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Use of the Northern and Southern California Polynuclear Aromatic Hydrocarbon (PAH) Studies in the Manufactured Gas Plant Site Cleanup Process

July 1, 2009

Polynuclear aromatic hydrocarbons[1] (PAHs) are associated with the combustion of fossil fuels, industrial and commercial activities, and natural sources such as wildfires and volcanic activity. PAHs are found in soils within both rural and urban areas, reflecting the many natural and anthropogenic sources of PAHs in the environment. PAHs that are not attributable to a specific point source are referred to as "ambient". PAHs are typically found at higher ambient concentrations in urban areas, near more heavily traveled roadways, in areas that have had longer human occupation, in areas receiving runoff from surface soils containing PAHs, and areas downwind of urbanized areas (Wang et al., 2008; Nam et al. 2008). Some studies have found that higher ambient concentrations can also be associated with soils having higher organic matter and/or clay content.

For sites where PAH-impacted soils have been identified and require cleanup, it may be necessary to evaluate ambient concentrations of PAHs in soil. This assessment may be needed because the calculated health-based or ecologically-based cleanup goal for PAHs can be one to two orders of magnitude below ambient PAH concentrations in developed areas. In general, DTSC does not require cleanup of sites to concentrations that are less than ambient. In these instances, the cleanup approach can be developed based on ambient PAH concentrations. This approach ensures that the health risks associated with exposure to the PAHs do not pose a health risk greater than that posed by ambient concentrations of PAHs.

PAHs are commonly identified as constituents of concern for former manufactured gas plant (MGP) sites because PAHs are by-products of the gasification process and are present in some MGP residues (e.g., coal tar, lamp black). Experience has shown that the ability to distinguish PAH-impacted soil related to MGP site activities from ambient PAH concentrations generated by non-point sources is a recurring issue in the cleanup of MGP sites.

To facilitate the MGP site cleanup process, the Southern California Gas Company, the Southern California Edison, the Pacific Gas and Electric Company, and the U.S. Navy

[1] Also known as polycyclic aromatic hydrocarbons

conducted studies in 2002 and developed a decision methodology for determining whether carcinogenic PAH concentrations at a particular site differ from ambient concentrations. These studies (referred to herein as the Northern or Southern California PAH Study or collectively as the PAH Studies) used data from samples collected in the vicinity of various MGP sites and a Navy hospital site.

Use of the ambient conditions for carcinogenic PAHs as defined by the Northern or Southern California PAH Study is an option for facilitating MGP site cleanup. Application of these studies allows more project resources to be directed toward site cleanup rather than site-specific ambient concentration studies.

PURPOSE OF THIS ADVISORY

The purpose of this advisory is to describe how the ambient conditions for carcinogenic PAHs identified by the Northern or Southern California PAH Study (i.e., the ambient data sets) might be used as a pragmatic tool in various stages of the soil cleanup process at MGP sites.

This advisory is to be applied on a case-by-case basis to cleanup PAHs in soil at MGP sites.

DECISION TO USE PAH STUDIES IN THE MGP SITE CLEANUP PROCESS

As part of the project scoping activities, DTSC staff should determine whether it is appropriate to apply the Northern or Southern California PAH Study to a given MGP site cleanup. Pertinent input from the project proponents should be considered when making a determination. The decision should be based on the following questions as well as other considerations (e.g., stakeholder perspectives) that may be appropriate for a particular site:

- Are site-specific conditions similar to the characteristics of the sites used to support the PAH Study data sets?
- Is it reasonable to interpret that the ambient concentration for a given MGP site should be similar to the sites included in the Northern or Southern California PAH Study data set?
- Does the site have the same suite of PAH compounds as are considered by the PAH Studies (see Table 1)?

The selection of which PAH Study to apply to a given site is a site-specific decision. In general, the PAH Study conducted within the geographic region applicable to the site should be selected (e.g., northern California sites should use the Northern California PAH Study). Sites located in central California have some discretion as to which study is applied.

OVERVIEW OF NORTHERN AND SOUTHERN CALIFORNIA PAH STUDIES

The PAH Studies combine existing data for selected sites to produce a single ambient data set for carcinogenic PAHs that has greater statistical power than typically is offered by site-specific ambient studies. The sites included in this data set are largely from downtown areas of various sized cities, including areas that have been urbanized for over a hundred years. Several of the sites are located in industrialized areas having various influences that may have contributed ambient PAHs to soil.

Sixteen PAH compounds (identified in Table 1) were evaluated by the sites included in the PAH Studies. Eight of these PAH compounds are considered to be non-carcinogenic. The other eight PAH compounds are considered to be probable human carcinogens.

