE) to cis-1,2-dichloroethene (cis-1,2-DCE). A detailed description of the REMChlor-MD model is presented in the REMChlor-MD User's Manual (Farhat et al. 2018).

The REMChlor-MD model employs several simplifying assumptions and therefore is intended to be used as a screening-level tool. These assumptions include the number and type of sources present in the plume, homogenous hydrogeology, steady flow with no local sources or sinks, and application of first-order decay rates. Model assumptions and limitations are detailed in the User's Manual (Farhat et al. 2018). Because the model can be limited in its representation of true site conditions, it can provide only approximate estimates of remediation timeframes. However, the REMChlor-MD model can be a useful tool to compare potential outcomes from different remediation scenarios and evaluate the four questions above

4. Baseline REMChlor-MD Model

To provide a foundation for the SSFL modeling assessment, a baseline REMChlor-MD model was created before evaluating the impacts of matrix diffusion. The intent of this model was to establish baseline results that other model scenarios could be compared with to address the model objectives and questions identified above.

The Delta Area, located within the Coca/Delta Area of Impacted Groundwater (AIG) was selected for the matrix diffusion modeling effort for SSFL (Figure 1). The Delta Area was selected because it has the highest estimated contaminant mass at SSFL (NASA 2020a) and therefore is considered to have greater matrix diffusion effects than the other source areas at the site. The REMChlor-MD model was set up with fractured rock conditions based on the Site Conceptual Model (SCM).

Models like REMChlor-MD can only include one source release area and date. The SSFL model for the Delta Area was developed with the source area located at monitoring well C-6 and a source release date of 1960. These assumptions are consistent with the one-dimensional screening solute transport model that was developed for the Delta Skim Pond as part of the Phase 1 CMS (NASA 2020b). The model dimensions were based on the 2015 TCE plume extent (Figure 1), as presented in the SCM in the *NASA Groundwater RFI Report* (NASA 2020c).

Tables 1 and 2 present input data for the SSFL modeling assessment. Coca/Delta AIG-specific input parameter values were used when available, as noted on the tables. General model input for the source component includes the initial source concentration, source mass, source dimensions, and a power function (gamma) that controls the source mass flux rate. General model input for the dissolved plume component includes the Darcy velocity, contaminant retardation rate, dispersivity, and first-order decay rates for TCE and its reductive degradation products. General model input for the matrix diffusion component of the model includes the distance between fractures, which is related to the diffusion length, and fracture aperture thickness. In addition, the model assumed that matrix diffusion is only occurring within the fractured aquifer system itself, and there are no underlying or overlying low-permeability units. As previously mentioned, a gamma value is used by the model to control the mass flux rate from the source component to the dissolved plume. For this modeling effort, a gamma value of 1, which represents simple exponential decay, was selected in an effort to simplify the model and focus on matrix diffusion effects. The bulk hydraulic conductivity and natural attenuation contaminant decay rates were estimated by roughly calibrating the model, using a simple trial-and-error approach, to the plume extent presented in the SCM for the Delta Area (NASA 2020c) before incorporating any source or plume treatment. The calibrated model parameters are considered to be reasonable values based on the range of data collected at SSFL and those reported in literature, as referenced in Table 2.

Literature was also evaluated to assess the range of decay rates for chlorinated ethenes in fractured sandstone. Table 2 identifies the values used in the model (estimated based on model calibration) and comparison is provided to relevant literature values. The work cited by Yu et al. (2018 and 2020), and Darlington et al. (2013) is relevant and based on samples collected from SSFL. The references are based on work completed at SSFL and are considered the most relevant. Matrix diffusion rates are dependent on a variety of site-specific variables, including porosity, pore structure, and matrix diffusion length (fracture spacing). Therefore, evaluating modeled degradation rates against SSFL-specific information was considered more appropriate than considering matrix diffusion results from other sites.

To facilitate the evaluation of matrix diffusion effects in the model, two of the primary factors that influence mass flux (source discharge and biodegradation) were removed from the model after a period of mass loading into the bedrock matrix. All remaining source mass contributions were removed in model year 40 (calendar year 2000) to allow the baseline model to equilibrate without continuous source discharge for approximately 25 years before simulating plume remediation (refer to Section 5). If the source mass is not removed, then contaminant mass continues to enter the dissolved plume component of the model and it is more difficult to discern whether potential increases in contaminant concentrations over time are associated with back diffusion or source discharge. Following artificial plume removal (refer to Section 5), the first-order decay rates were set at zero. Even low degradation rates will continue to remove contaminant mass from the model. Therefore, natural degradation was removed to avoid potentially underestimating back diffusion effects.

A comparison of total CVOC contaminant mass within the transmissive fracture zone and the low-permeability bedrock zone in the baseline model, which assumed no plume treatment, is presented in Chart 1. As shown, contaminant mass immediately loads (diffuses) into the bedrock matrix. The total CVOC mass within the bedrock zone of the model is approximately three orders of magnitude higher than within the fracture zone of the model. Contaminant mass in both zones increases until model year 40, at which point the source discharge factor is removed. Contaminant mass then decreases until model year 65, when biodegradation is removed. At that point in the model, the fracture concentrations equilibrate with the contaminant mass in the adjacent bedrock matrix with the only on-going mass transfer being dominated by matrix diffusion and the mass trend curve becomes stable in both zones. As stated previously, the biodegradation component was removed to avoid potentially underestimating back diffusion effects.

5. Matrix Diffusion Evaluation

5.1 Artificial Removal of Contaminants from Fractures to Assess Matrix Diffusion

An artificial contaminant removal model scenario was developed to evaluate the following model objective:

- How quickly will back diffusion occur if the dissolved contamination is artificially removed from the more permeable fracture zones?

The artificial plume removal model incorporated idealized treatment of groundwater contamination within the fracture domain into the baseline model. It was assumed that removal of all dissolved contamination would occur over a 1-year period in model year 65 (calendar year 2025) over the entire length of the plume (Table 1). This also represents an unrealistic treatment approach that encompasses the entire footprint of the plume above groundwater maximum contaminant levels (MCLs) (refer to Figure 1). The scale of this treatment, as represented in the model, is impractical but was used to simulate an ideal treatment scenario to isolate the effects of matrix diffusion. To accomplish this, the fracture domain (transmissive zone) decay rates were artificially increased several orders of magnitude to ensure that contaminant concentrations were degraded below their cleanup values (MCLs) within the 1-year treatment period (Table 2, refer to values for period 2). The bedrock (matrix domain) decay rates were retained at their natural attenuation decay rates, as it was assumed that any plume treatment would not appreciably influence contamination within the bedrock matrix for this assessment.

5.2 Matrix Diffusion Effects Observed in Contaminant Mass, Concentration, and Mass Discharge

The results from the artificial plume removal model were compared to the results from the baseline model to assess potential matrix diffusion effects at SSFL. Charts 2A through 2C present total CVOC mass versus time for the fracture zone, bedrock matrix, and combined fracture and bedrock matrix, respectively. Charts 3A through 3E present TCE concentrations in the fracture zone versus time at five locations along the model plume: 5 meters, 55 meters, 155 meters, 255 meters, and 355 meters. Charts 4A through 4E present TCE mass discharge in the fracture zone versus time at five locations along the model plume: 5 meters, 55 meters, 155 meters, 255 meters, and 355 meters. TCE was selected for detailed evaluation since it is a parent compound at SSFL and has the highest estimated mass of the CVOC constituents at the Delta Area.

The temporal total CVOC mass, TCE mass discharge, and TCE concentration charts all suggest that back diffusion would occur relatively quickly after the idealized decay period ceases. Within the fracture zone, contaminant mass continued to rebound until model year 80, which is 15 years after plume treatment in the fracture domain, and then stabilized due to the lack of biodegradation (Chart 2A). As expected, the total CVOC mass in both the fracture and bedrock zones are lower in the artificial plume removal model than in the baseline model because of active treatment of the fractures. Because the decay rates in the bedrock zone were maintained at the low natural decay rates during the plume removal period, the rapid decrease of mass observed within the bedrock zone is attributed to back diffusion of mass out of the bedrock and immediate degradation within the transmissive fracture domain. In addition, the extremely high (idealized) treatment decay rates within the fracture domain increase the concentration gradients between the fractures and the bedrock matrix and might be driving more back diffusion to occur over the treatment period. As a result, the rapid and large decreases in mass within the bedrock matrix domain is considered an artifact of the extremely high treatment decay rates used in the model simulations and are not expected to occur under realistic remediation scenarios.

During the treatment period, TCE concentrations in the fracture zone were degraded to almost zero and the mass was reduced by 100%, and there was likely a stronger drive for diffusion out of the bedrock zone and into the fracture zone of the model. After idealized plume fracture treatment, the total CVOC mass in both zones eventually became stable due to the lack of biodegradation after treatment, similar to the baseline model. Total CVOC mass continued to be over three orders of magnitude higher in the bedrock zone (Chart 2B) compared to the fracture zone (Chart 2A). Following contaminant rebound (approximately 15 years after treatment), the mass in the fracture domain was observed to have been reduced by 20% overall and the mass in the bedrock matrix was reduced by 19% with this artificial removal scenario. This is an overestimate of mass removal, based on the model assumption of nearly instantaneous contaminant removal in the fracture during treatment, which cannot be achieved with available treatment technology.

The temporal TCE concentration results (Charts 3A through 3E) and TCE mass discharge results (Charts 4A through 4E) follow similar patterns to each other. Closest to the source (5 meters), TCE is observed to rebound because of back diffusion to its maximum post-treatment concentration and mass discharge rate approximately 5 years after the idealized treatment period (Charts 3A and 4A). Subsequently, TCE concentrations and mass discharge decrease as the plume migrates downgradient and as “clean” groundwater flushes into the plume from the upgradient side of the model. These results are similar to the baseline model. In later years at the 5-meter distance, the TCE concentration and mass discharge curves converge with the baseline model curve. At the 55-meter distance, the concentration and mass discharge curves (Charts 3B and 4B) are similar to the results at the 5-meter distance, except that the maximum rebound is observed around 12 years after idealized treatment of the entire plume; this rebound is attributed to back diffusion and some plume advection. Within the mid- and downgradient areas of the plume (155 meters, 255 meters, and 355 meters), the model shows increasing TCE concentrations and mass discharge over time, which is mostly attributed to plume advection. At these three downgradient distances, the model curves do not converge with the baseline model results, like they did closer to the source. This may occur because a smaller amount of contaminant mass loaded, or diffused, into the bedrock matrix at locations farther from the source. As a result, the concentration gradient between the transmissive fracture domain and the low-permeability bedrock matrix would not be as high as it is near the source, resulting in lower and slower mass flux rates out of the bedrock matrix in later years. Another factor could be that there is less contamination in the model to be transported downgradient after idealized treatment in the artificial plume removal model. In general, after contaminant rebound, the 1-year idealized treatment of the entire plume made little impact on the rock matrix mass and concentrations in the fractures, even accounting for the overestimate of the reduction in the overall plume mass reduction, as show on Figure 2C.

6. Extended Time for Artificial Removal of Contaminants from Fractures

Following the matrix diffusion evaluation discussed in Section 5, the plume remediation model was modified to evaluate the following model objective:

- If dissolved contamination in the fractures is idealistically treated for an extended period of time, then how much are matrix diffusion effects potentially lowered?

Because REMChlor-MD only allows for three model time periods, a pulsed remediation scenario could not be applied to the model. Therefore, idealized treatment of dissolved contamination in the fractures was assumed to occur continuously over the entire treatment timeframe (model Period 2, refer to Table 1); however, the length of treatment (model Period 2) was varied between 10 years, and 20 years. During each of the treatment events, the model was able to instantaneously degrade contaminant mass that diffused out of the bedrock matrix into the fracture zone over the entire plume length. For simplicity, the elevated decay rates from the original plume remediation model were also used for this assessment (Table 2). This original artificial plume removal model is referenced as the 1-year model in this discussion and the remainder of this memorandum. The extended artificial plume removal scenarios decay rate assumed that CVOCs would degrade at natural attenuation rates within the bedrock zone over the idealized treatment period. Post-treatment, decay rates in both the fracture and bedrock zones were set to zero, to be consistent with the baseline and artificial plume removal (1-year) models.

Charts 5A through 5C present total CVOC mass versus time for the extended artificial plume removal scenarios. Note, these charts are presented using a log-scale given the range in model output. Similar to the original artificial plume removal (1-year) model, total CVOC mass rebounds relatively quickly in the fracture zone following idealized treatment in all of the extended removal scenarios (Figure 5A). As stated in Section 5.2, under the 1-year removal scenario, contaminant mass in the fracture zone reaches maximum stable conditions 15 years after idealized fracture treatment. In comparison, under the 10-year and 20-year removal scenarios, contaminant mass in the fracture zone rebounds to stable conditions within 20 years. Total CVOC mass in both the fracture and bedrock zones decreased in proportion to the length of the idealized fracture treatment period. Increasing the length of the idealized treatment period (model Period 2) to 10 years and 20 years resulted in a 2-time and 4-time decrease in total mass, respectively. Nevertheless, as discussed in Section 5.2, the mass reduction observed in these idealized treatment scenarios is considered to be overestimated based on the model assumption of nearly instantaneous contaminant removal in the fracture during treatment.

Charts 6A through 6E present TCE concentrations in the fracture zone versus time at five locations along the model plume: 5 meters, 55 meters, 155 meters, 255 meters, and 355 meters. Mass discharge trends are not shown, as they show the same pattern as the TCE concentrations trend charts. The overall concentration trends for the 10-year, and 20-year treatment scenarios match the shape of the trends observed in the original artificial plume removal (1-year) model, but the magnitudes of the concentrations are lower. Near the source (5-meter distance), TCE concentrations rebound to their maximum post-treatment level within 5 years after idealized treatment has stopped, primarily because of back diffusion (Chart 6A). At the 55-meter distance, TCE concentrations rebound to their maximum post-treatment level within 13 years due to back diffusion and some plume advection (Chart 6B). In the mid-gradient and downgradient areas of the plume, TCE concentrations rebound the year after idealized fracture treatment is stopped and then continue to increase. This continued increase is mostly attributed to plume advection and the lack of biodegradation post-treatment.

The extended artificial plume removal scenarios also resulted in a decrease in TCE concentrations in the fracture zone, in comparison to the artificial plume removal (1-year) model results. However, unlike the total CVOC mass value, the magnitude of the decrease in concentrations varied with distance from the source. For the 10-year treatment period, TCE concentrations were 2 to 3 times lower than the artificial plume removal (1-year) model scenario. For the 20-year treatment period, TCE concentrations were 3 to 10 times lower than the artificial plume removal (1-year) model scenario. In both of the extended plume removal scenarios, the largest difference in TCE concentrations was observed in the downgradient portions of the plume.

Based on this evaluation, an extended fracture treatment period would lower the observed matrix diffusion effects at the Delta Area. As expected, the magnitude of the impact is related to how much the idealized treatment period duration is increased. A larger impact was observed on the TCE concentrations, particularly the downgradient portion of the plume, than on the total CVOC mass.

7. Assessment of Matrix Diffusion Findings on High Concentration Area Plume Remediation Scenarios

Following the matrix diffusion evaluations, the REMChlor-MD model was used to assess the impact of more realistic remediation of the highest VOC concentrations within the dissolved plume. As discussed in Sections 5 and 6, in order to isolate the effects of matrix diffusion-only, idealized treatment was applied to the previous model scenarios. However, these scenarios were unrealistic in that they assumed instantaneous decay within the fracture domain over the entire plume length. This remediation assessment was conducted to evaluate the following model objective:

- If VOCs within the fractures are remediated over the area with the highest concentrations, then what is the reduction in contaminant mass and concentrations compared to natural attenuation alone, given the back diffusion effects at the site?

To develop a more realistic basis for this assessment, it was assumed that contamination would return to natural decay rates after high concentration area remediation ceased. As discussed in earlier sections of this technical memorandum, the previous REMChlor-MD models for the Delta Area assumed that no degradation occurred after the idealized treatment period to focus on matrix diffusion effects. However, it is more likely that natural degradation will continue after active remediation. Therefore, for comparison purposes, the following model scenarios were developed with the assumption that decay rates would return to natural attenuation rates after treatment instead of being set to zero.

- Baseline with Natural Attenuation: The baseline model described in Section 4 was used as the basis for this model scenario. The original baseline model was modified to simulate natural degradation throughout the entire model duration.

- Artificial 20-year Treatment with Natural Attenuation: The 20-year artificial plume removal model was used as the basis for this model scenario. For the 20-year treatment period, an unrealistic instantaneous treatment decay rate was still used. However, the treatment zone (model zone 1) was reduced from the entire plume to only the highest concentration area (125 feet or 38 meters). The 125-foot zone includes the highest VOC concentrations. Also, the model was simulated with natural degradation after the idealized treatment period.

- Remediation - Scenario 1: This model simulation was identical to the Artificial 20-year Treatment with Natural Attenuation model, described in the bullet above, with one exception. For the treatment period, a decay rate consistent with 90% TCE reduction every 10 years (first-order decay rate of 0.23 per year) was used.

- Remediation - Scenario 2: This model simulation was identical to the Artificial 20-year Treatment with Natural Attenuation model, described previously, with one exception. For the treatment period, a decay rate consistent with 90% TCE reduction every year (first-order decay rate of 2.3 per year) was used.

The results from the two remediation scenarios were compared to the results from the Baseline with Natural Attenuation model and the Artificial 20-year Treatment with Natural Attenuation model. Charts 7A and 7B present total CVOC mass versus time in the fracture and bedrock domains of the model, respectively. In all model scenarios, the amount of VOC mass in the bedrock matrix was about three orders of magnitude higher than in the dissolved phase fracture domain. Although difficult to discern in the trend charts, the total CVOC mass in the fractures and the bedrock were slightly lower under the source remediation scenarios (decay rates of 2.3 per year and 0.23 per year) than under the Baseline with Natural

Attenuation model. For example, at model year 90, the TCE mass in the fracture domain was estimated at 1.124 kilograms (kg) for the baseline model, 1.123 for Remediation Scenario 1 (0.23 per year), and 1.119 for Remediation Scenario 2 (2.3 per year). The TCE mass in the bedrock domain at model year 90 was estimated at 2,027 kg for the baseline model, 2026 for Remediation Scenario 1 (0.23 per year), and 2,020 kg for Remediation Scenario 2 (2.3 per year). Because the majority of contaminant mass is present within the bedrock matrix by the time that the remediation is implemented, even treating the dissolved contamination at an unrealistic decay rate (Artificial 20-year Treatment) only decreases the total mass by about 30%.

Charts 8A through 8E present TCE concentrations in the fracture zone versus time at five locations along the model plume (5 meters, 55 meters, 155 meters, 255 meters, and 355 meters). The concentration trends for the two remediation scenarios match the shape of the trends observed in the Baseline with Natural Attenuation model, but the magnitudes of the concentrations are slightly lower. Similar to the mass trends, the difference is so small that it is difficult to visually observe the difference in the trend charts. Near the source at the 5-meter distance, at the 55-meter distance, and at the 155-meter distance, TCE concentrations steadily decrease with time over the 200-year simulation period. In the more downgradient areas of the plume (255 meters and 355 meters), TCE concentrations show some increase before decreasing with time. This increase is primarily attributed to plume advection. The TCE concentrations are lower under the Artificial 20-year Treatment with Natural Attenuation model, but the slope and shape of the concentration curves match the remediation scenarios model runs. In addition, after the idealized treatment stops, concentration rebound is nearly instantaneous; this rebound is attributed to back diffusion.

8. Conclusions

A modeling assessment was conducted for CVOCs in groundwater at the Delta Area at SSFL using REMChlor-MD. Because groundwater contamination is present in a fractured bedrock environment at SSFL, it is subject to matrix diffusion effects, which can hinder the effectiveness of active treatment and increase remediation timeframes. To support the CMS at SSFL, the modeling assessment was conducted to evaluate the potential effects of matrix diffusion if dissolved CVOC contamination in the fractures was artificially removed via idealized (instantaneous) treatment across the entire plume. Although this level of treatment is unrealistic, it was used in the model to isolate the effects of matrix diffusion. The matrix diffusion modeling assessment results are summarized as follows:

- The estimated total CVOC mass was approximately three orders of magnitude higher within the low-permeability bedrock zone than in the transmissive fracture zone of the model.
- Following idealized (instantaneous) treatment of dissolved contamination in the fractures at SSFL across the entire plume, matrix back diffusion occurred relatively quickly in the model. TCE concentrations rebounded to their maximum post-treatment concentration within 5 years. Total CVOC mass rebounded and stabilized within15 years.
- When the artificial removal period was elongated, the observed magnitude of matrix diffusion effects were lower within the model. Total CVOC mass in both the fracture and bedrock zones decreased. Increasing the treatment period to 10 years, and 20 years resulted in a 2-time, and 4-time decrease in total mass, respectively. TCE concentrations within the fracture zone of the model also decreased. However, unlike the total CVOC mass, the difference in the magnitude of TCE concentrations varied with distance from the source. TCE concentrations were 2 to 15 times lower close to the source but were 3 to 300 times lower than the original plume remediation model in the downgradient plume.

Following the matrix diffusion evaluation, the REMChlor-MD model was used to assess the beneficial impacts of remediation to support treatment strategy decisions. The remediation modeling assessment results indicated that there was no meaningful change in VOC mass or TCE concentrations within fractures when applying more a realistic rate for remediation to the high concentration area of the plume. Given the magnitude of VOC mass residing within the bedrock matrix relative to the fractures, the influence of back-diffusion of contaminants from the matrix overwhelm any concentration or mass reduction due to treatment. As a semi-analytical model, REMChlor-MD incorporates several simplifying assumptions. Furthermore, to focus on matrix diffusion effects, the model SCM for the Delta Area was simplified by removing the source discharge factor approximately 20 years before plume fracture treatment and removing biodegradation after plume fracture treatment was completed. Therefore, it is assumed that there will be differences between the model output and actual future concentrations in groundwater at the Delta Area. The Delta Area could also be considered a worst-case scenario, given the very high concentrations and mass present in this area. However, similar model trends would likely be observed at areas with lower contaminant concentrations and mass. Nevertheless, the REMChlor-MD results can be used to assess how matrix diffusion may affect the outcome of different remedial actions at SSFL and provide support for planning-level decisions for different target treatment areas.