With the exception of naphthalene, measured concentrations of the carcinogenic PAHs were converted to benzo(a)pyrene equivalents (BaP equivalent value) using the California Environmental Protection Agency (Cal/EPA) potency equivalency factors listed in Table 1. The BaP values were then summed to obtain the total BaP value for each soil sample. Naphthalene is evaluated separately from the other carcinogenic PAHs because it has toxicity values that are not dependent upon benzo(a)pyrene. Additional volatile exposure pathways may need to be evaluated for naphthalene.

Table 2 summarizes the statistics of the BaP equivalent values for the ambient data sets. Note that the values summarized in Table 2 pertain to carcinogenic PAHs and do not represent non-carcinogenic PAHs. Attachment I is a compilation of the individual data points included in the ambient data sets. The ambient data sets are also available in Excel format on the DTSC Web-site.

The PAH Studies are primarily intended to support the following activities for cleanup of PAHs in soil:

- Determining whether the unremediated site has carcinogenic PAH levels above ambient levels;
- Determining which areas of the site should be targeted for remediation of carcinogenic PAHs in soil;
- Establishing a practical target to guide excavation/ remediation of carcinogenic PAHs in soil;
- Scoping the soil confirmation sampling program; and
- Determining whether residual carcinogenic PAH levels (as total BaP equivalent values) in remediated soils differ from ambient carcinogenic PAH levels (as total BaP equivalent values).

This advisory uses the decision methodology outlined by the PAH Studies which primarily relies on:

- Field observations of MGP process residues (i.e., visual identification of lamp black or coal tar);
- Evaluation of site-specific data to identify PAH-impacted soils attributable to the MGP site (e.g., clustered data points exceeding screening levels or the applicable ambient data set);
- Various statistical comparisons between site-specific and ambient soil data (both point estimates and distributional comparisons); and
- A post-cleanup evaluation to demonstrate that a site has been restored to ambient conditions.

Further details regarding the Northern and Southern California PAH Studies can be obtained from the original reports (ENVIRON, 2002; ENVIRON et al., 2002) which are available on the DTSC Web-site.

USE OF PAH STUDIES DURING SITE CHARACTERIZATION

The primary objectives of characterizing MGP sites are to:

- Identify the presence of any residues (e.g., lampblack, coal tar) or hazardous material releases associated with the MGP operations;
- Establish the nature, extent, and distribution of soil impacts attributable to the MGP site;
- Establish the nature, extent, and distribution of impacts to other environmental media (e.g., sediment, surface water, groundwater, soil vapor) that are attributable to the MGP site;
- Identify whether soil concentrations pose a threat to water quality;
- Collect data to assess potential site-related risk or threats to public health (e.g., whether soil or groundwater concentrations pose a threat to indoor air quality) and the environment; and
- Estimate site-specific ambient concentrations of PAHs in soil (if the Northern or Southern California PAH Study is not used to establish ambient conditions).

This advisory addresses the first two objectives in some detail. The remaining investigation objectives are beyond the scope of this advisory.

Site characterization should be conducted in accordance with a DTSC-approved workplan, including a field sampling plan and quality assurance project plan. Numerous guidance documents are available to assist with the design and implementation of site investigations. Table 3 summarizes some of the resources available on the DTSC, U.S. Environmental Protection Agency (EPA), and Interstate Technology and Regulatory Council (ITRC) websites.

The culmination of the characterization phase should be to prepare an updated conceptual site model.

Identifying MGP Residues That Contain PAHs

Characterization of a MGP site should include a task to locate and map the extent of distinct and distinguishable layers of MGP residues that contain PAHs. This characterization objective should be fulfilled through field observations and should be supported by samples collected from known or suspected layers of MGP residues.

- MGP residues that contain PAHs are typically identified by odor, visual inspection of soil in boreholes and trenches, and handheld field screening instrumentation (such as a photoionization detector). Visual evidence of these residues might include observation of lamp black, coal tar, and soil staining.
- For the purpose of identifying MGP residues containing PAHs, samples should be obtained solely from the zone containing the known or suspected residues. It is important to recognize that these samples are being used for a different purpose (i.e., to identify MGP residues) than samples collected to evaluate the risk posed by PAH concentrations throughout a soil profile. Sampling to support risk evaluation would likely use a larger sample interval than would be targeted for the purposes of residue identification.

The effort should address on-site and off-site areas that may have received MGP residues. Evidence of grade changes should be considered during the mapping process because MGP residues may have been used to fill in low-lying areas.

As discussed above, the PAH Studies characterize ambient PAH conditions in soil. The ambient conditions described by the PAH Studies do not apply to materials (e.g., MGP residues) which are attributable to a specific anthropogenic source. Therefore, the studies are not used to support remedy selection, design, and implementation for MGP residues. It is beyond the scope of this advisory to address the portion of the remedy that deals with MGP residues.

Defining the On-site Extent of PAH-Impacted Soil

For the purposes of identifying on-site impacts, the Northern or Southern California PAH Study should be used in conjunction with all available information for the site. Historical diagrams and aerial photographs of site operations should be used to segregate the site into discrete areas for investigation and to identify likely-impacted areas. Descriptive statistics[2] for the 16 individual PAH compounds should be developed for each investigation area. On-site PAH data should be evaluated (both qualitatively and quantitatively) to understand the indicators of PAH impacts at a given MGP site and/or a given source area. These analyses should involve examination and evaluation of all

[2] Descriptive statistics include the number of samples, the detection frequency, the maximum and minimum concentrations (range of the data), calculated measures of central tendency (mean, median), and calculated measures of dispersion (standard deviation, variance). The statistics may also include measures of relative standing (e.g., concentration corresponding to a certain percentile of the sample). Definitions for these parameters can be found in general statistical texts, EPA (2006c) and Helsel and Hirsch (2002).

carcinogenic and non-carcinogenic PAH compounds. The exact indicators of PAH impacts should be developed on a site-specific and/or source-area specific basis.

Example indicators of PAH impacts could include:

- One or more PAH compounds that are obviously associated with a specific MGP site process or area (e.g., spatial association, characteristic PAH compound(s));
- Elevated concentrations of one or more PAH compounds (e.g., a compound with concentrations one or more orders of magnitude higher than other PAH compounds);
- Spatially clustered detections or elevated concentrations of one or more PAH compounds;
- PAH compound concentration ratios[3] suggesting PAH impacts;
- An elevated detection frequency of PAH compounds in a given sample[4];
- Decreasing trends in PAH concentrations or another indicator parameter as one moves away from a given process area (determined via qualitative and/or quantitative techniques);
- PAH compound association with impacts from other types of contaminants; and
- Relative "pattern" of PAH compounds that is indicative of the site contamination and/or other source(s) (e.g., using radar charts, also known as radial or spider plots).

Other indicators developed to identify impacted areas may also be appropriate.

In addition to evaluating the individual PAH concentration data, carcinogenic PAH concentration data can be converted to BaP equivalent values and also used to calculate the descriptive statistics. The BaP equivalent values should be evaluated to identify potential PAH impacts. Examples of PAH impacts interpreted using the BaP equivalent values might include:

- Clustered site BaP equivalent values at or exceeding an upper bound of the PAH Study data set;
- Decreasing trends in site BaP equivalent values as one moves away from a given process area (determined by qualitative and/or quantitative approaches); and

[3] The PAH ratios determined to be indicative of MGP site impacts should be selected based on site-specific considerations. The following ratios may be useful for evaluating MGP site impacts: fluoranthene/ pyrene, phenanthrene/ anthracene, benz(a)anthracene/chrysene, benzo(b)fluoranthene/ benzo(k)fluoranthene.

[4] The data points included in the PAH Study data sets generally had detections of a few PAH compounds. Therefore, a sample in which several PAH compounds are detected might suggest PAH impacts. The detection frequency (i.e., the number of PAH compounds detected in a sample divided by the total number of PAH compounds analyzed) could be used as an indicator of PAH impacts.

- Qualitative and/or quantitative comparisons of site and ambient BaP equivalent values (e.g., mean, median, statistical distribution, upper tail) indicating that the site values for a given investigation area are higher than ambient values (e.g., elevated).

The outcome of this analysis is that on-site areas with PAH impacts should be defined. Areas deemed unimpacted should be shown via data set comparisons to be similar to the ambient data set (i.e., "ambient-like"; see section entitled "Demonstrating 'Ambient-Like' Conditions" for further discussion).

Defining the Off-site Extent of PAH-Impacted Soil Attributable to the MGP Site

Multiple lines of evidence should be used to identify off-site areas where MGP site operations/practices may have led to PAH impacts. Some of these lines of evidence might include historical diagrams, aerial photographs, current and historical uses of adjacent properties, and association of elevated PAH concentrations with a particular land use or feature (e.g., asphalt pavement, barbeque pit). Consideration should be given as to whether the elevated PAH compound and/or BaP equivalent values are observed in areas adjacent to (or contiguous with) the MGP site or known MGP site activities. Evidence of grade changes should be considered where PAH contamination occurs at depth, but is not observed at the surface because MGP residues were often used to fill-in low-lying areas (i.e., other types of fill may overlie the MGP residues).