9. References

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10. Attachments

Tables

Figure

Charts

Tables

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Table 1. Delta AIG Summary of Input Parameters for REMChlor-MD Modeling

REMChlor-MD Model, SSFL, Ventura County, California

Input Parameter	Units	Value	Reference
Model Configuration			
X-Direction (in direction of groundwater			
Cell Size	meter	10	Assumption
Model Size	meter	390	Approximate 20 meters longer than the length of TCE plume in the CFGW aquifer from source area well C-6 based on 2015 data
Y-Direction (transverse to groundwater flow)	meter		
Cell Size	meter	10	Assumption
Model Size	meter	360	Approximately 10 meters wider than width of TCE plume downgradient from monitoring well C-6 in the CFGW aquifer based on 2015 data
Z-Direction (vertical) (all layers have same hydrogeology)			
Cell Size	meter	20	Assumption
Model Size	meter	120	Approximate TCE plume thickness based on ND-169 boring sampling
Observation Well	meter		
Location X Value	meter	380	Edge of TCE plume; approximate distance from source area well C-6 to downgradient edge of plume based on 2015 data
Location Y-value	meter	0	Assume a centerline well
Z-Value Top of Screen	meter	120	Assume top of aquifer
Z-Value Bottom of Screen	meter	90	Based on SP-881 cluster
Starting Year of Simulation (year the source started)	year	1960	Consistent with timeframe used in NASA Solute Transport Model in the Groundwater CMS (2020a), area was active from 1957 to 1970; TCE release (45,000 gallons) reported between 1957 and 1961
Ending Year of Simulation	year	2160	200 years to 400 years
Media Characteristics (uniform for all cells)			
Hydrogeologic Setting	—	Sandstone	NASA Phase 1 Groundwater CMS (2020b)
Bulk Hydraulic Conductivity	cm/s	3.0E-05	Estimated value based on prelimary model run without source removal; Falls within range used for 3-D groundwater model of 1E-6 to 1E-4 cm/s (0.003 to 0.3 feet/day); lower than saturated hydraulic conductivity (K) value of 3.0E-04 cm/s (0.85 feet/day) used in NASA Solute Transport Model in the Groundwater CMS (2020a)
Fracture Effective Porosity	—	1	REMChlor-MD User's Manual recommendation (Farhat et al. 2018)
Transmissive Zone Tortuosity	—	1	REMChlor-MD User Guide recommendation (Farhat et al. 2018)
Matrix Total Porosity	—	0.14	NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a); MWH 2009
Matrix Tortuosity	—	0.13	NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a); MWH 2009
Hydraulic Gradient	meters/ meter	0.019	Value used in NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a)
Bulk Groundwater Darcy Velocity	meters/	Refer to Model	Internal Model Calculation

Table 1. Delta AIG Summary of Input Parameters for REMChlor-MD Modeling

REMChlor-MD Model, SSFL, Ventura County, California

Input Parameter	Units	Value	Reference
Matrix Diffusion			
Calculate Heterogeneity			
Upper and Lower Aquitards	—	No Matrix Diffusion in Under- and Overlying Low-k Units	Assume matrix diffusion is only occurring within the fractured aquifer system itself
Typical distance between parallel fractures	meter	0.763	Equates to diffusion length of 1.25 feet (0.381 m); NASA Screening-level Solute Transport Model Groundwater CMS (2020a); distances observed in C-15 log ranged between 0.006 m and 5.5 m (0.02 foot and 18 feet)
Typical thickness of aperture/fracture	meter	6.5E-05	Calculated based on relationship between fracture aperture, fracture spacing, fracture conductivity and equivalent porous media conductivity
Fracture Volume Fraction	%	Refer to Model	Internal Model Calculation
Average Diffusion Length	feet	Refer to Model	Internal Model Calculation
Surface Area of Matrix Interfaces	$meter^2$	Refer to Model	Internal Model Calculation
Contaminants and Source Term			
TCE (Parent)			
Initial Source Concentration	µg/L	1,100,000	Approximate water solubility, Soil Screening Guidance: User's Guide (EPA 1996); consistent with NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a)
Source Mass at Time of Release	kg	1.55E+05	Delta area groundwater mass estimate; NASA Coca/Delta AIG Data Evaluation Report; Volume 5 in the NASA Groundwater RFI Report (2020)
Fracture Retardation Factor	—	1.31	Assume retardation is occurring to a lesser degree within the fractures
Matrix Retardation Factor	—	1.62	Calculated using Retardation Equation
Dry Bulk Density, ρb	cm^3/g	2.28	Computed value in Screening-level NASA Solute Transport Model in the Groundwater CMS (2020a)
TCE Partition Coefficient, Koc	cm^3/g	137	Jeng et al. 1992
Fraction Organic Carbon, foc	—	0.00028	NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a); MWH 2009
cis-1,2-DCE (Degradation Product 1)			
Initial Source Concentration	µg/L	0	Assume not component of initial source release
Source Mass at Time of Release	kg	0	Assume not component of initial source release
Fracture Retardation Factor	—	1.18	Assume retardation is occurring to a lesser degree within the fractures
Matrix Retardation Factor	—	1.36	Calculated using Retardation Equation
cis-1,2-DCE Partition Coefficient, Koc	cm^3/g	80	Jeng et al. 1992

Table 1. Delta AIG Summary of Input Parameters for REMChlor-MD Modeling
REMChlor-MD Model, SSFL, Ventura County, California

Input Parameter	Units	Value	Reference
Vinyl Chloride (Degradation Product 2)			
Initial Source Concentration	µg/L	0	Assume not component of initial source release
Source Mass at Time of Release	kg	0	Assume not component of initial source release
Fracture Retardation Factor	—	1.13	Assume retardation is occurring to a lesser degree within the fractures
Matrix Retardation Factor	—	1.26	Calculated using Retardation Equation
VC Partition Coefficient, Koc	cm^3/g	57	Jeng et al. 1992
Source Width	meter	40	Assume Delta Skim Pond is primary source; Figure 2-35 of the Coca/Delta AIG Data Evaluation Report; Volume 5 in the NASA Groundwater RFI Report (2020c)
Z-Value for Top of Source	meter	120	Top of 50,000 ug/L contour at potentiometric surface; Figure 2-48 of the Coca/Delta AIG Data Evaluation Report; Volume 5 in the NASA Groundwater RFI Report (2020c); REMChlor-MD assumes the bottom of the model domain is at Z = 0
Z-Value for Bottom of Source	meter	80	Bottom of 50,000 ug/L contour; Figure 2-48 of the Coca/Delta AIG Data Evaluation Report; Volume 5 in the NASA Groundwater RFI Report (2020c); REMChlor-MD assumes the bottom of the model domain is at Z = 0
General Molecular Diffusion Coefficient for Constituents	cm^2/s	0.0000091	REMChlor-MD Default Value; matches value used in NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a)
Plume Degradation			
Time Period 1 (T1)	year	65	Assume contamination in fractures is removed in Year 2025.
Time Period 2 (T2)	year	66	Assume treatment occurs over a 1-year period.
Zone 1 Distance from Source - Matrix Diffusion	meter	380	Used for matrix diffusion evaluation; Edge of TCE plume; approximate distance from source area well C-6 to downgradient edge of plume based on 2015 data
Zone 1 Distance from Source - High Concentration Remediation	meter	38	Used for high concentration remediation model runs; Equates to a 125-foot zone.
Zone 2 Distance from Source	meter	390	Arbitrary
Microbial Yield			
TCE	—	0.54	Based on ratio between TCE and cis-1,2-DCE at source area location ND-169 boring (250-305 foot interval)
cis-1,2-DCE	—	0.02	Based on ratio between cis-1,2-DCE and VC at source area location ND-169 boring (250-305 foot interval)
Decay Rate	1/year	Refer to Table 2	
Plume Transport			
Longitudinal Dispersity	foot	3	Assumed value from NASA Screening-level Solute Transport Model in the Groundwater CMS (2020a)
Transverse Dispersity	meter	0.3	Assume alpha y = 0.1 * alpha x
Vertical Dispersity	meter	0.15	Assume alpha z = 0.05 * alpha x

Table 1. Delta AIG Summary of Input Parameters for REMChlor-MD Modeling
REMChlor-MD Model, SSFL, Ventura County, California

Input Parameter	Units	Value	Reference
Source Zone Remediation			
% Source Mass Removed by Remediation	%	100	Assume all of remaining source mass is removed to simplify source component of model and assess matrix diffusion effects alone; During preliminary model runs source component was observed to have strong impact on the model output
Remediation Started in Year	year	40	Assume source removed by year 2000, which is ~25 years before plume treatment
Remediation End in Year	year	40	
Mass Flux/Remaining Mass Term (Gamma)	—	1	Assume linear relationship between source mass and source discharge
Natural Source Decay Rate	1/year	0	Assume no source decay beyond flushing to simplify source component of model; entire (remaining) source mass is removed from model before source treatment
Modeling Parameters			
Timestep Size	year	1	Varies by model simulation between 1 and 10 years
Maximum Number of Iterations	—	500	Default model value
Convergence Tolerance	µg/L	0.02	Default model value
See Results Every	year	1	Varies by model simulation between 1 and 10 years

— = not applicable
µg/L = microgram(s) per liter
CFGW = Chatsworth Formation Groundwater
cm^3/g = cubic centimeter(s) per gram
CMS = Corrective Measures Study
DCE = dichloroethene
kg = kilogram(s)
m = meter(s)
REMChlor-MD = Remediation Evaluation Model with Matrix Diffusion for Chlorinated Solvents
TCE = trichloroethene
VC = vinyl chloride

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Table 2. Delta AIG Summary of Decay Rates for REMChlor-MD Modeling
REMChlor-MD Model, SSFL, Ventura County, California

Chemical/ Period	Decay Rate Zones 1, 2, and 3 (1/year)	Media	Reference
Baseline Model Run			
TCE			
Period 1	0.07	T-Zone (fracture)	Estimated value based on preliminary model run without source removal; falls within same order of magnitude of abiotic plus biotic decay rates in literature: pseudo-first-order rate for abiotic transformation for TCE of 0.038 ± 0.011 year−1 (95% confidence interval) (Yu et al. 2018); abiotic rate for TCE of 8.7 ± 2.1 year−1 in unamended microcosms and 5.4 ± 1.1 year−1 in autoclaved controls in crushed sandstone (Darlington et al. 2013); average initial rate coefficient for complete dechlorination of TCE estimated as 0.019 year−1 in unamended microcosms (Yu et al. 2020)
Period 1	0.07	Low-k Zone (matrix)	Same as transmissive zone
Period 2	0.07	T-Zone (fracture)	Same as period 1
Period 2	0.07	Low-k Zone (matrix)	Same as period 1
Period 3	0	T-Zone (fracture)	Assume no decay for comparison to artificial removal model runs
Period 3	0	Low-k Zone (matrix)	Assume no decay for comparison to artificial removal model runs
cis-1,2-DCE			
Period 1	0.05	T-Zone (fracture)	Estimated value based on preliminary model run without source removal; Falls within same order of magnitude of abiotic plus biotic decay rates in literature: Pseudo-first-order rate for abiotic transformation for cis-DCE is 0.044 ± 0.022 year−1 (95% confidence interval) (Yu et al. 2018); first Order Decay range of 0 to 0.130/day (47/year) field/in-situ studies (Suarez and Rifai 1999)
Period 1	0.05	Low-k Zone (matrix)	Same as transmissive zone
Period 2	0.05	T-Zone (fracture)	Same as period 1
Period 2	0.05	Low-k Zone (matrix)	Same as period 1
Period 3	0	T-Zone (fracture)	Assume no decay for comparison to artificial removal model runs
Period 3	0	Low-k Zone (matrix)	Assume no decay for comparison to artificial removal model runs
VC			
Period 1	1	T-Zone (fracture)	Estimated value based on preliminary model run without source removal; calibrated to 2015 plume (Model Year 55); falls within same order of magnitude of biotic decay rates in literature: First Order Decay range of 0 to 0.052/day (19/year) field/in situ studies (Suarez and Rifai 1999)
Period 1	1	Low-k Zone (matrix)	Same as transmissive zone
Period 2	1	T-Zone (fracture)	Same as period 1
Period 2	1	Low-k Zone (matrix)	Same as period 1
Period 3	0	T-Zone (fracture)	Assume no decay for comparison to artificial removal model runs
Period 3	0	Low-k Zone (matrix)	Assume no decay for comparison to artificial removal model runs

Table 2. Delta AIG Summary of Decay Rates for REMChlor-MD Modeling

REMChlor-MD Model, SSFL, Ventura County, California

Chemical/ Period	Decay Rate Zones 1, 2, and 3 (1/year)	Media	Reference
Artificial Removal of Contaminants Model Runs			
TCE			
Period 1	0.07	T-Zone (fracture)	Same as Baseline Model Run
Period 1	0.07	Low-k Zone (matrix)	Same as Baseline Model Run
Period 2	1.00E+08	T-Zone (fracture)	Decay rate was artificially increased to deplete TCE concentrations below 1 µg/L within fractures within 1 year treatment time period (note, even with lengthened treatment period, decay rate had to be increased substantially due to very high concentrations in the plume)
Period 2	0.07	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0	T-Zone (fracture)	Assume no decay for all model runs to focus on matrix diffusion effects
Period 3	0	Low-k Zone (matrix)	Assume no decay for all model runs to focus on matrix diffusion effects
cis-1,2-DCE			
Period 1	0.05	T-Zone (fracture)	Same as Baseline Model Run
Period 1	0.05	Low-k Zone (matrix)	Same as Baseline Model Run
Period 2	1.00E+08	T-Zone (fracture)	Decay rate was artificially increased to deplete TCE concentrations below 1 µg/L within fractures within 1 year treatment time period
Period 2	0.05	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0	T-Zone (fracture)	
Period 3	0	Low-k Zone (matrix)	Assume no decay for all model runs to focus on matrix diffusion effects
VC			
Period 1	1	T-Zone (fracture)	Same as Baseline Model Run
Period 1	1	Low-k Zone (matrix)	Same as Baseline Model Run
Period 2	1.00E+06	T-Zone (fracture)	Decay rate was artificially increased to deplete TCE concentrations below 1 µg/L within fractures within 1 year treatment time period
Period 2	1	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0	T-Zone (fracture)	Assume no decay for all model runs to focus on matrix diffusion effects
Period 3	0	Low-k Zone (matrix)	Same as transmissive zone
Highest Concentration Zone Remediation - Scenario 1			
TCE			
Period 1	0.07	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	0.07	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	0.23	T-Zone (fracture)	Equates to approximately 90% TCE reduction in the fractures every 10 years
Period 2	0.07	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0.07	T-Zone (fracture)	Same as period 1
Period 3	0.07	Low-k Zone (matrix)	Same as transmissive zone
cis-1,2-DCE			
Period 1	0.05	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	0.05	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	0.23	T-Zone (fracture)	Same as value used for TCE
Period 2	0.05	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0.05	T-Zone (fracture)	Same as period 1
Period 3	0.05	Low-k Zone (matrix)	Same as period 1
VC			
Period 1	1	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	1	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	0.23	T-Zone (fracture)	Same as value used for TCE
Period 2	1	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	1	T-Zone (fracture)	Same as period 1
Period 3	1	Low-k Zone (matrix)	Same as period 1

Table 2. Delta AIG Summary of Decay Rates for REMChlor-MD Modeling

REMChlor-MD Model, SSFL, Ventura County, California

Chemical/ Period	Decay Rate Zones 1, 2, and 3 (1/year)	Media	Reference
Highest Concentration Zone Remediation - Scenario 2			
TCE			
Period 1	0.07	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	0.07	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	2.3	T-Zone (fracture)	Equates to approximately 90% TCE reduction in the fractures every year
Period 2	0.07	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0.07	T-Zone (fracture)	Same as period 1
Period 3	0.07	Low-k Zone (matrix)	Same as period 1
cis-1,2-DCE			
Period 1	0.05	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	0.05	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	2.3	T-Zone (fracture)	Same as value used for TCE
Period 2	0.05	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	0.05	T-Zone (fracture)	Same as period 1
Period 3	0.05	Low-k Zone (matrix)	Same as period 1
VC			
Period 1	1	T-Zone (fracture)	Same as Baseline Model Run; Natural decay rate
Period 1	1	Low-k Zone (matrix)	Same as Baseline Model Run; Natural decay rate
Period 2	1	T-Zone (fracture)	Retained to be same as period 1.
Period 2	1	Low-k Zone (matrix)	Assume no enhanced treatment in bedrock matrix to focus on matrix diffusion impacts
Period 3	1	T-Zone (fracture)	Same as period 1
Period 3	1	Low-k Zone (matrix)	Same as period 1

Notes:

For the baseline model and artificial plume removal model (1-Year), the following time periods were used:

Period 1 = 0 to 65 years

Period 2 = 65 to 66 years

Period 3 = 66 to 200 years

Low-K Zone = low hydraulic conductivity zone

T-zone = transmissive zone

μg/L = microgram(s) per liter

DCE = dichloroethene

REMChlor-MD = Remediation Evaluation Model with Matrix Diffusion for Chlorinated Solvents

TCE = trichloroethene

TOR = time of remediation

References:

Darlington, R., L. G. Lehmicke, R. G. Andrachek, D. L. Freedman. 2013. "Anaerobic abiotic transformations of cis-1,2-dichloroethene in fractured sandstone." *Chemosphere* . 90: 2226–2232.

Suarez, M. P. and H. S. Rifai. 1999. *Biodegradation Rates for Fuel Hydrocarbons and Chlorinated Solvents in Groundwater. Bioremediation Journal* , 3(4): 337-362.

Yu, R., R. G. Andrachek, L. G. Lehmicke, D. L. Freedman. 2018. "Remediation of chlorinated ethenes in fractured sandstone by natural and enhanced biotic and abiotic processes: A crushed rock microcosm study." *Science of the Total Environment.* 626: 497-506. https://doi.org/10.1016/j.scitotenv.2018.01.064.

Yu, R., L. C. Murdoch, R. W. Falta, R. G. Andrachek, A. A. Pierce, B. L. Parker, J. A. Cherry, D. L. Freedman. 2020. "Chlorinated Ethene Degradation Rate Coefficients Simulated with Intact Sandstone Core Microcosms." *Environmental Science & Technology.* 54 (24): 15829-15839. DOI: 10.1021/acs.est.0c05083.

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Figure

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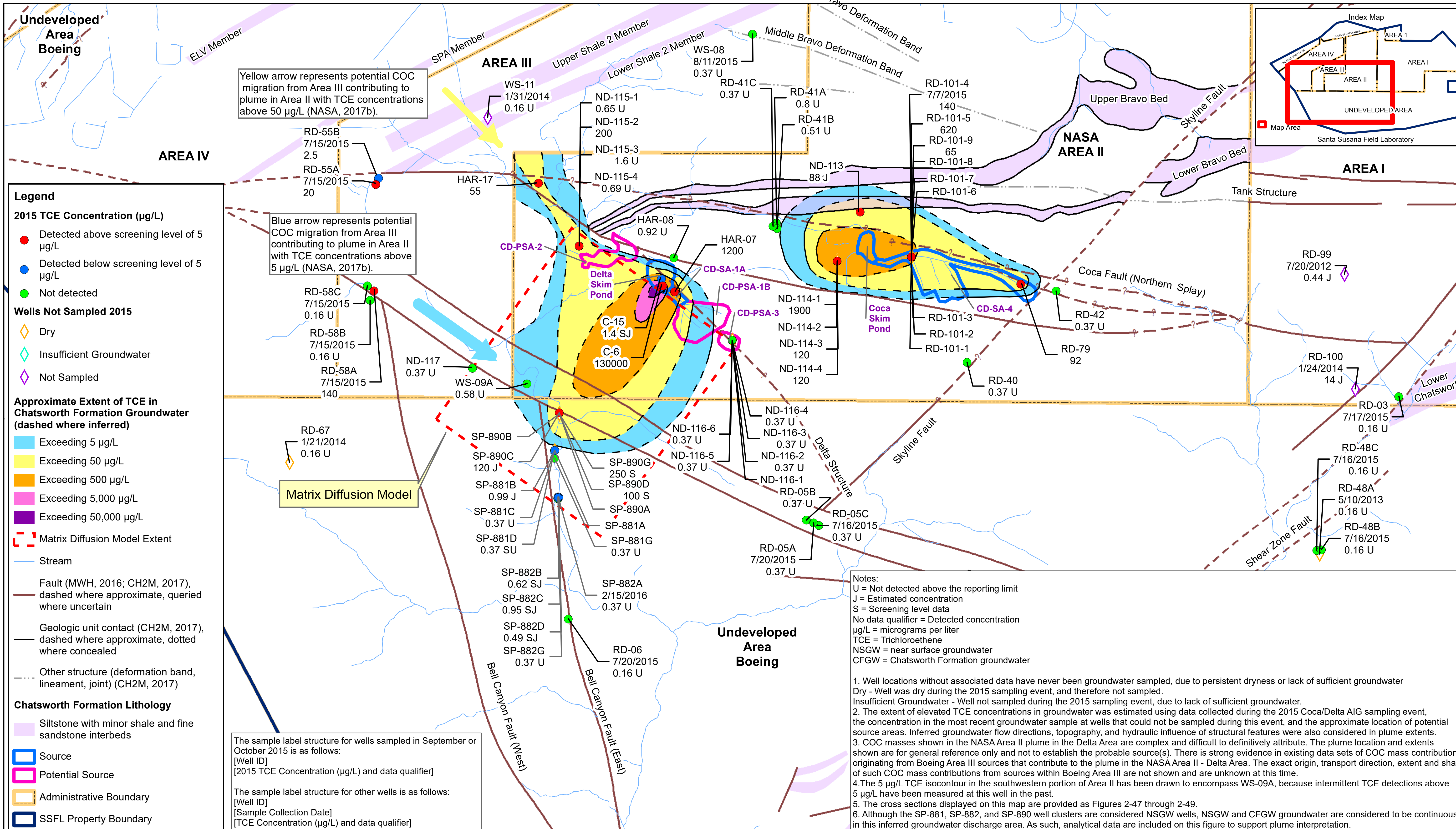

Figure 1
Extent of Trichloroethene in Coca/Delta AIG CFGW
Matrix Diffusion Modeling Assessment
NASA SSFL, Ventura County, California

Map Document: O:\NASA\SSFL\maps\Groundwater\RFI\CD_AIG-CFGW_MTXDiff.mxd

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Charts

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Chart 1: Baseline Model

Total VOC Mass vs. Time (Fracture and Bedrock Zones)

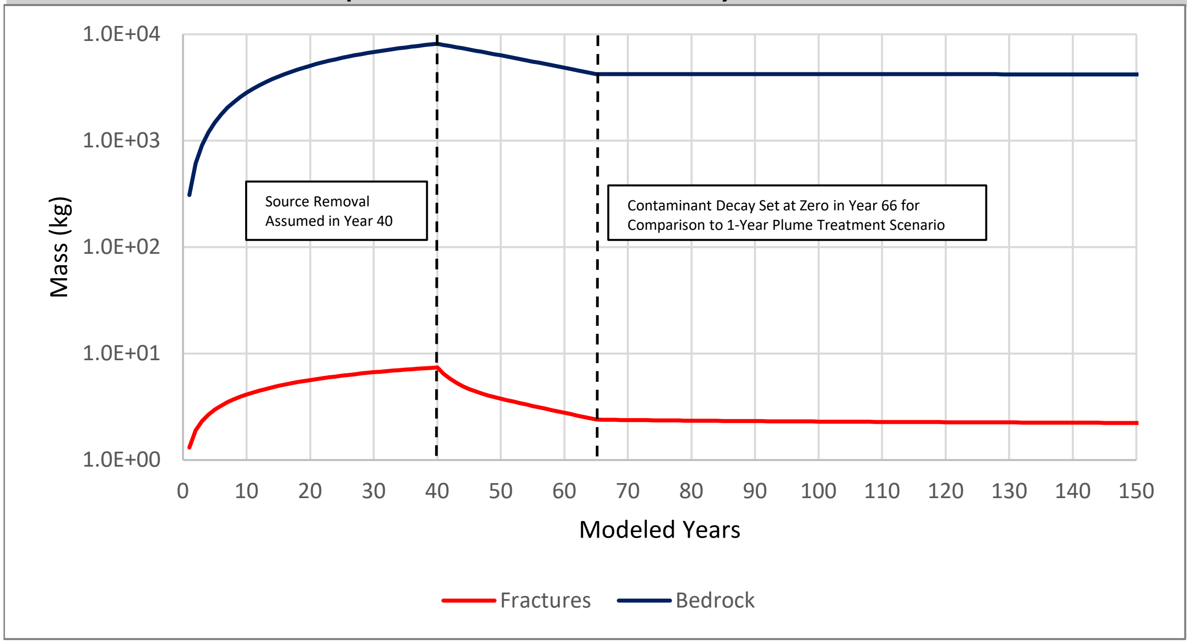


Chart 2A: Comparison of Baseline and Artificial Removal Models
Total VOC Mass vs. Time (Fracture Zone)

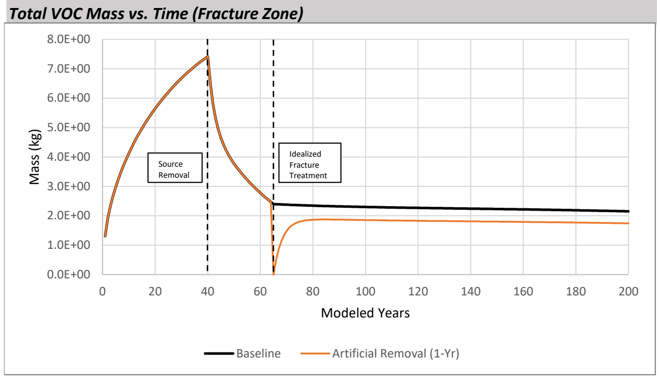


Chart 2B: Comparison of Baseline and Artificial Removal Models
Total VOC Mass vs. Time (Bedrock Matrix)

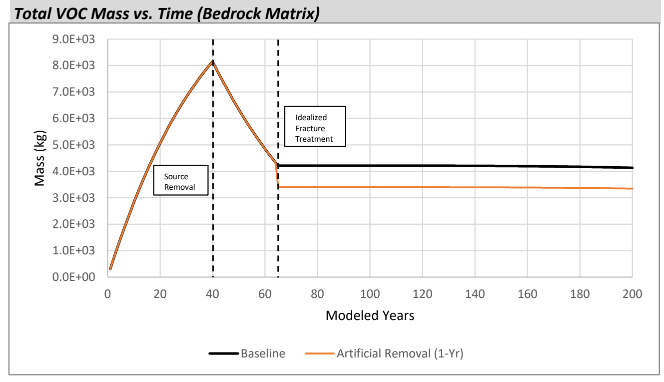


Chart 2C: Comparison of Baseline and Artificial Removal Models
Total VOC Mass vs. Time (Combined Fracture Zone and Bedrock Matrix)

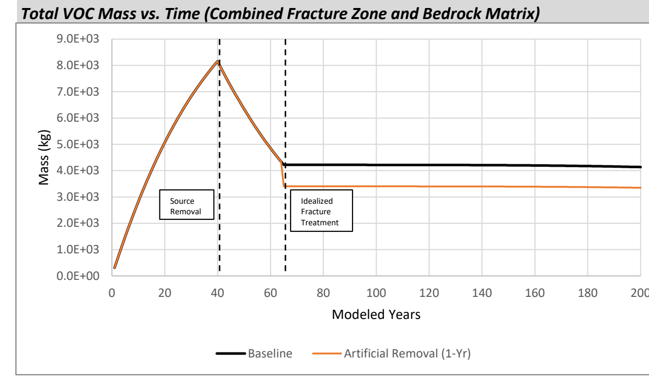


Chart 3A: Comparison of Baseline and Artificial Removal Models
TCE Concentration Fracture Zone Vs. Time (X= 5 m)