An approach similar to that used to define the on-site extent of impacted soil (see above) can also be used to define off-site impacts attributable to the MGP site. As described above, the PAH concentration data and BaP equivalent values should be evaluated using appropriate qualitative and quantitative techniques. Additionally, the PAH concentration data and BaP equivalent values should be evaluated for determining whether impacts extend from on-site to off-site areas and/or in combination with known or suspected MGP residues (see section entitled "Identifying MGP Residues That Contain PAHs" for further discussion).

Areas with trends[5] in, or clusters of, PAH concentrations and/or BaP equivalent values could indicate impacts from MGP site activities, but could also reflect other historical industrial sources. Professional judgment should be used to evaluate the available data and to determine the extent of off-site soil impact attributable to MGP site activities.

Off-site areas adjacent to and/or contiguous with the MGP site that are deemed unimpacted by MGP site activities should look "ambient-like" (see section entitled "Demonstrating 'Ambient-Like' Conditions" for further discussion).

USE OF PAH STUDIES TO GUIDE SOIL EXCAVATION/REMEDIATION ACTIVITIES

This section describes how the ambient data sets presented in the PAH Studies can be used to guide and determine the completeness of soil excavation/remediation. The ambient data sets are used in lieu of a calculated health-based or ecologically-based

[5] i.e., decreasing away from the site

cleanup goal for carcinogenic PAHs. The health-based or ecologically-based cleanup goals for PAHs can be one to two orders of magnitude below ambient carcinogenic PAH levels in urban areas. In general, DTSC does not require cleanup of sites to concentrations that are less than ambient levels.

Establishing a Practical Target to Guide Soil Excavation/Remediation

A value of 0.9 milligrams per kilogram (mg/Kg) in BaP equivalents can be used as a pragmatic target for guiding soil excavation/remediation. As shown in Table 2, this value corresponds to upper bounds of the ambient data sets. Experience at various MGP sites has shown that removal/remediation of soil areas and hotspots exceeding 0.9 mg/Kg BaP equivalents is a reasonably conservative guide for the main phase of excavation/remediation activities. This experience has also shown that excavation/ remediation of additional soil (i.e., soil with concentrations less than 0.9 mg/Kg) may be necessary to achieve an "ambient-like" condition (see section entitled "Demonstrating 'Ambient-Like' Conditions").

The 0.9 mg/Kg BaP equivalent value does not represent the final remedial goal. Rather, completion of the remedy is based on a demonstration that the residual soil concentrations are "ambient-like" (see section entitled "Demonstrating 'Ambient-Like' Conditions").

Assessing Completeness of Soil Excavation/Remediation Activities

Data from confirmation samples taken within a given excavation/remediation area can be compared to the applicable ambient data set. If the comparison indicates similar populations (i.e., the residual BaP equivalent values at the site are "ambient-like" (see section entitled "Demonstrating 'Ambient-Like' Conditions"), the excavation/remediation for that site area can be considered complete. If the comparison indicates higher BaP equivalent values in the site population, additional excavation/remediation is needed.

Ultimately, the final determination regarding the completeness of soil excavation/ remediation is a risk management decision made by the project team. This decision should be based on a demonstration that the overall distribution of the residual PAH concentrations (as BaP equivalent values) is "ambient-like" (see next section).

DEMONSTRATING "AMBIENT-LIKE" CONDITIONS

Various stages of a MGP site cleanup process require a demonstration that PAH concentrations in soil are "ambient-like". The term "ambient-like" refers to the total BaP equivalent values (and not the concentration of individual carcinogenic PAH compounds). Therefore, "ambient-like" is referring to the level of risk associated with exposure to ambient carcinogenic PAH levels.

The demonstration of "ambient-like" conditions is based on comparisons of the applicable PAH Study data set and the MGP site data set. Both qualitative and

quantitative techniques should be used to compare site and ambient BaP equivalent values.

- Qualitative techniques could include a graphical comparison of site-specific and ambient samples (e.g., histograms, box plots).

- Quantitative comparisons, made using appropriate statistical tests, are used to determine whether the site and ambient data sets have similar measures of central tendency (e.g., 95 percent upper confidence limit of the arithmetic mean (95% UCL), mean, median) and similar upper tail of the data distributions (e.g., 95th percentile, 95 percent upper tolerance limit (95% UTL)). *Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S* (EPA, 2006c) is a good starting point for identifying appropriate statistical techniques. Statistical software (such as EPA's ProUCL (EPA, 2007)) can be used to perform many of the quantitative statistical techniques.