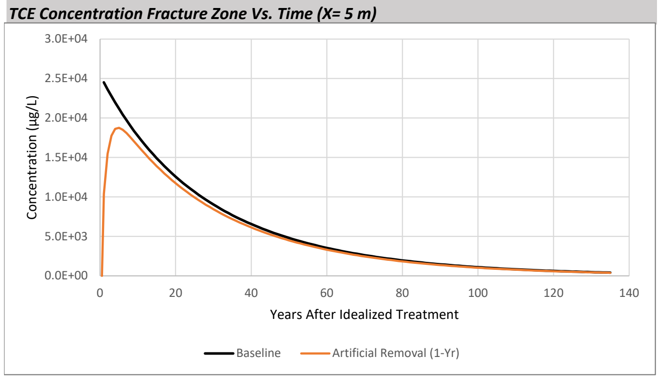


Chart 4A: Comparison of Baseline and Artificial Removal Models
TCE Mass Discharge Fracture Zone Vs. Time (X= 5 m)

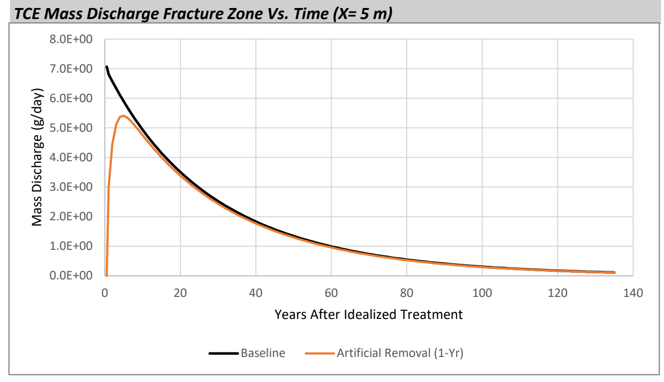


Chart 3B: Comparison of Baseline and Artificial Removal Models
TCE Concentration Fracture Zone Vs. Time (X= 55 m)

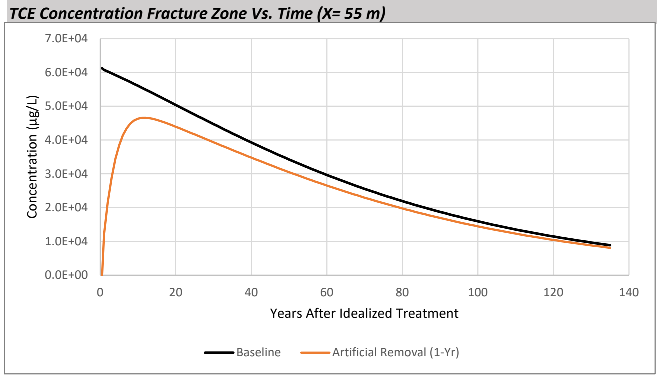


Chart 4B: Comparison of Baseline and Artificial Removal Models
TCE Mass Discharge Fracture Zone Vs. Time (X= 55 m)

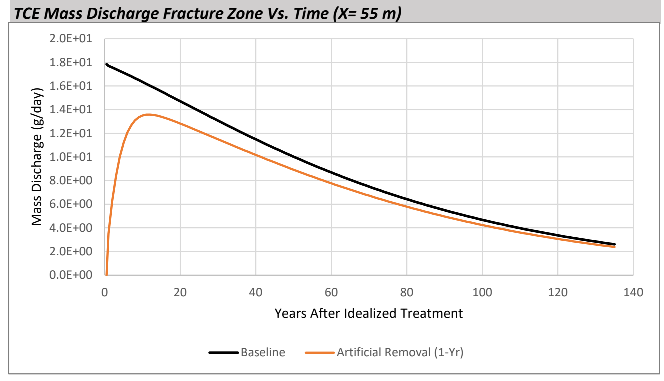


Chart 3C: Comparison of Baseline and Artificial Removal Models
TCE Concentration Fracture Zone Vs. Time (X= 155 m)

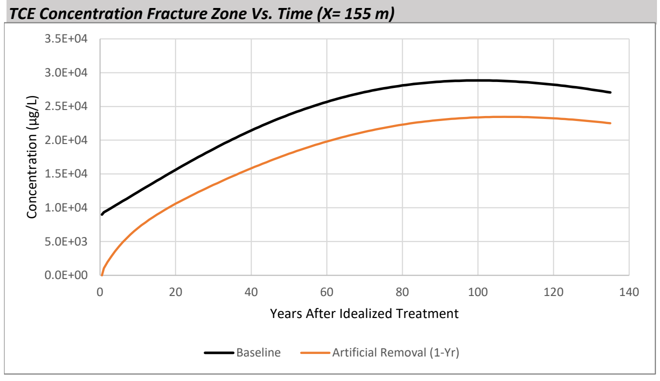


Chart 4C: Comparison of Baseline and Artificial Removal Models
TCE Mass Discharge Fracture Zone Vs. Time (X= 155 m)

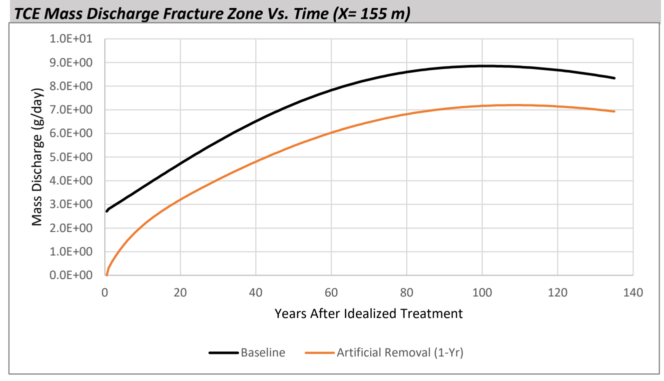


Chart 3D: Comparison of Baseline and Artificial Removal Models
TCE Concentration Fracture Zone Vs. Time (X= 255 m)

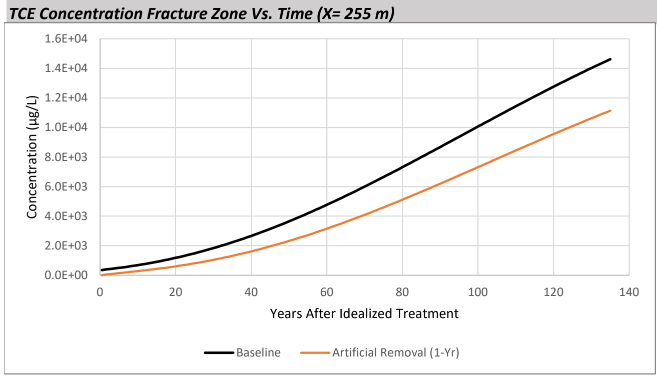


Chart 4D: Comparison of Baseline and Artificial Removal Models
TCE Mass Discharge Fracture Zone Vs. Time (X= 255 m)

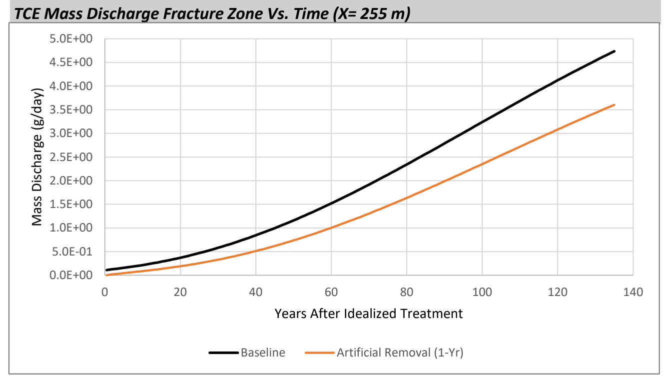


Chart 3E: Comparison of Baseline and Artificial Removal Models
TCE Concentration Fracture Zone Vs. Time (X= 355 m)

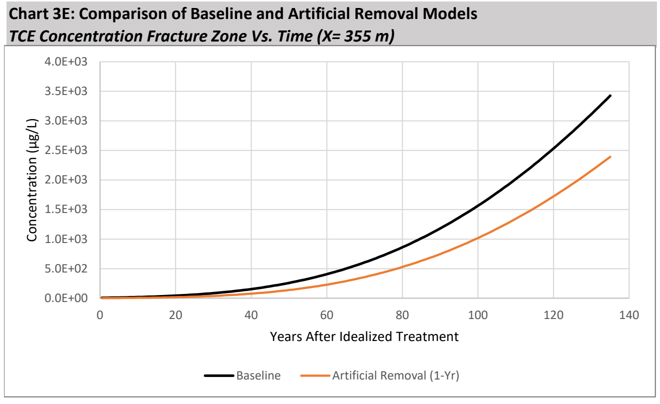


Chart 4E: Comparison of Baseline and Artificial Removal Models
TCE Mass Discharge Fracture Zone Vs. Time (X= 355 m)

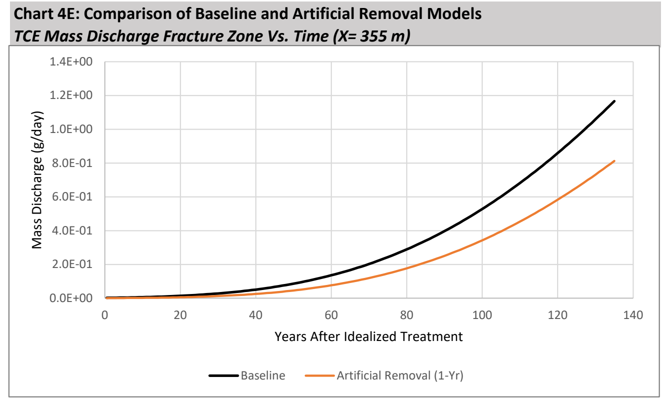


Chart 5A: Enhanced Artificial Plume Removal Scenarios
Total VOC Mass vs. Time (Fracture Zone); Log-Scale

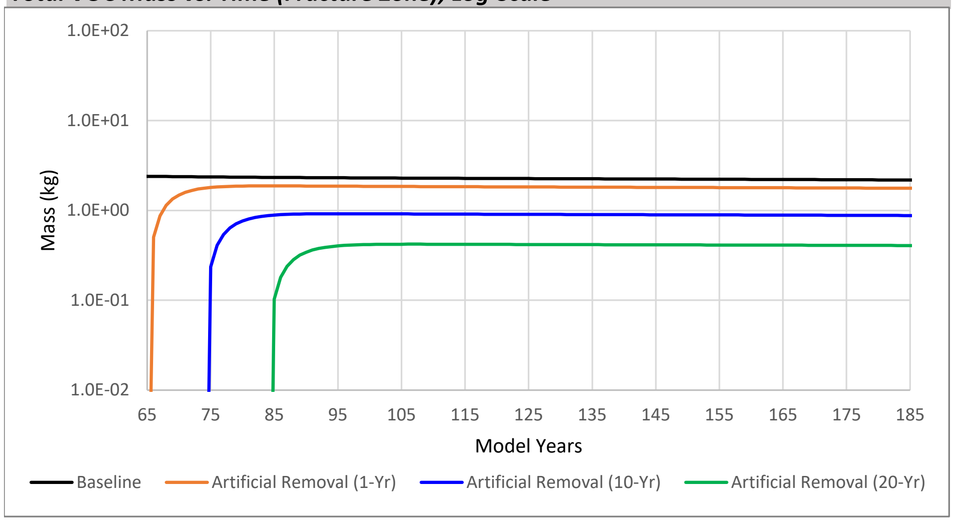


Chart 6A: Enhanced Artificial Plume Removal Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 5 m); Log-Scale

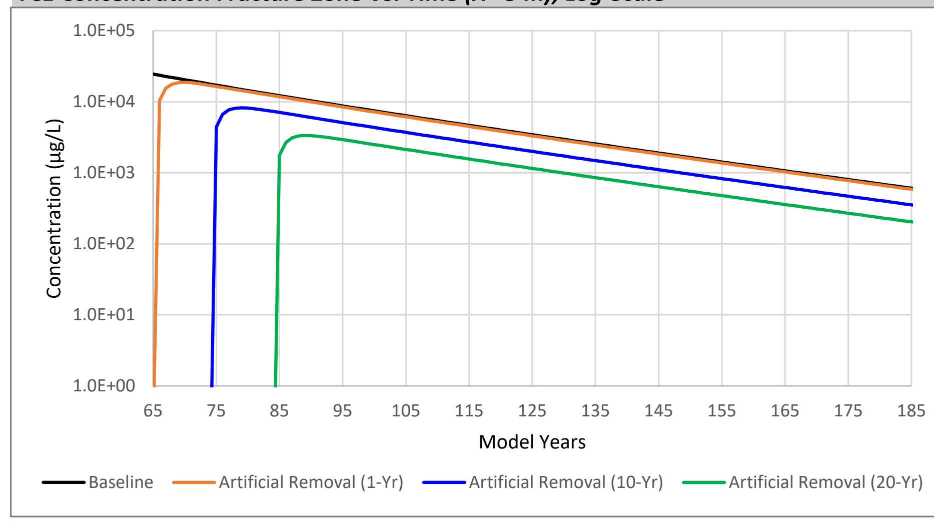


Chart 5B: Enhanced Artificial Plume Removal Scenarios
Total VOC Mass vs. Time (Bedrock Matrix); Log-Scale

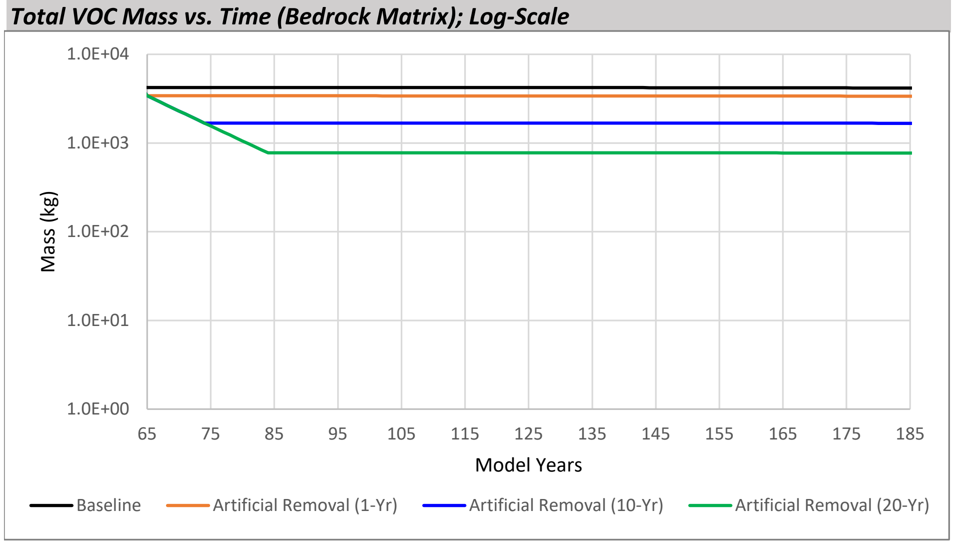


Chart 6B: Enhanced Artificial Plume Removal Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 55 m); Log-Scale

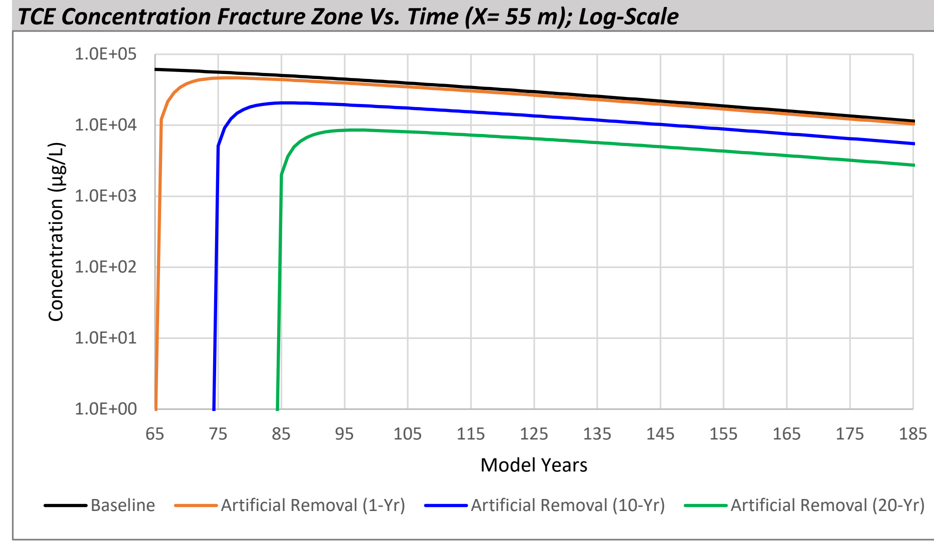


Chart 5C: Enhanced Artificial Plume Removal Scenarios
Total VOC Mass vs. Time (Combined Fracture Zone and Bedrock Matrix); Log-Scale

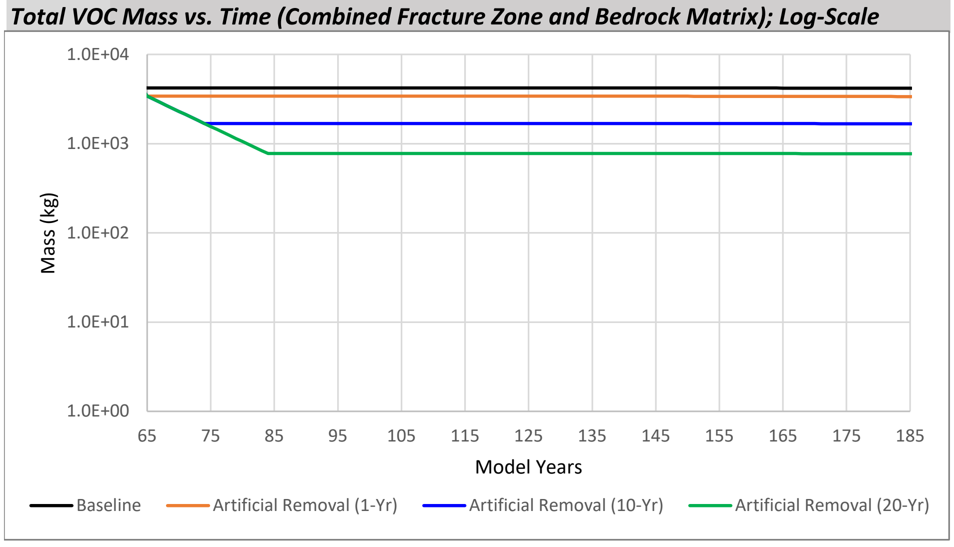
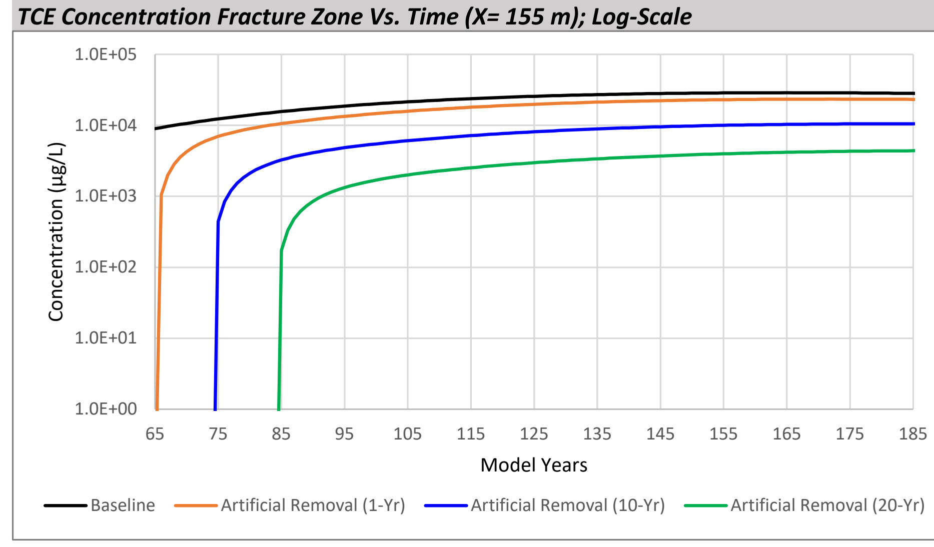


Chart 6C: Enhanced Artificial Plume Removal Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 155 m); Log-Scale



Note: Plume treatment applied to fractures over the following model years:
1 Yr = Model Year 65
10 Yr = Model Years 65 - 74
20 Yr = Model Years 65 - 84

Chart 6D: Enhanced Artificial Plume Removal Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 255 m); Log-Scale

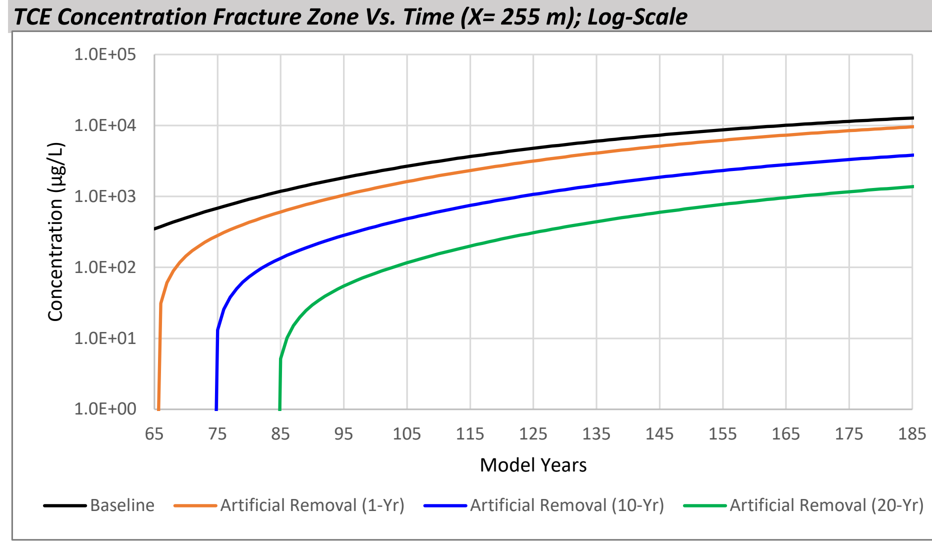


Chart 6E: Enhanced Artificial Plume Removal Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 355 m); Log-Scale

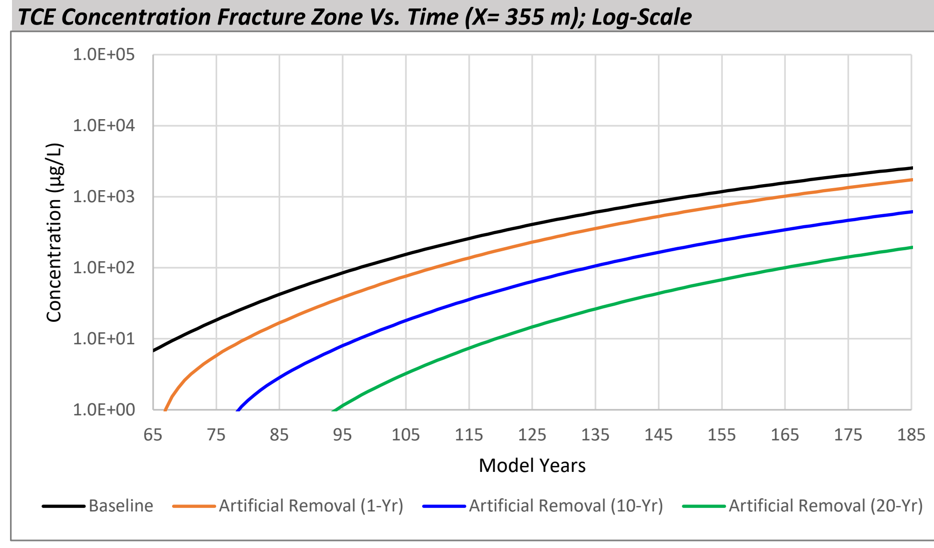


Chart 7A: Comparison of High Concentration Area Remediation Scenarios
Total VOC Mass vs. Time (Fracture Zone)

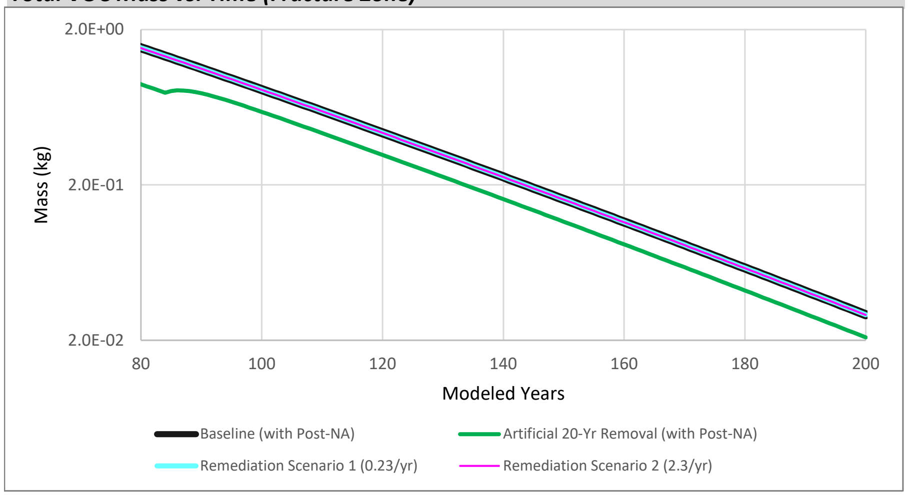


Chart 8A: Comparison of High Concentration Area Remediation Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 5 m); Linear-Scale

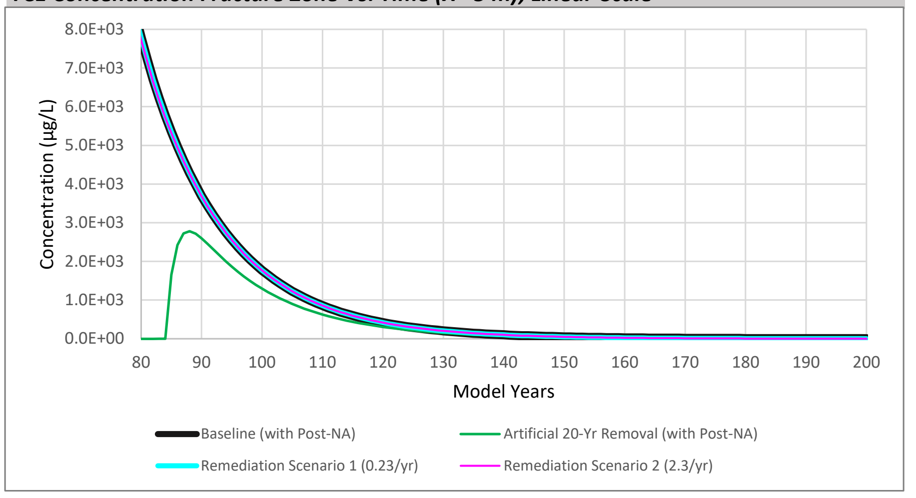


Chart 7B: Comparison of High Concentration Area Remediation Scenarios
Total VOC Mass vs. Time (Bedrock Matrix)

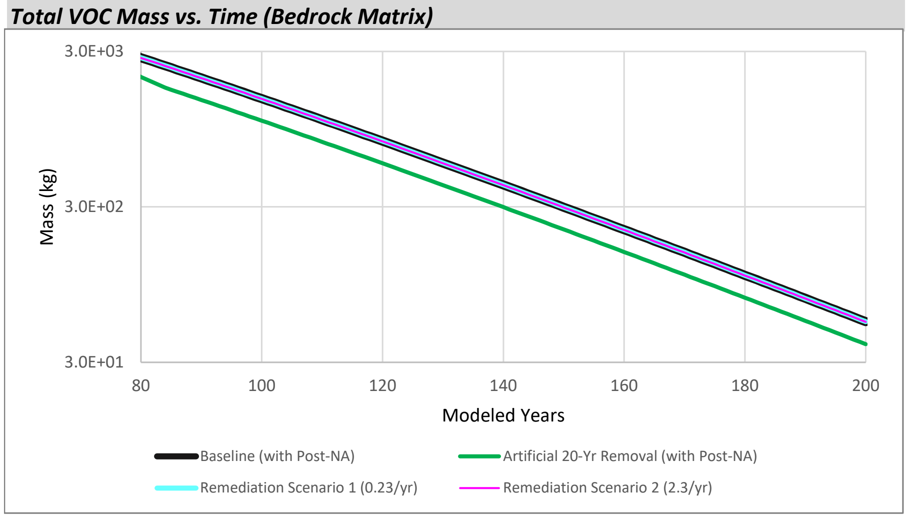
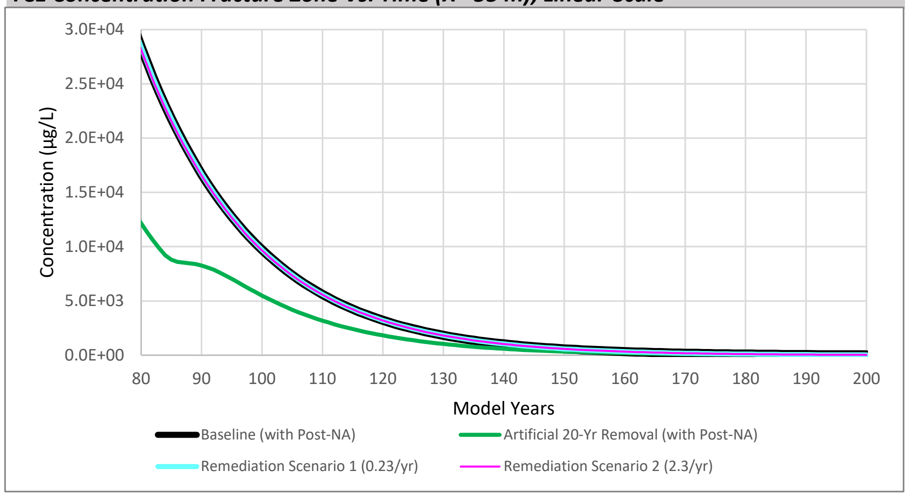


Chart 8B: Comparison of High Concentration Area Remediation Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 55 m); Linear-Scale



Note: Plume treatment applied to fractures over Model Years 65 - 84.

NA = natural attenuation degradation

Chart 8C: Comparison of High Concentration Area Remediation Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 155 m); Linear-Scale

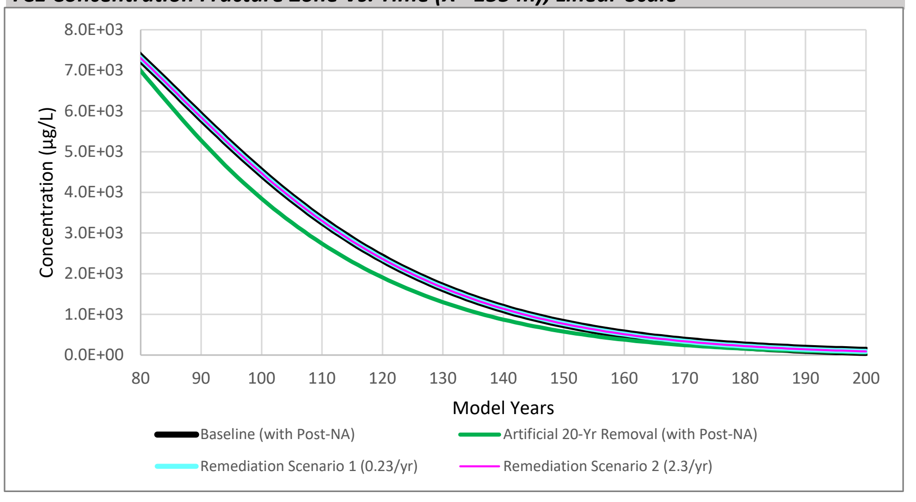


Chart 8D: Comparison of High Concentration Area Remediation Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 255 m); Linear-Scale

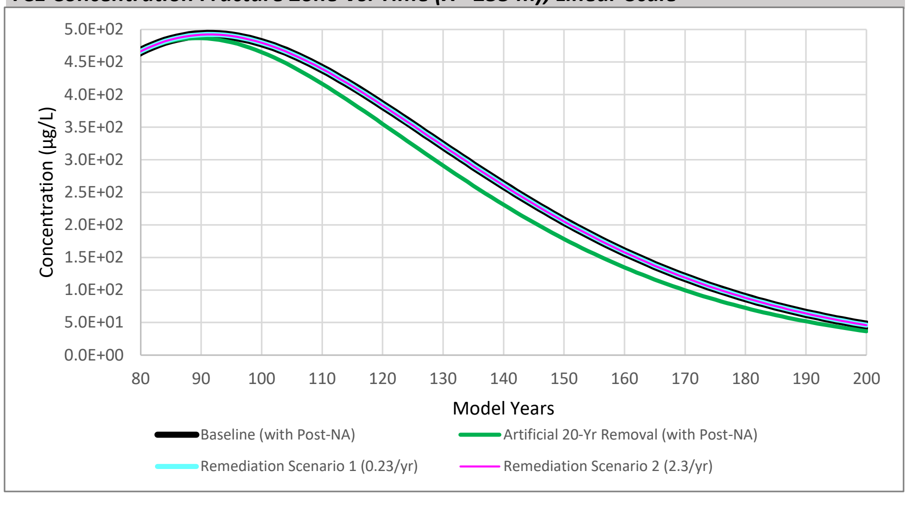
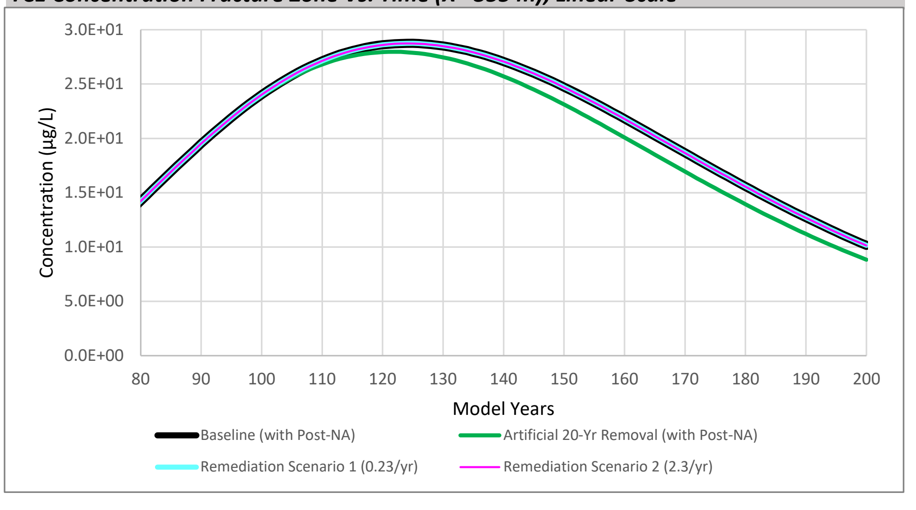


Chart 8E: Comparison of High Concentration Area Remediation Scenarios
TCE Concentration Fracture Zone Vs. Time (X= 355 m); Linear-Scale



Appendix J
Response to DTSC Comments on the May 2018 Draft NASA Groundwater CMS Report

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No.	Section(s)	Page(s)	Comment(s)	Original NASA Response(s)	DTSC Response(s) to NASA Response(s)	Additional NASA Response
Gen 1	N/A	N/A	Include a description of the proposed Phase 1 CMS and Phase 2 CMS at the beginning of the report. Recommend describing the criteria for inclusion of areas in Phase 1 and Phase 2 in that description and then referring to them as Phase 1 and Phase 2 throughout the rest of the document (instead of calling Phase 1 "source areas" or "Target Treatment Areas").	The requested change will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	The following paragraph has been inserted after the first paragraph of the introduction "This CMS is referred to as the Phase 1 groundwater CMS because DTSC and NASA agreed there was adequate information for three groundwater sources areas, one bedrock vapor source area, and two seep areas to proceed to the remedy evaluation phase of the RCRA process. The rationale for including these areas in the Phase 1 groundwater CMS are immediately described below. All other groundwater related areas requiring NASA actions will be addressed in the Phase 2 groundwater CMS.". The term "Target Treatment Area (TTA)" has been replaced with "sources" or "seeps", in most cases, in Sections 1, 2, and 3. However, in Sections 4.2 through 7 the term TTA is predominantly used as it is important to evaluate technologies in terms of the areas where remediation is applied. A paragraph defining the TTA term, and its relevance, has been added to Section 1 of the revised Phase 1 groundwater CMS. NASA believes the periodic references to "Phase 1" and "Phase 2" are necessary, in part, to address previous DTSC CMS comments. In the revised Phase 1 groundwater CMS, NASA will modify the text so as to be more consistent in how specific locations are referred to.
Gen 2	N/A	N/A	High concentrations of contaminant mass in the vadose zone at ND-112 at LOX and WS-09 at Bravo present threats of further contamination migration to groundwater. DTSC and NASA previously agreed to include the area near ND-112 at LOX as a soil vapor target treatment area (TTA). However, in the draft report, NASA calls this a "contingency" TTA. At a minimum, these areas will need to be addressed as part of Phase 2 CMS. However, DTSC strongly recommends treating these higher concentration areas now, as part of Phase 1 CMS.	NASA removed 25 kg of VOCs by BVE from the former LOX Plant AIG source area (from well ND-112) in 2015 as documented in the November 2020 NASA SSFL Groundwater RFI Report. The inclusion of the ND-112 TTA in Phase 1 was going to be based on current vapor concentrations in the area, which were resampled between October 2021 and February 2022. This recent vapor data in the former LOX Plant AIG ND-112 source area (maximum of 760,000 µg/m^3 TCE) are below the Phase 1 groundwater CMS TTA for active BVE remediation in the Phase 1 CMI (TCE greater than 12,000,000 µg/m^3). Because the ND-112 TTA does not exceed the Phase 1 TTA threshold of 12,000,000 µg/m^3 TCE for vapor (or the 10,000 µg/L TCE Phase 1 TTA threshold for groundwater), the ND-112 TTA will be evaluated as a Phase 2 groundwater CMS source area. Bravo does not have any vapor data documenting high concentrations in the vadose zone above the Phase 1 TTA threshold of 12,000,000 µg/m^3 TCE and will be evaluated further in the Phase 2 groundwater CMS.	DTSC believes that the ND-112 LOX plant area TTA needs to be addressed in the Phase 1 CMS. DTSC does not agree with using the vapor concentration after the extraction period to determine Phase 1 TTAs; rather, pre-pilot test concentrations should be used because it was conducted as a pilot test and not a final remedy. Although recent (2021-2022) concentrations do not reach the TCE threshold of 12,000,000 µg/m3 (12gr/m3), TCE is still detected at 760,000 µg/m3 (0.76gr/m3). This concentration is still high, and it is estimated that approximately 24 kg of TCE mass remain in the former LOX plant AIG vadose zone, with an estimated 267 kg TCE present in the saturated zone that need to be addressed.	As discussed in the 2/8/23 response to DTSC comments on the "Bedrock Vapor Data Investigation report for the Groundwater CMS at the Former LOX Plant", which DTSC concurred with in a letter dated 3/24/23, the ND-112 TTA will not be included in the Phase 1 groundwater CMS because its current vapor and groundwater TCE concentrations do not exceed the Phase 1 groundwater CMS TTA treatment threshold (established in the Phase 1 groundwater CMS document). Instead, NASA prepared a former LOX Plant area BVE pilot study work plan, which was submitted to DTSC review on 8/23/23. BVE pilot study treatment in the former LOX Plant area will occur after the Alfa Area BVE pilot study (using the existing mobile BVE system and solar power array) and the results used to support Phase 2 BVE treatment evaluations. A sentence will be added to the revised Phase 1 groundwater CMS to reference the former LOX Plant area BVE pilot study work plan and indicate the source area and plume will be further evaluated in the Phase 2 groundwater CMS.
Gen 3	N/A	N/A	The report could be clearer and more concise. A primary goal is for it to be accessible to a reader. DTSC recommends minimizing repetition of the same information as much as possible and including summary tables for comparisons wherever feasible.	The requested change will be included in the next submittal. Redundancy will be minimized by using summary tables. An example template was presented to DTSC on July 28, 2022, and was approved.	Response adequate. DTSC will review changes when submitted.	No additional response.
Gen 4	N/A	N/A	NASA will need to evaluate potential future soil-to-groundwater impacts. This evaluation is not only to identify long-term monitoring needs. Acknowledge in the report that potential future soil-to-groundwater impacts will be evaluated as part of the Phase 2 Groundwater CMS.	Text will be added to indicate the soil-to-groundwater impact analysis will be included in the Phase 2 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	As agreed to with DTSC in the final NASA SSFL groundwater RFI soil-to-groundwater analysis flowchart, analytes with soil Look-up Table (LUT) exceedances will be assessed as potential chemicals of concern for inclusion in the Phase 2 groundwater CMS for remedial evaluation or continued monitoring. Additional groundwater data collection associated with these constituents will also be evaluated for inclusion in the updated Sitewide WQSAP DTSC has requested.
Gen 5	N/A	N/A	A full evaluation of all source areas at the site will be needed as part of Phase 2 CMS. Full delineation of plumes onsite will be required regardless of whether a groundwater remedy is deemed necessary in the areas.	The Phase 2 groundwater CMS will include updated plume stability and nature and extent assessments using available data. These assessments will utilize additional information obtained associated with the CMI data gap wells installed in Alfa, Bravo, Delta, and former LOX Plant areas (documented in DTSC approved work plans) and routine groundwater monitoring programs at the site since the NASA SSFL Groundwater RFI Report. Full plume delineation is not considered feasible at the site; however, some additional plume delineation will be needed to support the CMI and design and remedial monitoring needs and will be prioritized by NASA with input from DTSC as part of the design and CMI.	DTSC disagrees with the statement "Full plume delineation is not considered feasible at the site;" and suggests it be removed from the report. Full plume delineation will need to be achieved prior to implementing a final remedy and will be necessary to monitor the effectiveness of the chosen remedy(ies).	The statement "Full plume delineation is not considered feasible at the site;" is not included in the Phase 1 groundwater CMS report text and will not be added. This statement is just in the NASA original response to this DTSC General Comment 5. Adequate plume delineation will be implemented as part of, and in conjunction with, the final remedy (end of Phase 2 CMS/CMI). NASA acknowledges there are data gaps in groundwater source area delineation and plume extents at the site. As agreed to with DTSC as part of the groundwater RFI approval, the current state of plume delineation is adequate to support completion of the Phase 1 groundwater CMS. Additional characterization to support treatment decisions and remedial monitoring will be collected as part of the Phase 1 groundwater CMI. These data will support the development of the Phase 2 groundwater CMS/CMI. NASA has already installed (or is in the process of drilling) several groundwater and vapor data gap monitoring wells at the site after the submittal of the final NASA SSFL groundwater RFI and draft Phase 1 groundwater CMS. This includes wells associated with the Alfa Area EISB (ND-162 through ND-167) and BVE pilot studies (NV-003 through NV-005), Alfa Test Stand 2 source area (ND-160), LOX northern groundwater migration and vapor source area (ND-118, NV-001, and NV-002), Delta Skim Pond source area (ND-169), Bravo source area (ND-168 and NV-006), ELV North Fault Zone (deepening ND-127), and the Coca Area downgradient plume (ND-161). These are documented in work plans submitted to, and approved by, DTSC and associated well installation reports submitted to DTSC for completed wells. NASA plans to have step-wise understanding of source and plume extents as part of remedial work and adaptive management. Additional wells will be evaluated to fill key data gaps to support remedial action and monitoring as part of the Phase 1 groundwater CMI and Phase 2 groundwater CMS/CMI.

No.	Section(s)	Page(s)	Comment(s)	Original NASA Response(s)	DTSC Response(s) to NASA Response(s)	Additional NASA Response
Gen 6	N/A	N/A	Section 3 will need to be harmonized with the DTSC-approved version of the NASA Groundwater Risk Assessment. DTSC is currently reviewing the draft final version of this document. Please also ensure Water Board resolutions are properly acknowledged and addressed throughout this section. NASA needs to establish a clear methodology for how COCs are identified, how they are evaluated, and which COCs are retained. If not retained, DTSC, NASA, and the Regional Board will need to agree on the lines of evidence that allow them to be excluded as COCs. DTSC disagrees with the rationale used to eliminate COCs in this section, which includes chemicals with low detection frequencies, chemicals that contribute less than one percent of the total cancer risk or noncancer hazard, and lack of identified soil sources.	Site COCs identified for CMS-level treatment evaluations are based on site-specific lines of evidence including the nature and extent of contamination and risk assessment results. This process is not inconsistent with the CERCLA and RCRA process for remedial investigations and risk assessments. NASA is using multiple lines of evidence to establish CMS COCs as is typical for remediation sites. This is especially important considering the identification of COCs in the Groundwater Risk Assessment is based on single maximum detected concentrations which in most cases vastly overestimates risk for those chemicals that were eliminated as COCs in the CMS. NASA and DTSC need to discuss and agree on acceptable criteria for CMS COC selection as NASA does not agree that no site-specific considerations, especially low detection frequencies and the magnitude of the risk estimates, can be applied to COC selection for remedial option analysis. DTSC needs to provide applicable comments on the NASA Groundwater Risk Assessment to allow resolution of this comment in the Phase 1 groundwater CMS.	*Provided by email from DTSC on 10/6/23:* In USEPA's 1989 Risk Assessment Guidance for Superfund (RAGS Vol-1, Part A), guidance was provided for elimination of analytes that were detected infrequently. DTSC views this as no longer necessary and recommends against eliminating groundwater COCs for the following reasons. First, desktop computers now make tracking each chemical easy and convenient with minimal time needed to track even seldom detected COCs. Second, NASA's own evaluation of new 2017-2020 groundwater data provide numerous examples of analytes that were either not detected in GW data collected before 2016, or were detected at maximum concentrations below their respective residential groundwater-RBSLs (rGW-RBSLs). The 2017-2020 data show that these same analytes now exceed their rGW-RBSLs by 3-300 fold, thus becoming new risk drivers (see Appendix Tables E2-2, E2-3, F2-2 and F2-3 in the 2021 Human Health and Ecological Risk Assessments for NASA AIGs). DTSC thus prefers not to eliminate COCs at this stage. In addition, a vadose zone risk to groundwater evaluation has not yet been performed. This evaluation needs to be performed with the goal of aquifer restoration in accordance with RWQCB Resolution 92-49. Any COC with the potential to reach groundwater above background concentrations will need to be included in CMS evaluations. This evaluation needs to be completed prior to or as part of the Phase 2 CMS evaluation. DTSC provided comments on the NASA Groundwater Risk Assessment (dated January 2021) to NASA on October 21, 2022.	NASA requests DTSC provide comments on, or concurrence with, the NASA HHRA response to DTSC comments submitted on 5/18/23. As agreed to with DTSC and RWQCB, the Phase 1 groundwater CMS is focused on the highest concentration, highest risk COCs for NASA SSFL, which includes chlorinated ethenes (that drive over 99% of the groundwater COC risk). The Phase 2 groundwater CMS will include an evaluation of remaining chemicals above background (with soil concentrations greater than the soil Look-up Table [LUT] values), with the goal of aquifer restoration (if T&E feasible) in accordance with RWQCB Resolution 92-49.
Gen 7	N/A	N/A	Acknowledge the requirement for an overall approach for cleanup of the entire SSFL, especially for comingled plumes.	The Phase 1 groundwater CMS will be revised to clarify that the Phase 2 groundwater CMS will evaluate NASA-related source areas and plumes at SSFL not addressed in the Phase 1 groundwater CMS, including coordination with other RPs if needed to address co-mingled plumes associated with NASA sources.	Response adequate. DTSC will review changes when submitted.	No additional response.
Gen 8	N/A	N/A	Key adaptive site management elements that should be included in Corrective Measures Implementation are regular optimization of the treatment system(s) throughout its operation and a process to consider alternative active technologies (use of contingency remedies). When a selected active treatment technology is no longer effective, alternate active treatment technologies will be considered prior to switching to monitored natural attenuation (MNA) only.	The CMI will include an adaptive management plan to address assessment of remedy effectiveness, optimization, and a decision process for alternate treatment strategies and implementation. It is assumed the Adaptive Management process will not require additional CMS documents in the future if contingency remedies are considered needed.	Response adequate. DTSC will review changes when submitted.	No additional response.
Gen 9	N/A	N/A	Alternatives should be evaluated on an individual source zone basis, rather than site-wide. Each TTA has unique conditions and characteristics. A brief evaluation should present how each alternative would be applied to each TTA. This could be presented as a table or series of tables to allow easy comparison.	Presenting technology evaluations on an individual source area basis, especially carried in the Phase 2 groundwater CMS, could create further redundancy (in conflict with General Comment 3). As discussed with DTSC, NASA will present the evaluation of source zones in one alternative evaluation table. Any unique differences between the source areas that could affect how the alternative is evaluated for a specific criterion will be described in the alternative evaluation table. NASA will use summary tables in the next submittal to include source zone differences and considerations.	Response adequate. DTSC will review changes when submitted.	No additional response.
1	ES	ES-1	Please include a brief summary table (e.g., comparative analysis summary for remedial alternatives) that includes alternatives considered and their relative scoring on the balancing criteria (decision factors).	The requested information will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
2	ES	ES-1	Recommend including less detail in the Executive Summary, instead focusing on the most important elements. Suggestions include: • The first three paragraphs could be deleted and addressed in the introduction or another section of the report. • Suggest minimizing references to other report sections throughout the Executive Summary and concisely explain the work performed. • Recommend deleting repeated "source treatment using…" This phrase does not provide additional clarification or value to the report. • Recommend deleting repeated references to TTA definitions. These are already defined on the first page of the document. An example of this is on page ES-2: "…(EISB) (**groundwater TCE concentrations greater than 10,000 ug/L**) and BVE (**unsaturated rock with potential to leach TCE to groundwater, which would result in TCE concentrations greater than 10,000 ug/L**)…" • Page ES-4, Comparative Summary of High Concentration TCE TTA Alternatives and Page ES-5, Comparative Summary of Seep TTA Alternatives: These may be easier to present as a table. Consider presenting the information in table format and minimizing text.	The requested information will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
3	ES, 1	ES-1, 1-1	Include a brief narrative that the CMS is being conducted in 2 phases. Then, define phase 1 and phase 2 CMS, similar to Section 1.1 of NASA's October 2020 EISB Work Plan. The current language around this ("Each report would focus on specific areas and restoration objectives.") does not accurately describe the proposed approach.	The requested information will be included in the next Phase 1 groundwater CMS submittal.	Same as Gen 2 comment	It is unclear if response is supposed to reference General Comment 2 or General Comment 1. Refer to additional response to General Comment 1.
4	ES	ES-1	"DTSC and NASA agreed to the following format with respect to the components of the Phase 1 Groundwater CMS. The ND-112 TTA is considered a contingency TTA as the latest bedrock vapor concentrations…" This statement is inaccurate. DTSC and NASA agreed that the ND-112 TTA would be included in the Phase 1 Groundwater CMS.	As discussed in the response to General Comment 2, NASA evaluated whether the former LOX Plant AIG ND-112 source area vadose zone TCE concentrations are above the Phase 1 groundwater CMS treatment threshold of 12,000,000 $\mu g/m^3$. The highest TCE concentration in LOX based on 2021 and 2022 vapor samples is 760,000 $\mu g/m^3$. Therefore, the ND-112 TTA will be evaluated as a Phase 2 groundwater CMS source area.	Same as Gen 4 comment	It is unclear if response is supposed to reference General Comment 2 or General Comment 4. Refer to additional response to General Comment 2.

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5	ES	ES-2	"However, addressing contaminated soil is outside the scope of the Phase 1 and Phase 2 groundwater CMSs." NASA will need to evaluate potential future soil-to-groundwater impacts. This is not only to identify long-term monitoring needs. Update the report text to acknowledge that this will need to be done as part of Phase 2 groundwater CMS.	The requested information will be noted as a component of the Phase 2 groundwater CMS in the next Phase 1 groundwater CMS submittal.	Same as Gen 4 comment Response adequate. DTSC will review changes when submitted.	As agreed to with DTSC in the final NASA SSFL groundwater RFI soil-to-groundwater analysis flowchart, analytes with soil LUT exceedances will be assessed as potential chemicals of concern for inclusion in the Phase 2 groundwater CMS for remedial evaluation or continued monitoring. Additional groundwater data collection associated with these constituents will also be evaluated for inclusion in the updated Sitewide WQSAP DTSC has requested.
6	ES	ES-2	"The alternatives applied to the Northern Seep Area are considered contingency remedies because seep water and groundwater are below concentrations and do not…" Please specify what concentrations the seep water and groundwater are being compared to.	Concentrations were compared to the MCOs in Section 3. The text will be modified to clarify this.	Response adequate. DTSC will review changes when submitted.	No additional response.
7	ES	ES-6	Though it is not a requirement, this would be an effective place for NASA to present their recommended alternatives. The previous Draft CMS included a section called "Comparative Evaluation Conclusion."	The requested information will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
8	1	1-1	"In August 2018, the NASA Groundwater Corrective Measures…was submitted in fulfillment of the requirements of the 2007 Consent Order (DTSC, 2007)." This was a draft document, and it did not fulfill the requirements of the 2007 Consent Order. This section appears to include a lot of unnecessary information. Suggest less (or no) focus on previous documents and proposals and agreements between NASA and DTSC.	The requested information will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
9	1	1-2	"At the conclusion of the study, the concentrations were reduced to below the soil vapor threshold for treatment in this Phase 1 groundwater CMS…" This proposed approach to address the LOX area misses the point. Including LOX in the Phase 1 groundwater CMI would result in significant mass removal in an area that is a potential continuing source of contamination to groundwater. The brief LOX BVE event was not sufficient to remediate that area. Please include LOX in the Phase 1 groundwater CMS as a soil vapor TTA as agreed to between NASA and DTSC. This will require a global update of the document wherever BVE at LOX (ND-112) is mentioned.	See response to General Comment 4.	Same as #4 and Gen 2 comment.	NASA agrees this response should have referenced General Comment 2 and Specific Comment 4.
10	1	1-2	*Seep Areas bullet* : Please add a definition of Northern Seep area and Southern Seep Area.	The definition will be added as requested.	Response adequate. DTSC will review changes when submitted.	No additional response.
11	2	2-1	"Current land use at SSFL is zoned by Ventura County as rural agricultural but modified by a special use permit to allow industrial use." Current zoning for SSFL is OS-160 SSFL and AE-40ac for the offsite Shooting Range area In November 2017, the Ventura County Board of Supervisors approved an ordinance amending the zoning classifications of seven parcels within the SSFL site, including Areas I, II, III, and IV from RA-5 to OS-160. The purpose of rezoning these parcels was to establish consistency between the zoning and the General Plan designation.	The text will be updated to provide current zoning information based on information from Ventura County.	Response adequate. DTSC will review changes when submitted.	No additional response.
12	2.3.2.2	2-15	"However, due to the extremely low and sporadic 1,4-dioxane concentrations in RD-83, this area is not targeted for active groundwater remediation during Phase 1 groundwater CMS. Further evaluation of this area may be conducted during the Phase 2 groundwater CMS evaluation." Please revise this to say that further evaluation **will be** conducted during the Phase 2 groundwater CMS evaluation.	The text will be changed to indicate that further evaluation of RD-83 groundwater will be included in the Phase 2 groundwater CMS using existing data from the sitewide groundwater monitoring program.	Response adequate. DTSC will review changes when submitted.	The Human Health Risk Assessment has been updated to include significantly more COCs (refer to Section 3). As the focus of this Phase 1 CMS is reducing the greatest risk drivers (TCE, cis- and trans-DCE, and VC), references to previously referenced COCs (e.g., 1,4 dioxane, formaldehyde, 1, 2, 3-TCP, Toluene, lead, cadmium) have been removed from Section 2. All other COCs (outside TCE, cis-and trans-DCE, and VC) will be addressed in the Phase 2 CMS.
13	2.3.2.3	2-17	"Recommendations will be made in a separate technical memorandum identifying boreholes that may pose a threat of cross-contamination." Please provide an estimated time frame for when NASA will submit this memorandum.	NASA-sponsored former inactive water supply wells were evaluated for cross-contamination threat as part of the request to change the permit designation of these wells to monitoring wells with Ventura County. WS-03 will be abandoned and WS-12 will be converted into a dual-completion monitoring well to reduce this threat (as presented to DTSC by PowerPoint presentation on October 15, 2021). Other long-open borehole evaluations and recommendations will be included as part of the CMI. NASA will not modify or abandon other wells until the remedy monitoring network needs are identified.	DTSC would like to review existing correspondence between NASA and the County about former water supply wells.	The Former Water Supply Well information package, originally compiled to support a Certificate of Exemption request from Ventura County for the NASA former water supply wells (which is no longer needed because these wells were re-permitted as monitoring wells instead), will be provided to DTSC as a courtesy copy.
14	2.3.3.2	2-20	Several paragraphs on this page and throughout the document include language like "…may be warranted as part of the Phase 2 groundwater CMS/CMI…" and "…additional data collection in this area may be necessary to support the Phase 2 CMI design and implementation if a groundwater remedy is deemed necessary in this area." A full evaluation of all source areas at the site will be needed as part of Phase 2 CMS. Full delineation of the AP/STP plume and other plumes onsite will be required regardless of whether a groundwater remedy is deemed necessary in the areas. Please adjust the wording throughout the entire document accordingly.	An updated evaluation of all NASA plumes will be conducted in the Phase 2 groundwater CMS based on data obtained since the NASA SSFL Groundwater RFI Report evaluations. However, full plume delineation is not considered feasible at the site. Some additional plume delineation will be a needed to support the CMI and design and remedial monitoring needs and will be prioritized by NASA with input from DTSC as part of the Corrective Measures Design and CMI.	Same as Gen 5	Refer to additional response to General Comment 5.
15	2.3.3.2	2-20	"Seep and seep well detections, the majority of which are flagged as estimated concentrations, occurred at the following seep locations (refer to Figure 2-9)." Recommend including the J-flags along with the data presented here. Recommend providing additional justification and supporting information here to demonstrate that these COC detections were very low and sporadic and not likely representative of groundwater quality in the area or an indication of offsite migration of contamination.	J flags will be added to the COC seep and seep well data presented in the bullet list in this section. NASA provided additional data related to the seeps (a data table, cross section, and 3D viewer file) by email to DTSC and the LARWQCB on April 14, 2021. NASA believes the current Phase 1 groundwater CMS text, including referencing the evaluation in the NASA SSFL Groundwater RFI Report, is sufficient to show the sporadic nature of the seep-related detections. NASA will continue to monitor these northern seep wells to help further evaluate this area as part of the Phase 2 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	The text has been updated to address TCE, VC, and cis- and trans-DCE. The Human Health Risk Assessment has been updated to include significantly more COCs (Refer to Section 3). As the focus of this Phase 1 CMS is reducing the greatest risk drivers (TCE, cis- and trans-DCE, and VC), references to previously referenced COCs (e.g., 1,4 dioxane, formaldehyde, 1, 2, 3-TCP, Toluene, lead, cadmium) have been removed from Section 2. All other COCs (outside TCE, cis-and trans-DCE, and VC) will be addressed in the Phase 2 CMS.
16	2.3.4.3	2-26	Potential typo: "…groundwater concentrations are as high as 13,000 (measured at ND-136 in 2016)…" Figure 2-15 shows a maximum concentration of 11,000 µg/L at ND-136. Please verify and resolve the discrepancy.	The ND-136 data displayed on Figure 2-15 will be corrected to match that shown on Figure 2-13, which shows the correct maximum value through 2016 (13,000 µg/L).	Response adequate. DTSC will review changes when submitted.	No additional response.
17	Table 2-2	1	Consider also including estimated CVOC mass in this table. For example, page 2-14 says 77 pounds of CVOC mass in LOX AIG vadose zone.	Inclusion of CVOC mass in this table is not considered necessary to the CMS evaluation process and is highly uncertain. CVOC mass will be estimated during remedial action based on additional source treatment data, but it is still noted that these estimates will be highly uncertain.	No change will be made. Response adequate. DTSC will review if changes are made.	No additional response.

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18	Table 2-2	1	Consider highlighting or identifying the source areas proposed for Phase 1 CMS.	A new column will be added to Table 2-2 to flag the source areas proposed for the Phase 1 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.
19	Table 2-2	1	Note f does not appear to be referenced anywhere on the table. Please verify.	The footnotes in Table 2-2 will be corrected in the next submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
20	3.1.1.1	3-3	Under Former LOX Plant AIG NSGW, NASA proposes to eliminate COCs that "…are not associated with a past site release (that is, related to soil contamination)." COCs present in groundwater above background that are not associated with a past site release are a data gap. It is not appropriate to eliminate them from the list of COCs to be evaluated in CMS.	See response to General Comment 6.	See response to General Comment 6.	Refer to response to General Comment 6. All text discussing lines of evidence for removal of COCs have been removed from the Phase 1 CMS. This information will be re-evaluated in the forthcoming TEFA and/or Phase 2 CMS.
21	3.1.1.1	3-3	"…the fact that the maximum detected lead concentration in CFGW samples is less than the action level…" Please explain what action level is being used for comparison here.	The Lead Action Level is the California State Water Board and EPA action level for drinking water according to U.S. EPA's Lead and Copper Rule.	Response adequate. DTSC will review changes when submitted.	The subject text ahs been removed. Refer to response to specific comment 20.
22	3.2	3-18	NASA may focus on a shorter list of groundwater COCs for purposes of the Phase 1 groundwater CMS. However, all applicable COCs will need to be evaluated in Phase 2 groundwater CMS.	See response to General Comment 6.	See response to General Comment 6.	Refer to response to General Comment 6.
23	3.3	3-21	Typo: "NASA acknowledges the primary goal is aquifer <u>remediation</u> and that DTSC determines the cleanup goals." Please revise to "…aquifer <u>restoration</u>…"	The requested changes will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
24	3.4	3-21	This section references the 2014 FEIS. Verify whether the 2020 supplemental EIS should also be referenced.	The applicable versions of the EIS will be referenced.	Response adequate. DTSC will review changes when submitted.	No additional response.
25	3.4	3-21	This section mentions a future ROD for groundwater cleanup activities. Verify whether NASA anticipates preparing an additional ROD for groundwater cleanup activities. Note that the two-phase approach will result in two DTSC decision documents (Statements of Basis) that will go out for public comment with their respective Draft Final CMS Report.	NASA does not plan another NEPA groundwater ROD. The text will be updated to reference the current groundwater ROD and the Phase 1 groundwater CMS Statement of Basis.	Response adequate. DTSC will review changes when submitted. Please add "ROD" (Record of Decision) to the Acronyms list	ROD will be added to the acronym list.
26	4.1.3	4-6	NASA discusses treatment intervals throughout this section. Recommend referencing a brief summary table that shows the depths and other relevant information for each TTA and screens through each of these technologies. This table should be included as part of the main document for easy reference (not in an appendix).	A brief summary table will be generated and included in the next Phase 1 groundwater CMS submittal, as requested.	Response adequate. DTSC will review changes when submitted.	No additional response.
27	4.1.3	4-6	"As a result, a case for ISTT application in any area of the site where all three conditions are reasonably satisfied is improbable." Please revise this sentence to make it clear that the "site" being referenced includes the NASA Phase 1 TTAs, not the entire SSFL.	The subject sentence will be revised to: "As a result, a case for ISTT application in any *of the areas addressed in this Phase 1 groundwater CMS* where all three conditions are reasonably satisfied is improbable.", where italicized text represents the modified portion of the subject sentence.	Response adequate. DTSC will review changes when submitted.	No additional response.
28	4.1.3	4-8	"Thus, it may be feasible to increase groundwater temperature on the order of 10 degrees Celsius…" In a recent Clemson heat study, increasing SSFL groundwater temperature appeared to notably increase the reaction rate.	NASA included a thermally enhanced EISB treatment alternative in the Phase 1 groundwater CMS (that included aboveground heating of the treated water). The technology ranking considered the potential increase in reaction rates. Based on this comment from DTSC, NASA further reviewed the Clemson heat study and discussed the technology with vendors. While in situ thermal treatment is theoretically possible, it has not been performed at the depths required for SSFL treatment and would require the development of new equipment and methods, as well as testing. This technology is too experimental to include in SSFL remedial treatment alternatives as this time. If the technology is further developed in the near future, use of thermal could be included as part of NASA SSFL groundwater remediation adaptive management.	While low temperature heating of the subsurface to aid in in-situ remediation has not been widely implemented in a field-scale setting, studies show substantial reduction in VOC contaminant mass can be achieved using thermally enhanced EISB. In addition to the Clemson study, a field research project funded by the Department of Defense's Environmental Security Technology Certification Program (ESTCP) titled "Combining Low-Energy Electrical Resistance Heating with Biotic and Abiotic Reactions for Treatment of Chlorinated Solvent DNAPL Source Areas," and a pilot study funded by EPA Region 10 titled "Applying Electrical Resistance Heating at Below Steaming Temperatures to Enhance Bioremediation Kinetics at the Well 12A Superfund Site" both demonstrate significant increases in VOC contaminant mass reduction by coupling heat with in-situ bioremediation. The Well 12A study successfully introduced heat to groundwater to depths of up to 50 feet below ground surface (bgs), which resulted in total VOC mass and molar concentrations decreasing by more than 99% from maximum concentrations observed prior to heating. While this technology may not be applicable at all of NASA's AIGs, it has potential and should be retained and evaluated where it may be an appropriate technology. A pilot study may be needed to determine applicability to NASA areas at SSFL. DTSC is open to discussing this technology and its applicability at SSFL.	NASA has retained a thermally enhanced EISB alternative, Alternative 2b - Source Treatment using BVE and Thermally Assisted EISB, followed by MNA, with LUCs. The technology description provided for "Thermally Assisted EISB" in Section 4.1.3 will be updated to reflect that several different heating technologies can be used to apply heat to the EISB technology. This text will further describe that the addition of applying heat above ground is the most applicable for the Phase 1 groundwater CMS, given the limitations of other technologies applying heat to depths of 500 feet. The other heating technologies could be considered in the future as part of the Phase 2 groundwater CMS or adaptive management if it can be demonstrated these technologies can be practically implemented at the depths of contamination at NASA SSFL.
29	4.1.5	4-10	"… (refer to Section 4.1.4)." Section 4.1.4 does not appear to have any additional information regarding the detection of BAV1. Please verify.	The parenthetical phrase (refer to Section 4.1.4) in Section 4.1.5 was intended to direct the reader to Section 4.1.4 for a more general discussion of the activities conducted to date to evaluate the potential role of MNA at SSFL. The parenthetical phrase will be changed to "(refer to Section 4.1.4 for details regarding evaluations conducted to date to assess the applicability of MNA at SSFL)."	Response adequate. DTSC will review changes when submitted.	No additional response.
30	4.1.5	4-10	Now that the EISB work plan has been approved by DTSC, recommend updating this section to include new information available such as anticipated timeline for EISB study.	The recommended information will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
31	4.2.1	4-11	"The TTA for the C-6 location cannot address the full limits of the 10,000 µg/L plume represented on Figure 2-16 due to access restrictions south of the Delta Skim Pond, specifically, rocky terrain and culturally sensitive areas." NASA should consider other methods to access this groundwater. Though the surface above sensitive areas may prevent access, the groundwater underneath may be accessible another way (e.g., angled borings).	Decisions regarding critical source and plume data gaps to support remedial design and monitoring in the C-6 TTA will be identified in the CMI and balanced with technical and cost feasibility. A new 500-foot monitoring well (ND-169) was drilled in the Delta Skim Pond in this area and the data report is being prepared to submit to DTSC. NASA has done a preliminary evaluation of angled-boring drilling in the area and has concluded there is a low probability of getting high quality data at a reasonable cost to aid with decision making.	Response adequate. DTSC would like to revisit this issue when the CMI is submitted.	The ND-169 report was submitted to DTSC in August 2022.
32	4.2.1	4-12	Recommend updating this section based on more current GETs interim measures information.	The recommendation will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
33	4.2.2	4-13	Typo: "… (Appendix A) **and** where groundwater concentrations…"	The recommended change will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.

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34	4.3	4-15	"Achieving MCOs in a reasonable amount of time within the high concentration source zones is considered impossible and has not been achieved at other cleanup sites with similar challenges. However, implementation of different treatment technologies can be effective in reducing contaminant concentrations…Given this, the effectiveness criteria have been evaluated in terms of what the best available technology can achieve in terms of general contaminant reduction, as no technologies are available to achieve MCOs in a reasonable amount of time." The rationale for this statement is not adequately supported, and reasonable amount of time is not defined. Phase 2 groundwater CMS needs to include plume-scale evaluations (and the associated remedial time frames), including potential adaptive site remedies (e.g., concurrent evaluation of emerging technologies).	NASA will modify the text to state: "Achieving MCOs in a reasonable amount of time (several decades) within the high concentration source zones is considered impractical and has not been achieved at other cleanup sites with similar challenges. However, implementation of different treatment technologies can be effective in reducing contaminant concentrations… Given this, the effectiveness criteria have been evaluated in terms of what the best available technology can achieve for general mass removal and contaminant reduction." Text will also be added to discuss the results of the Phase 1 groundwater CMS 1-D modeling on the reduction of TOR after source treatment. The Phase 2 groundwater CMS will include plume-scale remedial alternatives with associated TOR calculations from the plume-scale fate and transport modeling (including biodegradation rates from Yu et al. [2020]) to support the evaluations. Evaluation metrics and document decision processes will be included in NASA SSFL groundwater remediation adaptive management.	Rather than state that achieving MCOs in a reasonable amount of time is impossible or impractical, NASA needs to remove this statement and just evaluate each remedial alternative for what it is. The estimated TOR for each alternative should be considered in the evaluation of each treatment technology; however, achieving MCOs should not be dismissed as impossible or impractical.	NASA recognizes DTSCs concerns pertaining to inferring cleanup to MCOs in a reasonable time as "impossible or impractical". The tone of these kinds of statements will change to "the ability to achieve MCOs within the near term (e.g., several decades) is uncertain." More data is needed to better estimate time of remediation for NASA SSFL source areas and plumes and assess the feasibility to remediate to background as the MCO. Additional data are expected to come from the implementation and operation of current pilot studies and the Phase 1 CMS/CMI remedies. Other data will be gathered as part of implementing the Phase 2 groundwater CMS alternatives and the follow-on adaptive management phase. If aquifer restoration to background is infeasible (if identified through a T&E feasibility assessment), the overall goal for the combined Phase 1 and Phase 2 groundwater CMS/CMI will be to use the lowest T&E feasible MCO for the site. Please note that given the long projected timeframes to achieve cleanup objectives, it is not practical to differentiate differences in time of remediation of the different alternatives evaluated in the Phase 1 groundwater CMS. Please refer to Additional NASA Response to Specific Comment 45.
35	4.3.1	4-16	Consider numbering the technologies here to coordinate with Figure 4-6.	The numbers on Figure 4-6 are only an example representation of how different technologies are evaluated and filtered before considering inclusion into alternatives. This information will be clarified in the next submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
36	4.3.1	4-16	There are many references here to phrases like "highly contaminated" and "high concentrations of TCE." Recommend revising this section to eliminate these repetitive references. These are the technologies considered for the Phase 1 CMS TTAs, which by definition have high concentrations.	The recommended change will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
37	4.3.1	4-16	Biosparging bullet: Recommend adding information from RTC #23 here (maybe as a footnote) or on following page - no maximum historical concentration of EFH exceeds 10 mg/L, and more than 85% of maximum historical concentrations are less than 1 mg/L EFH.	The recommended text from response to Specific Comment 23 will be added to the biosparging bullet on page 4-17 of the draft Phase 1 groundwater CMS as rationale for why biosparging was not retained.	Response adequate. DTSC will review changes when submitted.	No additional response.
38	4.3.1	4-16	MNA bullet: This was not updated to address previous comment #21. Please update it accordingly.	The criteria for applying MNA as a remedy is well established in regulatory guidance. It involves demonstrating the suitability of MNA through a weight of evidence approach, using multiple lines of evidence, as provided for in in EPA documents such as OSWER Directive 9200.4-17 (1999). These lines of evidence include temporal and spatial trends in VOC concentrations with emphasis on wells located near the downgradient plume perimeter, evaluation of groundwater geochemistry vis-à-vis attenuation processes known to be effective for degrading VOCs, and additional lines of evidence through field or microcosm studies demonstrating specific degradation processes. More recently, analytical techniques to evaluate changes in carbon or chlorine isotope ratios (compound specific isotope ratios) or the presence in groundwater of functional genes known to be used by specific dechlorinating microbes have been used to provide evidence for MNA processes to be occurring. NASA will continue to collect and will present data to support each of these lines of evidence regarding the potential for MNA to be an effective process at the site as part of the Phase 2 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.
39	Table 4-2	2	Potential typo: ISCO, Conceptual Development, "Extraction wells are paired with extraction wells to facilitate recirculation…" Verify if one of the "extraction wells" should be changed to "injection well".	The comment is correct. The text will be refined to indicate "Extraction wells are paired with *injection wells* to facilitate…", where italics represent the modified portion of the subject sentence.	Response adequate. DTSC will review changes when submitted.	No additional response.
40	Table 4-2 and 4-3	3	MNA, Implementability: This technology would likely also require additional monitoring well installation (see original DTSC comment #90). Please acknowledge in the report (and throughout the report) that additional monitoring wells would likely be needed for MNA although this was not considered in the Phase 1 CMS evaluation. This will be evaluated further in the Phase 2 CMS.	The text will be updated to indicate that the need for additional MNA wells to support remedial monitoring for NASA AIG plumes will be evaluated in the Phase 2 groundwater CMS and the CMI design.	Response adequate. DTSC will review changes when submitted.	No additional response.
41	Table 4-3	1	The table contains several references to para-dioxane, while the report text refers to 1,4-dioxane. Recommend revising for consistency.	The recommended change will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	Reference to 1,4-dioxane have been removed from this table. Refer to response to specific comment 15.
42	Table 4-3	1	Potential typo: Phytoremediation of Seep Water, "The technology is proven to chlorinated ethenes…" Please revise as needed.	This is a typo. The subject sentences has been revised as "The technology is proven *to be effective in reducing* chlorinated ethenes and para-dioxane concentrations.", where the italicized text represents the modified portion of the sentence.	Response adequate. DTSC will review changes when submitted.	Reference to 1,4-dioxane have been removed from this table. Refer to response to specific comment 15.
43	5.1	5-1	TTA selection criteria has already been defined in the document. Thus, it is unnecessary and repetitive to continue including "groundwater TCE concentrations greater than 10,000 ug/L" and similar throughout this section.	Agree, the subject text will be addressed throughout the document.	Response adequate. DTSC will review changes when submitted.	No additional response.
44	6	6-1	This section is very repetitive without providing the type of information requested in previous comments. Recommend consolidating the repetitive material as much as possible to make this more readable. Then, add the details that are relevant to the analysis. Provide the basis for assumptions made (e.g., basis for 10 years for every active treatment). Evaluate existing site conditions (e.g., contamination) and how technologies in each alternative would work together to treat each TTA. Recommend including a summary table for each TTA showing estimated mass in each media, comparing how different alternatives would likely address a reduction, and the basis for assumptions made (site-specific data, literature, etc.).	See response to General Comment 3. Summary tables and additional information will be added as recommended in this comment. However, as discussed in the response to Specific Comment 17, mass estimates are highly uncertain and will not be included.	Response adequate. DTSC will review changes when submitted.	No additional response.

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45	6.1.1	6-2	"When comparing the length of time of remediation between natural attenuation and the active treatment technologies, the length of time to achieve one order of magnitude reduction is reduced…assuming a one order of magnitude reduction can be achieved with each active treatment technology in 10 years." And "For the purposes of this CMS, it was assumed that all active treatment components for groundwater would perform equally and operate for 10 years, with the potential for operating longer if practicable." Please provide the basis (site-specific data, literature, etc.) for these assumptions. Using the same time period for each active treatment technology makes it difficult to compare relative effectiveness and time of remediation for different technologies. It only allows a comparison of MNA to active treatment.	The basis for these assumptions will be added as requested. These assumptions were included to provide normalizing criteria for direct information comparisons because technology-specific estimates are not possible to predict with accuracy. The plume-specific fate and transport modeling (incorporating back diffusion) and BVE and EISB pilot study information that will be included in the Phase 2 groundwater CMS will provide TOR for comparative level analysis of treatment versus no treatment scenarios as well. See response to Specific Comment 34.	Response adequate. DTSC will review changes when submitted.	The following text has been added to Section 6.1.1: "The time of operation for the active treatment components of Alternatives 2a, 2b, 3 and 4 were all assumed to be 10 years. All four alternatives rely on treating or removing contaminant mass flowing in bedrock groundwater fractures. Given the uncertainties in rates of back diffusion from the rock matrix, groundwater velocities, and treatment effectiveness of each alternative, it is not possible to distinguish different treatment times for each of the four active treatment alternatives. The 10-year active treatment is an assumption based on application of the treatment technologies at other complex sites. The treatment time assumption is used for the purposes of developing a cost estimate for implementation of each alternative. However, as part of the adaptive management component of each alternative, if treatment continues to be effective after ten years, treatment will continue until a time where it becomes technically or economically infeasible."
46	6.1.2	6-5	"As new information becomes available, the monitoring well network identified in Tables 6-2 through 6-7 will be updated, in consultation with DTSC." The monitoring network will be part of the final remedy and must consider all portions of the remedy. While this preliminary monitoring well network needed to be established for cost estimation and other CMS purposes, it will be further refined in the future, throughout CMD and CMI.	See response to Specific Comment 40.	Response adequate. DTSC will review changes when submitted.	No additional response.
47	6.1.2	6-6	"If the results of those decisions indicate that MNA is not performing as planned, additional testing or mitigation measures may be warranted." Recommend changing "may" to "will", consistent with the anticipated adaptive site management practices.	The text will be modified to state: "…additional testing or mitigation measures will follow the Adaptive Management Plan."	Response adequate. DTSC will review changes when submitted.	No additional response.
48	6.1.4	6-7	"However, the focus of this technology [BVE] is only to remove high mass volumes." Please define "high mass volumes."	The subject sentence will be revised to "However, the focus of this technology [BVE] *in this Phase 1 groundwater CMS is to remove mass at high concentration areas, as described in Section 4.2.2.*", where the italicized text represents the modified portion of the sentence.	Response adequate. DTSC will review changes when submitted.	No additional response.
49	6.1.4	6-8	"Patterns of extraction rate will be tracked by laboratory analyses, and as the rate of rebound is observed to decline, extraction at well ND-112 will be terminated." Note that the rate of rebound would not be the only criteria to evaluate when deciding whether to discontinue BVE at ND-112.	The sentence will be modified to read "…extraction at the ND-112 TTA BVE well will be considered for shut down based on rate of rebound decline, the rate of mass recovery decline and the pattern of concentration decline."	Response adequate. DTSC will review changes when submitted.	The ND-112 TTA source area potential Phase 1 treatment will be removed from the Phase 1 groundwater CMS based on the results of the data gap vapor sampling data. A BVE pilot study is planned for the former LOX Plant area to support Phase 2 groundwater CMS remedial evaluations. Refer to response to General Comment 2.
50	6.1.4	6-8	Last paragraph of Section 6.1.4: • Recommend moving this paragraph above Alfa Area subsection as it applies to both Alfa and LOX. • "…possible sufficiency of a single well." Recommend revising to a single <u>extraction</u> well. • "Together, these data will be used to verify the target treatment threshold for source BVE is being addressed in the TTA." The meaning of this sentence is unclear. Please clarify.	First Bullet: some elements of this paragraph are specific to the former LOX Plant AIG (use of passive soil gas probes), and the Alfa Area section already discusses the fracture considerations, so it is not appropriate to move the paragraph. Second Bullet: "extraction" will be added as recommended. Third Bullet: the sentence referred to the data described in the previous two sentences (vapor monitoring wells; passive soil gas surveys). These two data types were suggested to be used to track the progress of the BVE treatment at the site. However, as identified in the Alfa Area BVE work plan, passive soil gas surveys are not included in that monitoring plan. Therefore the last paragraph of this section will be modified as follows: "At least two additional multi-level vapor monitoring wells will be installed and monitored to document active soil vapor concentration decline. Existing dry or partially saturated piezometers may also be converted to vapor monitoring wells (NASA, 2021). The vapor monitoring data will be used to verify the target treatment threshold for source BVE is being addressed in the TTA." The NASA, 2021 reference will be the Alfa Area BVE work plan.	Response adequate. DTSC will review changes when submitted.	Based on NASA's additional response to General Comment 2, references to BVE treatment at the former LOX Plant area in Phase 1 will be removed from the Phase 1 groundwater CMS.
51	6.1.5.1	6-9	"This change in extraction wells was approved in a letter from DTSC in 2019 (Appendix C)." Please note that the letter included in Appendix C is the letter from the Regional Board to DTSC authorizing the requested extraction well change.	The reference to the letter will be corrected in the text.	Response adequate. DTSC will review changes when submitted.	No additional response.
52	6.1.5.1	6-10	"Based on the RFI data, hydraulic containment is not warranted because the plume boundaries are not expanding, which results in the objective for use of this technology to be mass removal." Hydraulic containment is not necessarily limited to plume boundary containment, especially in release areas with high contamination such as the TTAs. Hydraulic containment should be considered for source zones and the plume core to prevent migration of groundwater contamination and to facilitate plume reduction.	NASA has already considered groundwater pump and treat (P&T), which provides hydraulic containment of high concentration source areas, in the Phase 1 groundwater CMS for the designated Phase 1 TTAs. Similarly, P&T/hydraulic containment will be assessed for other source areas and plume cores in the Phase 2 groundwater CMS. The text will be revised as necessary to describe the role of P&T in source zone remediation.	Response adequate. DTSC will review changes when submitted.	No additional response.
53	Table 6-2	6-11	Please provide the calculation details for this table. The calculations for ND-136 and WS-09 could not be replicated.	Additional information will be added to the table to clarify the calculations.	Response adequate. DTSC will review changes when submitted.	The calculations were reviewed and corrected in Table 6-2.
54	6.1.7	6-18	This section describes that an electric-powered steam boiler would be used to heat the water. Please include narrative why solar heating was not considered.	A new sentence, following the subject sentence will be added and state: "The electricity to power the boiler may be provided by solar or line power.".	Response adequate. DTSC will review changes when submitted.	No additional response.

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55	6.3.2	6-25	"Alternatively, the impacts of not addressing bedrock vapor in high TCE concentration source areas has not been accounted for on the time of remediation estimates. Therefore, the time to achieve MCOs could be longer if bedrock vapor is continuing to add COC mass to groundwater." This is very likely, especially in areas with high bedrock vapor concentrations. Recommend evaluating the impacts of vadose zone contamination to groundwater as part of the remediation estimates.	NASA understands bedrock vapor mass has the potential to extend TOR; however this will be difficult to predict. NASA will learn more from the planned Alfa Area BVE pilot test as well as the plume-scale modeling of matrix diffusion effects. During remediation, it will be uncertain if increases in groundwater concentrations will be from matrix diffusion, vadose zone, or both (and in what proportion). NASA can better estimate vadose zone impacts, and matrix diffusion, in the future based on how our sources and plume respond to treatment. The Adaptive Management Plan will need to include monitoring and mitigation measures to help address this. Bedrock vapor impacts will be further evaluated in the Phase 2 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	NASA's original comment response has been updated to reflect the following (information added to the initial comment response is underlined): NASA understands bedrock vapor mass has the potential to extend groundwater TOR; however this will be difficult to predict. NASA will learn more from the planned Alfa Area BVE pilot test as well as the plume-scale modeling of matrix diffusion effects. During remediation, it will be uncertain if potential increases in groundwater concentrations will be from matrix diffusion, vadose zone, or both (and in what proportion). NASA can better estimate vadose zone impacts, and matrix diffusion, in the future based on how our sources and plume respond to treatment. The Adaptive Management Plan will need to include monitoring and mitigation measures to help address this. Bedrock vapor impacts will be further evaluated in the Phase 2 groundwater CMS. The following text will be included in the subject section: "NASA is currently completing fate and transport modeling, which can be used to estimate time of remediation for different alternatives. As part of the future Phase 2 CMS, NASA will evaluate potential bedrock contaminant migration scenarios and forecast potential impacts on time of remediation. Additionally, as more performance data is collected on Phase 1 and Phase 2 alternatives implementation, NASA will be able to better predict the impacts of bedrock vapor on contaminant recharge, versus matrix diffusion."
56	6.3.5.1	6-29	Additional studies or mitigation **will be** reauired if MNA or any other alternative does no operate as anticipated.	The text will be modified to state: "The MNA monitoring program will be designed to evaluate this potential concern. Additional testing or mitigation measures will follow the Adaptive Management Plan."	Response adequate. DTSC will review changes when submitted.	No additional response.
57	6.4.5.4	6-37	Explain whether BVE and EISB are anticipated to operate concurrently and whether there are any benefits and/or drawbacks for operating these two technologies together.	The text will be amended to note that the two technologies can be operated concurrently. The Alfa Area EISB pilot study and BVE pilot study work plans will be referenced.	Response adequate. DTSC will review changes when submitted.	NASA added text (Section 6.1.4) that discusses potential benefits of concurrent operations. The following text has been added after the first sentence of the section: "The technology may operate concurrently with the groundwater treatment components of the alternatives. There may be benefits to concurrent treatment including simplifying treatment operations management. NASA is currently performing a pilot study in the ND-136 TTA where EISB and BVE are operating concurrently. The information from this pilot study will help determine if there are benefits to concurrent operations.". The discussion of the combined benefits of groundwater treatment and BVE are presented in the "Assessment of Long-Term Performance and Effectiveness" sections of each alternative.
58	6.4.5.5	6-37	"Monitoring of the formation and subsequent attenuation of these daughter products is an important element of an MNA remedy and performance monitoring." Monitoring is also an important element of the EISB remedy.	The subject sentence has been revised to "Monitoring of the formation and subsequent attenuation of these daughter products is an important element of *the EISB and* MNA remedy and performance monitoring.", where italicized text represents the modified portion of the sentence.	Response adequate. DTSC will review changes when submitted.	No additional response.
59	6.4.7.1	6-39	"The MNA operations will be initiated at the completion of the CMD and operate until cleanup objectives are achieved." Verify whether NASA anticipates starting MNA operations at the same time as starting the BVE/EISB.	The subject sentence has been revised to "The MNA operations will be initiated at the *start of EISB activities* and operate until cleanup objectives are achieved.", where italicized text represents the modified portion of the sentence.	Response adequate. DTSC will review changes when submitted.	NASA has amended their initial response to include the following: The MNA activities for this alternative, and other alternatives, will be initiated after the corrective measures design is completed. MNA monitoring will be initiated before active treatment operations.
60	6.4.7.4	6-39	Recommend updating this section with recent information when the document is revised.	The text will be updated to refer to the ND-136 TTA EISB pilot study WDR permit if it is received prior to the next submittal of the Phase 1 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.
61	6.5.2	6-41	"The heating of groundwater is expected to have a minimal effect on the rate of back diffusion of contaminants from the sandstone to the fractures." Please clarify what is meant by "minimal effect on the rate of back diffusion" and provide support for this statement. "For this reason, while the rate of biodegradation is expected to increase with increasing temperature, the rate of biodegradation without heating water is not expected to be limiting. Furthermore, an increased biodegradation rate is expected to exhaust the fermentable carbon source more quickly, leaving less carbon available to support biodegradation of contaminants as they diffuse back out of the rock matrix. This could result in an increased application rate of fermentable carbon with seemingly little to no benefit to decreasing the remediation time period, which is expected to be governed more by back diffusion." This statement seems to imply that neither the application of carbon nor heat is expected to penetrate the matrix and that the reactions are only occurring in the fractures, not within the matrix. Please provide clarification. Additionally, please provide discussion why and how the halo-respiring bacteria would continue to consume the carbon source if the chemicals in the fracture water are depleted (see comment 68 below).	Please see response to Specific Comment 28. NASA has completed additional modeling activities that show increasing the rate of biodegradation in the rock matrix by a factor of 2 to 4 has limited benefits in achieving MCOs in a reasonable period of time. The results of these modeling efforts will be presented as a new appendix to the Phase 1 groundwater CMS.	Same as Comment 28	Refer to updated response to Specific Comment 28.

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62	6.6.4.2	6-47	Please present the anticipated potential benefits of concurrent BVE/P&T treatment for each groundwater TTA.	See response to Specific Comment 55.	Verify whether comment 55 is referenced correctly. The response to Specific Comment 55 does not directly address this comment. NASA needs to discuss the potential benefits of concurrent BVE/P&T treatment for Phase 1 groundwater TTAs.	Comment 55 is referenced to point out uncertainty in estimating time of remediation benefit for BVE. Bedrock vapor impacts will be further evaluated in the Phase 2 groundwater CMS. The following has been added to the subject text: "Concurrent BVE treatment with P&T at the ND-136 TTA is expected to reduce the amount of contaminant recharge from the vadose zone migration to groundwater. It is uncertain, however, if this benefit can be verified with field measurements. During remediation, it will be uncertain if potential increases in groundwater concentrations will be from matrix diffusion, vadose zone, or both (and in what proportion). NASA can better estimate vadose zone impacts, and matrix diffusion, in the future based on how ND-136 TTA responds to treatment. The benefits of concurrent groundwater treatment and BVE at the same well location will be further evaluated in the Phase 2 CMS."
63	6.6.5.5	6-49	Recommend evaluating a contingency method for the discharge of treated groundwater (e.g., surface discharge and dust suppression).	Discharge water contingency use will be added at a conceptual level to the Phase 1 groundwater CMS. NASA is interested in evaluating the use of treated discharge water for dust suppression related to soil remedial action work and would request support from DTSC for obtaining required permits. Surface discharge would require NPDES and potentially stream alteration permits and may be a less likely option.	Response adequate. DTSC will review changes when submitted.	No additional response.
64	6.8.5.3	6-65	"The result of natural attenuation will be a reduction of mass available for transport, which will collapse the size of the contaminant plumes after a long period of time." This is not really demonstrating a reduction in volume. It is demonstrating a reduction in bioavailable contaminants and reduction in volume upgradient.	The sentence will be modified as follows: "The result of natural attenuation will be a reduction of mass available for transport, which will *reduce the overall mass and peak concentrations* of the contaminant plumes after a long period of time."	Response adequate. DTSC will review changes when submitted.	No additional response.
65	6.9.1	6-68	Recommend focusing on whether this alternative would meet requirements if a contingency remedy is needed (e.g., a hypothetical future situation has occurred where groundwater COCs have reached or expected to reach the northern seeps) rather than repeating in each section that no COCs have reached this area.	Repetitive text will be removed and replaced with a shortened discussion regarding what would trigger remedial action and a statement that the Adaptive Management Plan will be used to guide future action.	Response adequate. DTSC will review changes when submitted.	The following text has been added to the subject section: "Should groundwater COCs be observed at unacceptable levels in the future, this alternative could be implemented through an adaptive management process and would be expected to prevent further migration of site contaminants to the seep locations. "
66	6.9.5.5	6-71	"The types of treatment residuals for this alternative are identical to that described for Alternative 3." Verify whether this is correct, as Alternative 3 also involves BVE. Recommend including section number when referring to information from another alternative.	The subject sentence will be rewritten to be stand alone and focus only on Alternative SP-2. Section number references can be added as requested; however, this will be minimized to key locations (e.g., first introduction) to avoid significant redundancy.	Response adequate. DTSC will review changes when submitted.	No additional response.
67	6.9.7.2	6-72	Potential typo: "…permitted with limited comments…" Verify whether this is correct.	The subject text will be revised to "The technologies used in this alternative are expected to be permitted, as these technologies are commonly implemented". The phrase "with limited comments" will be removed. This change will also be incorporated in sections 6.10.7.2, 6.3.7.2, and 6.8.7.2 where similar text was used.	Response adequate. DTSC will review changes when submitted.	No additional response.
68	6.10.2	6-75	"The EISB technology is challenged when concentrations are already low because, in the case of halorespiring bacteria, elevated concentrations of chlorinated ethenes are required to create a critical mass of microbes that can degrade the contaminants." Recommend including information about what level of concentrations are needed and how that compares with the potential treatment area.	The recommendation will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
69	6.10.5.1	6-77	Potential typo: "This technology is not expected to be marginally effective for metals…" Please clarify.	The word "not" will be removed from the subject sentence.	Response adequate. DTSC will review changes when submitted.	No additional response.
70	6.10.7.1	6-79	"…as shown on Figure 4-5, has two transects and five EISB wells installed in each transect." Please verify, Figure 4-5 has two transects but does not show proposed EISB wells.	NASA did not intend to locate the injection wells on Figure 4-5. Section 6.1.6.1 states "For the Northern Seep Area, two transects containing five injection wells, each, near RD-56 and ND-125 (B204/ELV AIG) as shown on Figure 4-5, will be used to deliver the biostimulation and bioaugmentation reagents to the subsurface to a depth of approximately 400 feet (220 feet saturated) for te ELV transect and to 450 feet (150 feet saturated) for the Building 204 transect." The subject sntence will be revised to also reference Section 6.1.6.1.	Response adequate. DTSC will review changes when submitted.	NASA has amended their initial response to include the following (new text as underline, stricken text removed): NASA did not intend to locate the injection wells on Figure 4-5. Section 6.1.6.1 text has been revised to, "For the Northern Seep Area, two transects ~~containing~~ consisting of five injection wells, each, near RD-56 and ND-125 (B204/ELV AIG) as shown on Figure 4-5 (note, only the transects are shown; individual injection wells are not shown), will be used to deliver the biostimulation and bioaugmentation reagents to the subsurface to a depth of approximately 400 feet (220 feet saturated) for the ELV transect and to 450 feet (150 feet saturated) for the Building 204 transect." The subject sentence will be revised to ~~also~~ reference Section 6.1.6.1.
71	7	7-1	Each TTA has a different profile – concentrations, COCs, depth to GW, etc. Please include a summary table for the alternatives evaluated for each TTA.	See response to Specific Comment 26.	Response adequate. DTSC will review changes when submitted.	No additional response.
72	7	7-1	Recommend briefly recapping scoring criteria or referencing where it can be found.	The requested recommendation will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
73	7.1.1	7-1	For protection of human health and the environment, MNA scored 3 and the active alternatives scored 4. Provide justification for these scores being so similar.	The following text will be added to the subject section: "Based on time of remediation estimates, MNA is expected to achieve comparable cleanup levels as those anticipated for alternatives utilizing activate treatment, albeit in a slightly longer timeframe."	Response adequate. DTSC will review changes when submitted.	No additional response.

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74	7.1.4.2	7-3	Verify whether the score should be the same for all alternatives. This section discusses the similarities but does not address the differences. Please apply this comment throughout Section 7. For example, this is also applicable for Section 7.2.4.2.	The criterion evaluation text will be re-evaluated to determine if there should be differentiation of scores.	Please correct "activate treatment" to "active treatment"	Typo will be corrected. Given the definition of the screening criterion, NASA believes that each alternative should score the same for "Assessment of Long-Term Performance and Effectiveness". Other criterion address the relative differences in performance and effectiveness. This criterion only assess the ability to monitor performance and effectiveness.
75	7.1.4.3	7-3	Potential typo: The last sentence does not match Figure 7-1.	The score of "4" noted on Figure 7-1 for Alternative 1/Residual Risks will be changed to "1".	Response adequate. DTSC will review changes when submitted.	No additional response.
76	7.1.6.2	7-6	Verify whether P&T should have a higher worker hazard than ISCO or heated EISB.	The first sentence of the second paragraph will be changed to "…Alternative 3 was assigned the lowest score of 2, since it poses more work hazards due to the continued use of mechanical equipment and chemical reagents;…". The paragraph above this section will add "equipment" following "mechanical" in the last sentence of the first paragraph of the referenced section.	The last sentence of the response is incomplete. Response provided up to that point is adequate unless there is additional information that is missing.	The incomplete sentence is presented in its entirety in the Original NASA Response column (with incomplete portion was accidently cut off in the table printing and the row height has been corrected).
77	7.1.8.1	7-8	"Alternative 1 is the lowest cost alternative as the monitoring network is already established for the TTAs." Please acknowledge that is it very likely that additional monitoring wells would be needed for this alternative.	The text will be updated to indicate that the need for additional MNA wells to support remedial monitoring for NASA AIG plumes will be evaluated in the Phase 2 groundwater CMS and the CMI design.	Response adequate. DTSC will review changes when submitted.	No additional response.
78	7.2	7-10	"The same scoring scale used in Section 4 (Table 4-2) is used for this evaluation…" Verify whether this should reference Table 4-4. Consider copying the table here or in the beginning of section 7-1 for quick reference.	Table 4-4 will be repeated in Section 7 in the next submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
79	7.2.7.1	7-14	Potential typo: "Because of access challenges related to the installation of SP-3, it was assigned a lower score of 3 for the Northern Seep Area." Figure 7-3 shows a score of 5. Please verify.	The proper score of "3" for the Alternative SP-3 in the northern seep area will be included in the next submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
80	7.2.12	7-17	Please present the recommended alternatives for each TTA. The previous Draft CMS included a section called "Comparative Evaluation Conclusion."	The recommend alternative will be included in the next Phase 1 groundwater CMS submittal.	Response adequate. DTSC will review changes when submitted.	No additional response.
81	Figures	2-14	TCE and NDMA in the NSGW have very similar colors, and it is difficult to tell them apart. Recommend revising the figure to create more contrast between the two chemicals.	Figure 2-14 will be revised as recommended.	Response adequate. DTSC will review changes when submitted.	No additional response.
82	Figures	2-15	Verify whether this figure should also include the date for the historical maximum TCE concentration like the other similar figures (for example, Figure 2-12).	The associated sample dates were not included on Figure 2-5 to allow for less-cluttered labeling; instead, Note 2 indicates the range of sample dates involved. NASA feels that detailing the specific sample dates at each well on this figure is not necessary.	Response adequate. No changes.	No additional response.
83	Figures	4-1	Recommend the following revisions to the flow chart: • "Area considered for vadose zone treatment." -> "Area is a TTA for Phase 1 CMS." • "Other areas considered as part of Phase 2 CMS." -> "Other areas evaluated as part of Phase 2 CMS." • "Areas considered for active source treatment." -> "Area is a TTA for Phase 1 CMS." • "Other areas considered as part of Phase 2 CMS." -> "Other areas evaluated as part of Phase 2 CMS."	The flow chart will be revised as follows: • "Area is a TTA for Phase 1 CMS." (as requested) • "Other areas screened as part of Phase 2 CMS and considered for evaluation." • "Area is a TTA for Phase 1 CMS." (as requested) • "Other areas screened as part of Phase 2 CMS and considered for evaluation."	Response adequate. DTSC will review changes when submitted.	No additional response.
84	Figures	4-5	Please add TTA label to the legend.	NASA assumes DTSC is referencing the TTA symbology (as opposed to label, which is defined in the figure notes). The green TTA symbology will be added to the legend as requested.	Response adequate. DTSC will review changes when submitted.	No additional response.
85	Figures	4-6	Consider correlating the technology numbers (T1, T2, etc.) to the technologies either here or in the text.	See response to Specific Comment 35.	Response adequate. DTSC will review changes when submitted.	No additional response.
86	App A	General	The mean transit time of 500 years seems like a long time to go 270 feet. Please provide additional details about the simulation performed.	The rate of recharge and the rate of mass diffusion and transport are very low in the vadose zone, leading to long travel times. The model input parameters and methodology that lead to the calculation and results are provided in Appendix A.-Reference will be added for the recharge data source and length used.	Response adequate. DTSC will review changes when submitted.	NASA has updated their original response as follows (new text is underlined, removed text is stricken): The rate of recharge and the rate of mass diffusion and transport are very low in the vadose zone, leading to long travel times. The model input parameters and methodology that lead to the ~~calculation~~ simulation results was rigorously documented in Appendix A. ~~Reference will be added for the recharge data source and length used.~~ The parameters assumed and used as input to the HYDRUS simulations (along with data sources) that lead to low rates of mass diffusion and contaminant transport are summarized in Table 1 in Appendix A. The assumed rates of recharge of precipitation were obtained from an article published in the Journal of Hydrology based on data collected at SSFL; the full reference to this article in provided in Appendix A.
87	App B	B-4	The rate transfer model appears to have been correctly implemented with respect to mobile/immobile transfer. However, biodegradation half-lives of 1-3 years are used based upon "literature" and "professional judgement." These values are from alluvium studies, while Yu et al. studied intact cores from SSFL and found half-lives of 29-37 years (Yu et al., 2020). Recommend updating the half-lives based on the available SSFL-specific data.	The TOR analysis included in the Phase 1 groundwater CMS is a preliminary effort that will be superseded by the more comprehensive plume scale fate and transport models currently under development. The 1 to 3 year TCE half-lives within the plumes assumed in this effort were necessary to "calibrate" the simulated plume lengths to what is observed at the site and falls within the range of literature values. This half-life estimate should be viewed as a lumped parameter that accounts for the effects of both degradation and matrix diffusion exchange with the bedrock matrix in limiting plume migration at the site. The plume scale models incorporate biodegradation half-lives that are consistent with the site-specific estimates provided in Yu et al. (2020). Predictions of plume scale migration from the plume-scale models, incorporating more realistic influences of matrix diffusion on plume stability and persistence and site-specific biodegradation rates, will be utilized in the Phase 2 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.

No.	Section(s)	Page(s)	Comment(s)	Original NASA Response(s)	DTSC Response(s) to NASA Response(s)	Additional NASA Response
88	App D, Sections 1.3 to 1.5	D-2 to D-3	Please also provide cross sections for the Delta C-6 TTA, the Northern Seep Area, and the Southern Seep Area.	Existing cross section C-C' from Appendix D of the NASA Groundwater RFI (NASA, 2020), which covers both the Delta C-6 TTA and the Southern Seep Area, will be added to this document (see response to LARWQCB General Comment 3). The Building 204 Extended Hydrogeologic Cross Section will also be added to address the Northern Seep Area (see response to LARWQCB Specific Comment 3). Text will be added to discuss the similarity of the ELV northern seep area to the Building 204 cross section.	Response adequate. DTSC will review changes when submitted.	To address the additional comment from the LARWQCB, General Comment 3, an ELV northern seep area cross section will also be added to Appendix D.
89	App E	E-1 and E-2	Some of the items in these tables have a narrative of "not applicable," but they have scores. Please verify.	NASA does not see the issue DTSC raises with these table.	The "Land and Space" stressor under the Resource Depletion/Gain (recycling) contains scores for Alternatives deemed N/A (Alternatives 2a, 2b, and 4). If these alternatives are not applicable, they should not be scored. In addition, there are stressors that contain a narrative for some alternatives but are not scored. Please clarify why no score is necessary for these situations.	Thank you for the clarification. The table will be updated to ensure all criteria with scores are accompanied by narrative and all criteria narrative are accompanied by scores.
90	App F, 4.6	4-6	The last paragraph mentions the BVE activities completed at LOX and references the NASA Groundwater RFI Report. Please summarize the LOX BVE activities and results.	A summary of the former LOX Plant AIG BVE activities is presented in the technology description of BVE, Section 4.1.1 of the main text of the Phase 1 groundwater CMS. A reference will be added in Appendix F to this section.	Response adequate. DTSC will review changes when submitted.	No additional response.
91	App F	Table 3-2	Please include calculation information such as concentration used (and if calculated, how calculated), flow rate used (and basis if calculated), run time, and equations used. Verify whether concentrations used for these calculations were all based on laboratory data, just some via TO-15 and some using 8260B.	The mass-removed calculations are described in Section 3.2 of the document, and the operational data used in these calculations are in Appendix G of the Appendix F report, which presents the field measurements of flow and concentration. An average weekly flow was used for the flow measurements. Table 3-2 denotes whether 8260B or TO-15 was used by the italic and normal fonts. A footnote will be added to Table 3-2 to reference Section 3.2 and Appendix G.	Response adequate. DTSC will review changes when submitted.	No additional response.
92	App F	Table 3-5	Please explain why piezometers PZ-200 and PZ-203 are singled out for this evaluation, and why the table doesn't include similar information for the extraction well and other observation wells. Potential typo: One column includes "%" and the others don't.	In Table 3-5, % indicators will be restricted to the column headers (to define units). The % symbol will be removed from any numbers in the table. Table 3-5 compares the pattern of PZ-060 and PZ-071 as representative of the two principal characteristic behaviors during rebound. Table 3-4, immediately preceding, presents the PID readings for all piezometers; these rebound patterns are discussed in Section 3.5 and presented in Figures 3-17 through 3-24.	Response adequate. DTSC will review changes when submitted.	No additional response.
93	App F	Table 3-6	This table shows that the July 14, 2014 result for 2-Chloroethyl vinyl ether (2-CLEVE) was rejected. Please include a short note explaining why this result was rejected and what impact it has on data evaluation for the BVE study. Verify whether other results for this compound are available (i.e., during previous groundwater monitoring activities). If so, consider including that data in the note for reference.	HAR-19 has been monitored (twice annually) as part of the PCP/sitewide groundwater monitoring program. In all cases, 2-chloroethyl vinyl ether has been rejected due to acid preservation of sample degrading 2-CLEVE. This parameter is not a COC for the monitoring program. There is no impact of this on the BVE pilot study evaluation.	Response adequate	The rejected concentration analyte has been removed from Table 3-6.
94	App F	Table 3-6	Verify whether any later groundwater monitoring data is available and if it indicates any interesting trends.	HAR-19 has been monitored (twice annually) as part of the PCP/sitewide groundwater monitoring program. All of the listed parameters are J- or U-flagged since 2014 except TCE, cis- and trans-1,2 DCE and vinyl chloride. In all cases the groundwater concentrations rose during the BVE pilot test, persisted near this level for one or two sample events (<6 months), then dropped, and have stayed 50% or more below the pre-pilot test concentrations through February 2021. This may be the result of the removed mass (by the BVE pilot test) no longer being available to the water table in HAR-19, or in various fractures that may intersect the water table.	Response adequate	No additional response.
95	App F	Table 3-6	Please include reporting limits in this table. The definitions for J, R, and U are a little different from those presented in the data usability report (PDF page 656). Please verify.	The flag definitions will be made consistent in the table to match the definitions in Section 2 of the Data Usability Report (pg. 2-2), which is Appendix N of Appendix F of the Phase 1 groundwater CMS. The reporting limit is denoted by the value of U flagged data.	Response adequate. DTSC will review changes when submitted.	No additional response.
96	App F	Figure 1-1	Consider including the location of HAR-19 (extraction well) on this figure for context.	The approximate location of HAR-19 will be noted on Figure 1-1.	Response adequate. DTSC will review changes when submitted.	No additional response.
97	App F	Figure 1-4	Figure 1-4 shows 4Q2011 groundwater elevations while Figure 2-2 shows 4Q2014 groundwater elevations. Please verify and explain the inconsistency.	2011 was a very wet year, so the piezometer/wells in this figure were sounded to assess the extent of the near-surface groundwater. For BVE, this would represent a possible surface seal for a deep extraction well, not only historically, but also years later if saturated conditions persisted. The Figure 2-2 cross-section presents water levels in wells that did not exist in 2011, so were not sounded then, for a time and under conditions representative of the BVE pilot test.	Response adequate. DTSC will review changes when submitted.	No additional response.
98	App F	Figure 2-1	In addition to the note that the cross sections are presented in Section 3 of the BVE summary report, suggest referencing Figures 3-15 and 3-16 for the associated cross sections.	Agreed. The following note will be added to the Note on Figure 2-1: "…and in Figures 3-15 and 3-16."	Response adequate. DTSC will review changes when submitted.	No additional response.
99	App F	Figure 2-2	Verify whether there is a cross section that matches up with this figure. If it is intended to only show relative depths, recommend including a note that horizontal orientation is not to scale.	Figure 2-2 is a well profile graph to show relative depths of well screens/open boreholes and is sorted by the easting coordinate (farthest east well at the left and farthest west well at the right). This is not meant to represent a cross section and the well location is not to scale. A note will be added to the figure to clarify this.	Response adequate. DTSC will review changes when submitted.	No additional response.
100	App F	Figure 3-5	Note 4 is unclear. Verify whether there is a different basis for different PID reading dates included in the figure and explain why these results are comparable. Discrepancies should be noted in a main report table that includes the data.	The note will be modified to state: "Influent PID concentrations were collected between 8/26 /14 and 10/23/14 *as shown with the blue diamond symbol and blue-dotted line. However the 9/3/14 15:30 influent measurement was not directly collected; therefore, an estimated concentration was calculated from post-dilution PID readings* ."	Response adequate. DTSC will review changes when submitted.	No additional response.
101	App F	Figure 3-5	Note 5: Specify whether this total VOC concentration is based on laboratory results. Recommend including a reference to a summary table (included with the main report, not in an appendix) that includes these laboratory results, associated PID concentrations, and the total (sum).	Note 5 will be modified to state that the total VOCs are based on laboratory results (shown as the green filled circles); Appendix I presents the laboratory results used in the evaluation, which were most important for our mass removal calculations. These are presented and discussed in Section 3.2 of the main report.	Response adequate. DTSC will review changes when submitted.	No additional response.
102	App F	Figure 3-15	Recommend including a reference to Figure 2-1 for cross section locations.	The cross section location figure reference (Figure 2-1) will be added to the notes.	Response adequate. DTSC will review changes when submitted.	No additional response.
103	App F	Figure 3-16	Recommend including a reference to Figure 2-1 for cross section locations. Potential typo: symbols are missing for the legend in the title block, though they seem to be included above. Verify whether the partial legend in the title block should be deleted.	The cross section location figure reference (Figure 2-1) will be added to the notes. The partial legend entries in the title block area will be deleted.	Response adequate. DTSC will review changes when submitted.	NASA has amended their original response to the following (new text underlined, stricken text removed): The cross section location figure reference (Figure 2-1) will be added to the notes. The partial legend entries in the title block area will be ~~deleted~~ reconciled with Figure 3-15.

No.	Section(s)	Page(s)	Comment(s)	Original NASA Response(s)	DTSC Response(s) to NASA Response(s)	Additional NASA Response
104	App F	Table F-1	Include the reporting limit in this table. Also add the following notes: Sample type N, J, SVOC, VOC, etc. Check the notes for U and UJ against the data usability report for consistency.	The flag definitions will be made consistent in the table to match the definitions in Section 2 of the Data Usability Report (pg. 2-2), which is Appendix N of Appendix F of the Phase 1 groundwater CMS. The reporting limit is denoted by the value of U flagged data.	Response adequate. DTSC will review changes when submitted.	No additional response.
105	App F	Table G-1	Add the following notes: SCFM, ppm, meaning of grayed out cells, and calculation (equation for) calculated flow rate.	Notes to explain the following will be included at the bottom of Table G-1: SCFM (standard cubic feet per minute, calculated from calibrated Pitot Tube); ppm (parts per million); grayed out cells indicate no measurement made for that parameter at that time. Calculation for flow was not mathematical, but from a manufacturer-supplied chart.	Response adequate. DTSC will review changes when submitted.	No additional response.
106	App F	Table I-1	Recommend including all soil vapor analytical data into one table and displaying it sequentially to allow for easier comparison. Another column could be added for analytical method (fixed lab or mobile lab). Please explain why the difference in analytical method is being emphasized so much and why using the two different methods was appropriate for the study. Include reporting limits for all analytical data.	Modifying the format of the soil vapor analytical data tables is not considered necessary to support the HAR-19 BVE pilot study conclusions and would be a significant effort because the original data files are no longer available. In 2014, a mobile lab was available at the site for the pilot study to provide relatively quick results by field GC. Additional, regularly scheduled summa cannisters were collected for shipment to a fixed lab for GC-MS analysis. In 2014, GC-MS was not available in mobile laboratories.	Old data could be converted from PDF to excel. Reconsider finding and converting data.	The data will be converted and the table modified.
107	App F	Tables I-1 to I-3	Add notes as appropriate (sample type N, TO15, VOC, GENCHEM, SW8260B, EC3, etc.). Check the notes for U, J, and = against the data usability report for consistency.	Notes will be added to the table as requested to match the definitions in Section 2 of the Data Usability Report (pg. 2-2), which is Appendix N of Appendix F of the Phase 1 groundwater CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.
108	App F	App K K-31	Add notes as appropriate (in. Hg, ppm, PID, Q, L/min, min, etc.).	This appendix contains the manual pressure readings at HAR-19 and all of the instrumented piezometers; and the SVP purging records for the 22 monitored locations. The units for relevant columns are listed in the column label in Appendix K.	Response adequate.	Acronym definitions have been added after first occurrence in the associated field form in Appendix K.
109	App F	App L L-1	"The customized barometric signal for the well/transducer is then subtracted from the raw pressure time series resulting in data representing pressure responses solely from pumping." Verify whether this should refer to vapor extraction rather than pumping and that the signal processing was applied correctly for a vapor extraction application rather than a pumping application.	"Pumping" will be replaced by "*vapor extraction* ".	Response adequate. DTSC will review changes when submitted.	No additional response.
110	App F	App M Table M-1	Add notes (U, J, R, =, NM, N/A, SW8260B, µg/L, etc.) and reporting limits.	The presentation of the analytical reports, and their associated data, is found in Appendix I. The purpose of Table M-1 is to compare the result at the start of the HAR-19 BVE pilot test with the result at the end of the rebound period. It would impede the presentation of the focus in this table (did concentrations go up, overall, or down?) to include, redundantly with Appendix I, the original laboratory parameters.	Response adequate.	No additional response.
111	App F	App O	Please verify figure and table numbers. The ones cited in the RTCs do not appear to be included in the report.	The figure and table numbers cited in this RTC table are associated with the BVE summary TM DTSC reviewed (*Results from Bravo Bedrock Vapor Extraction Treatability Study for the Santa Susana Field Laboratory, Ventura County, California* dated 11/11/2015), not the current report.	Response adequate. DTSC will review changes when submitted.	No additional response.
112	App F	App O	#4: Based on the PID results, it looks like the concentration was climbing and had reached the highest concentration of the rebound period on October 23. Please explain why that would not have been a good time to collect a laboratory sample.	The HAR-19 extraction concentrations did vary from the low-to-mid-200s ppm by PID to the low 300s ppm by PID during the 2-day rebound period (Table G-1, Appendix F). The laboratory analyses were used primarily for quantifying the relative proportion of the individual constituents, and for these two ranges there would not be too large of a difference in these values. Logistically, as the final day of the test also involved shutting the site down, the sampling was performed the day before to eliminate items that might have received less attention on the final day.	Response adequate.	No additional response.
113	App F	App O	#16: DTSC's preference is for the laboratory data to be included in a main table (summarizing key constituents) with a comparison to PID concentrations. In addition, separating the laboratory data by fixed laboratory and mobile laboratory makes it difficult to evaluate trends in HAR-19. MRLs are not presented in the tables in Appendices I and M as previously requested. Please combine the laboratory data into one table and either include PID readings as a comparison or provide a separate table that includes the laboratory data and the PID readings. Explain why the main portion of the report includes a table presenting observation well PID measurements over time but not a table presenting HAR-19 (extraction well) PID and laboratory data over time. Provide MRLs for all laboratory analytical results.	Due to the age of the data, the loss of original files and staff, this request to include all data in a single table may not be possible. The requested modifications do not change the results or conclusions of the HAR-19 BVE pilot study. The use of frequent PID readings was intended to show the trend of concentrations according to a constant frame of reference. Although there was a mobile lab, it was not available throughout the pilot test, so its results did not represent a continuous sequence of data. Likewise, the fixed lab results provided precision, and were used (as more certain) to calibrate the mass removal estimates, but for understanding rebound and short-term removal patterns the PID data set was the best available to display these trends. The emphasis in the report is on the piezometer readings beause these represent the formation response to the extraction. The extraction well presents an integration of all flow inputs, so does	Old data could be converted from PDF to excel. Reconsider finding and converting data.	Data in Appendix F and I have been updated to include method detection limit and reporting limit information. See response to Specific Comments 104 and 106.
114	App F	App O	#19: The requested information has been provided for observation wells, but not for the extraction well. Appendix K only contains time and vacuum readings, no PID readings. Please update the report to include the requested information.	Due to the age of the data, the loss of original files and staff, this request may not be possible. The requested modifications do not change the results or conclusions of the HAR-19 BVE pilot study.	DTSC would like to encourage NASA to convert old data from PDF to excel. Please reconsider locating and converting old data.	Appendix K has been modified to include acronym definitions as specified in Specific Comment 108. The available data for the extraction well is already included in the report.
115	App H	Table 1 Page 7	#34: "NASA is unable to publish a figure for public consumption that includes any details or location information on culturally sensitive areas…Additionally, the entirety of the SSFL property was recently nominated as a Traditional Cultural Property and is in the process of being submitted to the National Register. As a result, the entire property could be classified as a culturally sensitive area." Groundwater cleanup can and will occur on the site even if is designated a culturally sensitive area. Remediation options and cleanup goals will necessarily consider the protection of cultural resources.	Previous DTSC comment: "PRB: This paragraph eliminates the use of a PRB due to its location in an ecologically sensitive area. However, the report does not explain where the possible PRB would be installed or include a map of ecologically sensitive areas. The recommended layout change of evaluating technologies on a source zone by source zone basis rather than NASA-wide will likely help with this. Recommend showing sensitive / protected areas on a figure and describing the associated limitations as part of that evaluation." See response to General Comment 9 related to document format changes (source zone by source zone evaluation request). PRBs are not practical for Phase 1 groundwater treatment at SSFL. Any PRB installation would require rock-blasting and it is screened out before alterative evaluations.	NASA's response does not directly address DTSC's comment. DTSC would keep any culturally sensitive area information confidential.	The PRB evaluated in Table 4-3 involves installation of a trench. Alternative SP-3 involves application of an EISB barrier upgradient of the seep area. The latter is a more practical barrier application. The text Section 4.3.2 will be updated to reflect that the EISB barrier is a more practical technology for the location, compared to the installation of the trench. The Burro Flats area is an ecologically and culturally sensitive area which limits the types of intrusive remedial actions that can be performed. NASA will meet with DTSC to discuss how the AOC-soil related exclusion area criteria may factor into remedial technology selection in the southern seep area.

No.	Section(s)	Page(s)	Comment(s)	Original NASA Response(s)	DTSC Response(s) to NASA Response(s)	Additional NASA Response
116	App H	Table 1 Page 7	#44: Sections reference performance monitoring and optimization but don't address requirements. Periodic reviews and reporting are not addressed. Suggest that this could be briefly addressed once for each technology.	Previous comment: "Include performance monitoring and optimization requirements for each alternative. Include section or subsection describing periodic reviews and reporting." The recommended addition related to reviews and reporting will be included in the appropriate places in the next Phase 1 groundwater CMS document submittal.	Response adequate. DTSC will review changes when submitted.	A new section has been added to Section 6.1 (6.1.10) to address this comment.
117	App H	Table 1 Page 7	#45: The requested figures are not included in the report. Please provide the figures with the revised report. They should show the proposed treatment area and capture zones and any other relevant information.	Previous comment: "Present figures depicting all of the alternatives." NASA provided figures of locations in the Phase 1 groundwater CMS (Figure 6-1 shows the process flow diagram for the groundwater treatment system, Figure 4-5 shows the location of potential treatment locations in the norther seep area, Figure 6-3 shows a conceptual view of the EISB treatment technology). Capture zones are highly uncertain and not depicted (see response to Specific Comment 52). Capture will need to be evaluated as part of Adaptive Management.	No changes to report.	No additional response.
118	App H	Table 1 Page 8	#48: This comment does not appear to have been addressed in the Phase 1 CMS.	Previous comment: "The document should specify what monitoring is anticipated for MNA (e.g., process monitoring, migration, monitoring, ambient monitoring)." The MNA monitoring that NASA expects to perform, and that is discussed in the Phase 1 groundwater CMS, includes monitoring of groundwater in various monitoring wells for constituents that assist in developing supporting lines of evidence regarding the degree to which natural attenuation of COCs is occurring. This includes monitoring of COC concentrations to evaluate the behavior of the plume and whether it is stable or expanding in the vicinity of the plume perimeter, analysis of geochemical parameters, such as electron acceptors (dissolved oxygen, nitrate iron, sulfate) and field parameters (such as ORP, pH and temperature) that assist in understanding the types of microbial respiration processes occurring in groundwater (such as aerobic oxidation or iron reduction), and additional parameters, such as DNA-based indicators for microbes and their functional genes and CSIA analyses for carbon isotope ratios, to provide additional insights as to the types of degradation processes occurring in site groundwater.	No changes to report	No additional response.
119	App H	Table 1 Page 8	#55: Recommend providing a summary table that includes the information requested in this comment, allowing a quick comparison of alternatives.	Previous comment: "Provide an evaluation of each technology including the pros and cons and relative costs of each. Show order of magnitude reduction or treatment levels each technology is anticipated to achieve." See previous comment on reduction (Specific Comment 44).	Response adequate. DTSC will review changes when submitted.	No additional response.
120	App H	Table 2 Page 7	#16: This comment does not appear to have been addressed (the locations of the proposed BVE well locations).	Previous comment: "A figure showing detailed locations of the proposed BVE wells and their respective radii of influence should be provided to demonstrate that the full extent of vapor mass will effectively be removed." Once the Alfa Area BVE pilot study work plan is approved by DTSC, the location of the Alfa Area BVE well, and associated monitoring wells, will be included in the next Phase 1 groundwater CMS submittal (otherwise the work plan will be referenced). If the upcoming new former LOX Plant area vapor well sampling confirms the ND-112 TTA is a Phase 1 TTA (versus a Phase 2 TTA; see response to General Comment 2), a former LOX Plant area BVE pilot study work plan will be developed for DTSC review/approval. The ND-112 TTA BVE well location(s) will included in the next Phase 1 groundwater CMS submittal if they are available (otherwise the future work plan will be referenced). As for radii of influence, in this fractured environment it is not possible to know ahead of time what this might be, nor to know which direction might have the highest vacuum propagation. We estimate a large radius for piezometer monitoring, and then monitor to see where the vacuum or concentration changes appear.	Response adequate.	No additional response.
121	App H	Table 2 Page 8	#18: Confirm that this information is included in the report and provide an appendix reference in the response so it can be easily located.	Previous comment: "NASA should provide a figure showing all well construction and system details as well as a process flow chart for managing extracted fluids." The 2020 draft Phase 1 groundwater CMS included a process flow diagram for the treatment system in Figure 6-1. A conceptual plan for an extraction well will be added to the Phase 1 groundwater CMS. Many construction system details will be worked out in the CMI design and are not known yet to include in the CMS.	Response adequate. DTSC will review changes when submitted.	No additional response.

No.	Section(s)	Page(s)	Comment(s)	Response(s)	LARWQCB Response(s) to NASA Response(s)	Additional NASA Response
G1	N/A	N/A	The Phase 1 CMS details COCs identified based on a risk assessment. These COCs were further evaluated to focus on a list of chemicals to be carried forward in the Phase 1 CMS, with the remaining risk assessment COCs to be further evaluated in the Phase 2 CMS. The Phase 1 CMS outlines the methodology used to remove detected chemicals from the list of Site COCs due to the assumption that these chemicals "result in an overestimation of risk, do not contribute significantly to the overall risk, or are not associated with a past site release (that is, related to soil contamination)." T**his methodology neglects certain requirements of State Water Resources Control Board (SWRCB) Resolution No. 92-49, as discussed below:** **a**. As previously stated in the Regional Water Board's January 15, 2020 Memorandum that provided comments to the 2018 CMS, the use of risk-based screening levels (RBSLs) to eliminate potential COCs without first evaluating cleanup of these COCs in a manner that promotes attainment of background water quality is not consistent with SWRCB Resolution No. 92-49. To use the RBSLs to screen potential COCs and be consistent with SWRCB Resolution 92-49, **NASA should add a section to the CMS detailing why background water quality cannot be restored and providing support for a conclusion that the RBSLs are the best water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible. Since the Phase 1 CMS is intended to propose a more focused, targeted source area cleanup, this section can be added to the Phase 2 CMS, when a more comprehensive cleanup plan for the Site is proposed; and** **b**. Chemicals not likely to occur naturally that are detected in the groundwater but have not yet been associated with detected soil contamination should not be ruled out as COCs. Given the complex hydrogeology at the Site, it is possible that the overlying source of groundwater contamination has not yet been identified in soils.	**a.** NASA will clarify that assessment of cleanup to background will be performed in the Phase 2 groundwater CMS. The DoD has negotiated ARARs statewide that address requirements of SWRCB Resolution No. 92-49 that can be used under RCRA. The ARARs memo documents agreement between the State and DoD to cleanup to MCLs and prepare a Technical and Economic Feasibility Assessment (TEFA). This can be a part of the Phase 2 groundwater CMS, or alternatively, an interim cleanup goal can be designated in the Statement of Basis and a TEFA conducted once the interim cleanup levels are achieved. On September 1, 2022, NASA proposed to revise the above comment via email as follows: "NASA will clarify that assessment of cleanup to background will be performed in the Phase 2 groundwater CMS. ~~The DoD has negotiated ARARs statewide that address requirements of SWRCB Resolution No. 92-49 that can be used under RCRA . The ARARs memo documents agreement between the State and DoD to cleanup to MCLs and prepare a Technical and Economic Feasibility Assessment (TEFA).~~ A Technical and Economic Feasibility Analysis (TEFA) can be a part of the Phase 2 groundwater CMS, or alternatively, a~~n interim~~ cleanup goal can be designated in the Statement of Basis and a TEFA conducted once the interim cleanup levels are achieved. " **b.** The list of COCs included in the Phase 1 and Phase 2 groundwater CMSs, and the acceptable criteria for site-specific consideration of COCs will be discussed with DTSC as indicated in the Response to DTSC General Comment #6.	a. The objective of the Phase 1 CMS is groundwater source control and source removal. A technical and economical (T&E) feasibility analysis has not yet been performed to establish cleanup to background or an alternative cleanup level as appropriate. Therefore, designation of Phase 1 ~~interim~~ cleanup levels for the Phase I CMS is premature, and the cleanup objective for the Phase 1 CMS should be cleanup to the extent that is technically and economically feasible. Cleanup levels should be established in the Phase 2 CMS based on the results of a T&E feasibility analysis following the SWRCB 92-49 process. b. The Regional Water Board reiterates our initial comment that chemicals not likely to occur naturally that are detected in the groundwater but have not yet been associated with detected soil contamination should not be ruled out as COCs.	The updated Phase 1 groundwater CMS will describe that a risk assessment has been completed to identify risks to human health and ecological receptors. The Phase 1 groundwater CMS cleanup objectives are focused on treating organic contaminants, primarily chlorinated ethenes, in the source and seep areas which drive more than 99% of the human health and ecological risk at the site. Remaining COCs, including detected chemicals above background, will be assessed in the Phase 2 groundwater CMS following the SWRCB 92-49 process. This statement will be added to the Phase 1 groundwater CMS. NASA will be completing a T&E feasibility analysis, to establish what level of treatment could be achieved, as part of the Phase 2 groundwater CMS. The T&E feasibility analysis will assess treatment results from ongoing GETS operations, the EISB pilot study, BVE pilot study, and Phase 1 CMI remedial actions. Because it is too early to establish if background is a feasible cleanup level for the Phase 2 groundwater CMS, and the Phase 1 groundwater CMS is focused on chlorinated ethenes, the evaluation of alternatives in the Phase 1 groundwater CMS will use promulgated MCLs or NLs as ~~interim~~ cleanup levels. NASA will note these ~~interim~~ cleanup levels are used as a point of reference to evaluate alternatives in Phase 1 and the T&E feasibility analysis will eventually determine the final cleanup levels for the site in the Phase 2 CMS.
G2	N/A	N/A	The proposed MCOs for the Phase 1 CMS COCs are the applicable Federal and California Maximum Contaminant Levels (MCLs) and California Notification Levels (NLs) with footnote "a" stating "Or background, if feasible". SWRCB Resolution No. 92-49 requires that the Regional Water Board, or DTSC where it is providing regulatory oversight, shall "Ensure that dischargers are required to clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable…" Therefore, the MCOs should be background water quality or the best water quality which is reasonable, which may be the Federal and California MCLs and California NLs. If MCLs and NLs are selected as the best water quality which is reasonable, to comply with SWRCB Resolution No. 92-49, it should be demonstrated that background water quality cannot be restored and that the Federal and California MCLs and California NLs are the best water quality that is reasonable, considering the factors in SWRCB Resolution No. 92-49, prior to their adoption as MCOs.	See response to General Comment #1a. Background cleanup will be evaluated in the Phase 2 groundwater CMS.	The Regional Water Board reiterates our initial comment that MCOs should be background water quality or the best water quality which is reasonable, which may be the Federal and California MCLs and California NLs. If MCLs and NLs are selected as the best water quality which is reasonable, to comply with SWRCB Resolution No. 92-49, it should be demonstrated that background water quality cannot be restored and that the Federal and California MCLs and California NLs are the best water quality that is reasonable, considering the factors in SWRCB Resolution No. 92-49, prior to their adoption as MCOs. See, also, response to comment G1.a, supra.	Refer to response to General Comment 1.
G3	N/A	N/A	The Regional Water Board's comments to the 2018 CMS requested that future CMS reports include cross-sections for the four NASA areas of impacted groundwater (AIGs). The cross-sections were requested to include lithology and the known and inferred extents of the COC plumes for soil vapor and groundwater to aid in review of reports. The Phase 1 CMS did not include the requested cross-sections. These cross-sections should be added to the final draft of the Phase 1 CMS to facilitate easier review of the report. This could be accomplished through an appendix to the Phase 1 CMS that includes excerpts of other previously submitted documents with these cross-sections.	NASA will add the existing groundwater RFI cross sections as an appendix to the Phase 1 CMS report instead of just referencing these figures.	Comment noted.	RFI cross sections associated with the Phase 1 groundwater CMS TTAs are now included in Appendix D of the revised Phase 1 groundwater CMS.
G4	N/A	N/A	The Regional Water Board originally commented to NASA (2019), "If per- and polyfluoroalkyl substances (PFAS) have not yet been evaluated as potential COCs and have not been analyzed as part of previous groundwater assessments, a screening for PFAS in groundwater should be performed." On April 7, 2020, DTSC issued a letter to NASA recommending evaluating the use of PFAS. NASA responded that "A PFAS Preliminary Assessment is being prepared by NASA in response to DTSC's letter and will be submitted separately. PFAS will be considered in the Phase 2 CMS if warranted." On May 24, 2021, NASA submitted the Site Inspection of Per- and Polyfluoroalkyl Substances in Soil and Groundwater Santa Susana Field Laboratory (SI) to DTSC and comments on the SI from DTSC and the Regional Water Board were provided to NASA in an email dated July 21, 2021. While PFAS is currently being evaluated, PFAS was not mentioned in the Phase 1 CMS. NASA should clarify in the Phase 1 CMS that PFAS is also a potential COC and will be addressed in the Phase 2 CMS as well as the updated human health risk assessment, which is currently in progress.	At this time, PFAS is not a NASA SSFL groundwater COC and will not be included in the Phase 1 groundwater CMS. If PFAS is identified as a COC for NASA SSFL based on the PFAS site investigation findings and state and federal regulatory requirements, PFAS remediation would addressed in the Phase 2 groundwater CMS or separately, if needed.	To clarify, NASA should acknowledge in the Phase 1 CMS that PFAS is currently being investigated and, if it is identified as a COC based on the investigation, PFAS will be addressed in the Phase 2 CMS as well as the updated human health risk assessment. Based on results on the initial PFAS investigation, and if source control is deemed necessary, PFAS should be addressed earlier, rather than waiting for the Phase 2 CMS.	NASA will address PFAS on a separate track than the Phase 1 groundwater CMS. It is an emerging contaminant and final regulatory values are not yet set. NASA will also need to follow an agency-wide approach, which is still in development. Text will be added to the Phase 1 groundwater CMS to indicate PFAS is on a separate track, but it may be included in the Phase 2 groundwater CMS if there are promulgated MCLs and a NASA-headquarter agency-wide PFAS remedial approach is established in time.
S1	2.3.2.1	2-13	*A TCE concentration of 14,000,000 μg/m^3 was measured in ND-112 during the RFI investigations; however, the vapor concentration was reduced to 390,000 μg/m^3 following a brief BVE period (NASA, 2020a). Because the post-extraction conditions reflect a dynamic condition, and soil vapor concentrations could have rebounded over time due to back-diffusion of TCE from the bedrock matrix to a concentration above 12,000,000 μg/m^3, ND-112 is considered a notable area of TCE impact and, therefore, a potential Phase 1 groundwater CMS TTA.* Comment: Since the ND-112 area is considered a notable area of TCE impact for soil vapors, this area should be considered for active treatment in the Phase 1 CMS.	NASA removed 25 kg of VOCs by BVE from the former LOX Plant AIG source area (from well ND-112) in 2015 as documented in the November 2020 NASA SSFL Groundwater RFI Report. The inclusion of the ND-112 TTA in Phase 1 was going to be based on current vapor concentrations in the area, which were resampled between October 2021 and February 2022. This recent vapor data in the former LOX Plant AIG ND-112 source area (maximum of 760,000 μg/m^3 TCE) are below the Phase 1 groundwater CMS TTA for active BVE remediation in the Phase 1 CMI (TCE greater than 12,000,000 μg/m^3). Because the ND-112 TTA does not exceed the Phase 1 TTA threshold of 12,000,000 μg/m^3 TCE for vapor (or the 10,000 μg/L TCE Phase 1 TTA threshold for groundwater), the ND-112 TTA will be evaluated as a Phase 2 groundwater CMS source area. Bravo does not have any vapor data documenting high concentrations in the vadose zone above the Phase 1 TTA threshold of 12,000,000 μg/m^3 TCE and will also be evaluated further in the Phase 2 groundwater CMS.	The Regional Water Board recommends that the ND-112 TTA should still be considered for active treatment in the Phase 1 CMS even though resampling demonstrated a reduction in TCE vapor concentrations. The original TCE concentration of 14,000,000 μg/m3 presents a substantial impact, and the remaining impacts up to 760,000 μg/m3 will require cleanup.	Please see additional response to DTSC's General Comment 2 in Table 1, repeated below: As discussed in the 2/8/23 response to DTSC comments on the "Bedrock Vapor Data Investigation report for the Groundwater CMS at the Former LOX Plant", which DTSC concurred with in a letter dated 3/24/23, the ND-112 TTA will not be included in the Phase 1 groundwater CMS because its current vapor and groundwater TCE concentrations do not exceed the Phase 1 groundwater CMS TTA treatment threshold (established in the Phase 1 groundwater CMS document). Instead, NASA prepared a former LOX Plant area BVE pilot study work plan, which was submitted to DTSC review on 8/23/23. BVE pilot study treatment in the former LOX Plant area will occur after the Alfa Area BVE pilot study (using the existing mobile BVE system and solar power array) and the results used to support Phase 2 BVE treatment evaluations. A sentence will be added to the revised Phase 1 groundwater CMS to reference the former LOX Plant area BVE pilot study work plan and indicate the source area and plume will be further evaluated in the Phase 2 groundwater CMS.

No.	Section(s)	Page(s)	Comment(s)	Response(s)	LARWQCB Response(s) to NASA Response(s)	Additional NASA Response
S2	2.3.2.2	2-14	*The exceedance of 1,4-dioxane at RD-83, as shown on Figure 2-8, is considered to be an anomalous isolated detection and not connected with the former LOX Plant AIG plume. Also, the most recent data from this location were reported as less than the GSL (NASA, 2020b). Given the uncertainty in the source of the 1,4-dioxane anomalous detection in well RD-83, this area will continue to be monitored. However, due to the extremely low and sporadic 1,4-dioxane concentrations in RD-83, this area is not targeted for active groundwater remediation during the Phase 1 groundwater CMS. Further evaluation of this area may be conducted during the Phase 2 groundwater CMS evaluation.* Comment: As discussed in the comments and responses to comments to the 2018 CMS, NASA acknowledges the uncertainty of the source of the 1,4-dioxane detected in well RD-83. Adequate lines of evidence have not been provided to demonstrate that the 1,4-dioxane in well RD-83 is not connected with the former LOX Plant AIG plume. Therefore, further evaluation should be conducted during the Phase 2 CMS, as recommended by the Regional Water Board's response to NASA's response to comments on the 2018 CMS.	The text will be changed to indicate that further evaluation of the RD-83 groundwater will be included in the Phase 2 groundwater CMS using data from the sitewide groundwater monitoring program.	The text should also be updated to clarify that the further evaluation of the RD-83 groundwater will be included to determine whether the 1,4-dioxane detected may be connected to the former LOX Plant AIG plume.	The Human Health Risk Assessment has been updated to include significantly more COCs (refer to Section 3). As the focus of this Phase 1 CMS is reducing the greatest risk drivers (TCE, cis- and trans-DCE, and VC), references to previously referenced COCs (e.g., 1,4 dioxane, formaldehyde, 1, 2, 3-TCP, Toluene, lead, cadmium) have been removed from Section 2. All other COCs (outside TCE, cis-and trans-DCE, and VC) will be addressed in the Phase 2 CMS. This well is sampled as part of Sitewide annual groundwater monitoring program and will be included in revised WQSAP DTSC has requested of NASA. The data will be further evaluated in the Phase 2 groundwater CMS. If 1,4-dioxane detections are persistent in this well, additional CMI-related data gap investigation could be performed to help evaluate the source of the 1,4-dioxane at this location.
S3	2.3.3.3	2-22	*The ultimate pathway for potential offsite COC migration under current hydraulic conditions is through seep water that emerges to the north of the B204/ELV AIG. However, the existing analytical data results show no COC detections above GSLs in seep clusters to the north, and no threat of offsite migration of the B204/ELV AIG COC plumes has been identified.* It should be noted that during the review of the Phase 1 CMS on April 28, 2021, NASA provided DTSC and the Regional Water Board an additional figure titled Building 204 Extended Hydrogeologic Cross Section to better understand the subsurface hydrological environment in this area. Comments: **a**. NASA should include the Building 204 Extended Hydrogeologic Cross Section in the Final Phase 1 CMS. **b**. Though the detections of COCs in seeps north of the B204/ELV AIG (as detailed in the Phase 1 CMS) may be below the selected groundwater screening levels and sporadic, additional monitoring at all available seep locations should be ongoing to further demonstrate and verify that there is no threat of offsite migration of the B204/ELV AIG COC plumes to the seep clusters to the north. Additionally, it is unclear why there is no TCE data available for the two shallower screened intervals below the approximate water table in the Upper Burro Flats Member for groundwater monitoring well ND-124 on the Building 204 Extended Hydrogeologic Cross Section figure. TCE is detected in adjacent and upgradient well RD-55A. ND-124 could serve as a sentinel well between the known RD-60/ND-128 area release to groundwater and the seeps to the north. Therefore, all available screened intervals of well ND-124 should be monitored on a periodic basis. Finally, in order to better understand potential migratory pathways in the northern seep area, NASA should provide a cross-section north from the contaminant plumes centered around wells ND-125/NS-42 through seep areas OS-08/S-25, SP-25 (A, B, C, D), SP-30 (A, B, C, D), and S-30 in the Final Phase 1 CMS.	**a**. The referenced Building 204 Extended Hydrogeologic Cross Section will be added to the Phase 1 groundwater CMS as requested. **b**. The seep well clusters will continue to be sampled annually as identified in the February 2021 Sitewide Groundwater Quality Sampling and Analysis Plan and the data evaluated for the Phase 1 CMI and Phase 2 groundwater CMS. All the ND-124 FLUTe ports are attempted for sampling at each annual sitewide groundwater sampling event since the well was installed in 2015 (attempted in the first and third quarters each year) but no water has been able to be collected from these two ports. NASA will continue to try and sample these ports annually in the annual first quarter sitewide events. NASA does not have an existing cross section that includes the more eastern wells in the northern seep area (e.g. SP-30). It will be a significant effort to put a new cross section together that includes this portion of the Northern Seep Area, and such a section will not provide much value beyond the Building 204 Extended Hydrogeologic Cross Section and 3D viewer NASA has already provided. The Building 204 Extended Hydrogeologic Cross Section will be provided in the Phase 1 groundwater CMS and referred to related to its similarity to the SP-30 seep well cluster area.	The Regional Water Board reiterates our initial comment that in order to better understand potential migratory pathways in the northern seep area, NASA should develop and provide the additional cross-section as detailed. The Regional Water Board believes the value of developing such a cross-section benefits the understanding of the area. Also, while the 3D Viewer is a beneficial tool, it is not easily or readily accessible to the public.	NASA will provide the requested cross section in the revised Phase 1 groundwater CMS.
S4	2.3.4.1	2-22, Figures 2-13, 4-2	*Additional data associated with these two TTAs will be obtained as part of preliminary work for the Phase 1 groundwater CMI.* Comment: Figures 2-13 and 4-2 display two separate contaminant groundwater plumes surrounding rocket test stands in the Alfa and Bravo area. The contaminant plumes are not fully delineated to the northwest, west and south of the Bravo test stand, or southeast, east, and northeast of the Alfa test stand as indicated by the inferred contaminant boundary lines. There are concerns that the existing test stand (Alfa Test Stand 3) located directly east of Alfa Test Stand 1 could also be a contaminant source area, and that potential contamination resulting from such a source may be contributing to groundwater contamination in the Alfa TTA plume area. Additional groundwater monitoring wells will likely be required to further refine the nature and extent and to monitor the plume(s) in this area. These data needs should be addressed as part of the Phase I groundwater CMI.	Additional evaluation of the Alfa Area is planned as part of the EISB pilot study, the BVE pilot study, and installation of a new, deep monitoring well adjacent to Alfa Test Stand 2. This data will be included in the Phase 1 CMI and the Phase 2 groundwater CMS to support remedial alternative evaluations. The need for additional data by Test Stand 3, if feasible, will be assessed after collection of this already planned Alfa Area data.	While the proposed monitoring well ND-160 will address some of the data gaps at the Alfa test stand area, it is not likely sufficient to complete delineation of the groundwater contaminant plume. Additionally, no wells have been proposed to address the data gaps at the Bravo test stand described in the original Regional Water Board comment. If the additional proposed well does not sufficiently delineate the full extent of the groundwater contaminant plumes, additional wells will be necessary to complete groundwater characterization. Therefore, the Regional Water Board reiterates that additional groundwater monitoring wells will likely be required to further refine the nature and extent and to monitor the plume(s) in these areas, and that these data gap should be addressed as part of the Phase I groundwater CMI.	Please refer to additional response to DTSC's General Comment 5 in Table 1, repeated here: Adequate plume delineation will be implemented as part of, and in conjunction with, the final remedy (end of Phase 2 CMS/CMI). NASA acknowledges there are data gaps in groundwater source area and plume extent at the site. As agreed to with DTSC as part of the groundwater RFI approval, the current state of plume delineation is adequate to support completion of the Phase 1 groundwater CMS. Additional characterization to support treatment decisions and remedial monitoring will be collected as part of the Phase 1 groundwater CMI. These data will support the development of the Phase 2 groundwater CMS/CMI. NASA has already installed (or is in the process of drilling) several groundwater and vapor data gap monitoring wells at the site after the submittal of the final NASA SSFL groundwater RFI and draft Phase 1 groundwater CMS. This includes wells associated with the Alfa Area EISB (ND-162 through ND-167) and BVE pilot studies (NV-003 through NV-005), Alfa Test Stand 2 source area (ND-160), LOX northern groundwater migration and vapor source area (ND-118, NV-001, and NV-002), Delta Skim Pond source area (ND-169), Bravo source area (ND-168 and NV-006), ELV North Fault Zone (deepening ND-127), and the Coca Area downgradient plume (ND-161). These are documented in work plans submitted to, and approved by, DTSC and associated well installation reports submitted to DTSC for completed wells. NASA plans to have step-wise understanding of source and plume extents as part of remedial work and adaptive management. Additional wells will be evaluated to fill key data gaps to support remedial action and monitoring as part of the Phase 1 groundwater CMI and Phase 2 groundwater CMS/CMI.

No.	Section(s)	Page(s)	Comment(s)	Response(s)	LARWQCB Response(s) to NASA Response(s)	Additional NASA Response
S5	2.3.4.3	2-27	*In well WS-09, as groundwater levels rose above 1,525 feet National Geodetic Vertical Datum of 1929 (NGVD29) in 2003, concentrations of TCE and cis-1,2-DCE increased by almost 2 orders of magnitude over several months, with lesser increases in trans-1,2-DCE and VC occurring at this same time. Similar behavior was observed in well RD-04 in 2005, potentially suggesting the same mechanism is responsible for increases in COC concentrations during 2005 in this well …* *… Overall it appears that while COC concentrations in wells internal to the plume footprint continue to fluctuate in response to the periodic climate-driven flushing of mass from vadose zone sources, distal portions of the plumes within this AIG are either not expanding or are shrinking. In the limited areas where small increases have been observed, it is possible that concentrations will show decreasing trends in the near future and limited expansion of the current plume footprints as a result of ongoing natural attenuation processes.* Comment: The data indicate that the vadose zone in the Bravo Area is a significant continuing source of COCs to groundwater. The WS-09 area is considered to be a TTA for groundwater. Since the continued presence of contaminant mass in the vadose zone continues to present a risk of further groundwater contamination, the vadose zone in this area should be considered for treatment in the Phase 1 CMS.	The vadose zone TCE concentrations in the Bravo Area do not meet the Phase 1 TTA BVE treatment threshold of 12,000,000 μg/m^3. BVE treatment in this area will be evaluated in the Phase 2 groundwater CMS. The pattern described in the cited text refers to zones that had been in a temporary vadose zone during a period of pumping-induced, exceptionally low water table. These zones now are a hundred feet or more below the current water table, so not in the vadose zone. The text will be modified to clarify this.	Comment noted. Since it has been demonstrated that dewatering this area via pumping is feasible, the feasibility of dewatering and performing dual-phase extraction to remove constituents of concern sorbed to the soil matrix below the current water table should be evaluated in the Phase 2 groundwater CMS.	Concur. The requested evaluation will be completed in the Phase 2 groundwater CMS.
S6	3.1	3-1	*Human health and ecological risk assessments were performed for the former LOX Plant, B204/ELV, Alfa/Bravo, and Coca/Delta AIGs is to assess whether exposure to groundwater, deep soil and bedrock vapor, seeps, and springs at the four AIGs poses a potential risk to human or ecological health that requires conducting remedial actions or establishing land use controls (LUCs). Comments were received on the draft human health and ecological risk assessments (NASA, 2017a); an updated risk assessment that addresses these comments is being prepared (NASA, 2020g [in progress]).* Comment: NASA should consider finalizing the updated risk assessment to include any findings that may be of significance to the scope of work proposed in the Phase 1 CMS prior to submitting a final Phase 1 CMS.	If DTSC comments are received on the SSFL groundwater risk assessment (submitted to DTSC in January 2021), any changes that impact the CMS will be captured in the next submittal.	Comment noted.	NASA will be incorporating updated risk assessment findings in the Phase 1 groundwater CMS based on document revisions to address DTSC comments. The response to DTSC comments on the SSFL groundwater risk assessment was submitted to DTSC on 5/18/23.
S7	6.1.5.2	6-12	*Hydraulic containment at the Southern Seep Area (ND-138A) in the Burro Flats Fault Zone area would be accomplished by a single extraction well, as is currently being performed.* Comment: If data indicates the current single extraction well is allowing groundwater to migrate to surface seeps, additional wells may be necessary for hydraulic containment of the groundwater plume.	Preliminary modeling performed using the SSFL mountain-scale groundwater flow model indicates that operation of ND-138A at 5 to 10 gallons per minute is capable of providing hydraulic capture of the Delta Area plume in the SP-890 seep well cluster area. A more refined plume scale groundwater flow and transport model of the Coca/Delta AIG is currently being developed. If simulations using this refined model suggest that additional extraction in the SP-890 seep well cluster area is required to provide hydraulic capture of the Delta Area plume, the installation of additional extraction wells, or other joint-RP remedial action, will be evaluated as part of the CMI and included in NASA SSFL groundwater remediation adaptive management. In addition, the Delta Skim Pond NASA source area, associated with the Southern Seep Area distal plume, will be treated as part of the Phase 1 CMI.	Comment noted. The Regional Water Board interprets NASA's response to mean that NASA will propose the installation of additional extraction wells, or other remedial action, if simulations using the refined model suggest that additional extraction of the SP-890 seep well cluster area is required to provide hydraulic capture of the Delta Area plume.	NASA has revised their original comment response, as shown here (new text has been underlined and stricken text has been deleted): Preliminary modeling performed using the SSFL mountain-scale groundwater flow model indicates that operation of ND-138A at 5 to 10 gallons per minute is capable of providing hydraulic capture of the Delta Area plume in the SP-890 seep well cluster area. ~~A~~The more recently developed ~~refined~~ plume scale groundwater flow and transport model of the Coca/Delta AIG ~~is currently being developed~~ was used to further evaluate the rate of groundwater extraction that would be required from Well ND-138A to hydraulically capture contaminated groundwater in the vicinity of the SP-890 seep cluster. The results of these model simulations, documented in a technical memorandum attached as an appendix to this report, suggest that an extraction rate of 5 gpm from Well ND-138A will reduce contaminated groundwater discharge to the southern seep area by more than 99 percent. ~~If simulations using this refined model suggest that additional extraction in the SP-890 seep well cluster area is required to provide hydraulic capture of the Delta Area plume, the installation of additional extraction wells, or other joint-RP remedial action, will be evaluated as part of the CMI and included in NASA SSFL groundwater remediation adaptive management.~~ In addition, the Delta Skim Pond NASA source area, associated with the Southern Seep Area distal plume, will be treated as part of the Phase 1 CMI.
S8	6.3.2	Tables 6-3 through 6-7, p. 6-25 through 6-27	Comment: Consider providing specific figures showing monitoring well networks for each TTA associated with these tables.	Existing figures in the CMS can be referenced that show the locations of the wells specified. These existing figure references will be added.	Comment noted.	No additional response.