To be considered "ambient-like", these tests should indicate that the site and ambient populations are similar.

POST-CLEANUP EVALUATION OF RESIDUAL PAHs IN SOIL

Following the completion of the remediation, a post-cleanup evaluation for residual PAH concentrations should be conducted for risk communication purposes. When the cleanup for soil is completed, residual levels of PAHs will remain at the site because ambient concentrations are present in the soil. However, the overall remaining residual carcinogenic PAH concentrations (as BaP equivalent values) across the site should be should look "ambient-like" (see section entitled "Demonstrating 'Ambient-Like' Conditions").

A statistical summary of the complete soil data set for the entire site remaining after mitigation (i.e., exclude data representative of soil that has been removed and/or remediated) should be incorporated into the cleanup completion report. The summary should include:

- Minimum, maximum, mean, 95% UCL of the arithmetic mean, 95th percentile concentration, and the 95% UTL of the residual carcinogenic PAHs (as BaP equivalent values) in on-site soil;
- Minimum, maximum, mean, 95% UCL of the arithmetic mean, 95th percentile concentration, and the 95% UTL of the residual carcinogenic PAHs (as BaP equivalent values) in off-site soil;
- Minimum, maximum, mean, 95% UCL of the arithmetic mean, 95th percentile concentration, and the 95% UTL of the ambient data set (as BaP equivalent values); and
- Graphs illustrating that the residual PAH levels (as BaP equivalent values) in on-site and off-site soils are "ambient-like" (see section entitled "Demonstrating 'Ambient-Like' Conditions").

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Table 1
Classification of PAHs by Category

Carcinogenic PAHs[1] (Potency Equivalency Factor[2])	Noncarcinogenic PAHs
Benzo(a)anthracene (0.1)	Acenaphthene
Benzo(a)pyrene (1)	Acenaphthylene
Benzo(b)fluoranthene (0.1)	Anthracene
Benzo(k)fluoranthene (0.1)	Benzo(ghi)perylene
Chyrsene (0.01)	Fluoranthene
Dibenzo(a,h)anthracene (0.34)	Fluorene
Indeno(1,2,3-cd)pyrene (0.1)	Phenanthracene
Naphthalene (n/a[3])	Pyrene

1 PAHs considered carcinogenic by State of California were obtained from Cal/EPA (1994, 2003).
2 Potency equivalency factors, with exception of dibenzo(a,h)anthracene were obtained from Cal/EPA (1993). The dibenzo(a,h)anthracene potency equivalency factor was obtained by taking the ratio of its cancer slope factor to the benzo(a)pyrene cancer slope factor, as given in Cal/EPA (1994).
3 California has designated naphthalene as a carcinogenic toxic air contaminant. A potency equivalency factor is not listed for naphthalene because this PAH is evaluated separately from the other carcinogenic PAHs (i.e., it is not included in the BaP equivalent value).

Table 2
Summary of Benzo(a)pyrene Equivalent Values for the Ambient Data Sets

Parameter	Northern California Data (mg/Kg)	Southern California Data (mg/Kg)
Number of Samples	86	185
Mean BaP Equivalent Value	0.21	0.16
Median BaP Equivalent Value	0.074	0.038
Standard Deviation for BaP Equivalent Values	0.41	0.41
95% UCL of the Mean BaP Equivalent Value	0.40	0.24
95th Percentile BaP Equivalent Value	0.9	0.61
95% UTL (95% confidence, 95% coverage)	1.5	0.9
Maximum BaP Equivalent Value	2.8	4.0
Data Distribution	Log normal	Log normal

Notes: BaP is benzo(a)pyrene equivalent concentration.
mg/Kg is milligrams per kilogram.
UCL is upper confidence limit.
UTL is the upper tolerance limit.

Table 3
Resources to Support Investigation of MGP Sites

- *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994)
- *Guidance on Systematic Planning Using the Data Quality Objective Process, EPA QA/G-4* (EPA, 2006a)
- *Guidance on Choosing a Sampling Design for Environmental Data Collection, for Use in Developing a Quality Assurance Project Plan, EPA QA/G-5S* (EPA, 2002)
- *Data Quality Assessment: A Reviewer's Guide, EPA QA/G-9R* (EPA, 2006b)
- *Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S* (EPA, 2006c)
- *Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management* (ITRC, 2003)
- Cal/EPA Guidance Manuals for Groundwater Investigations (www.dtsc.ca.gov/SiteCleanup/Ground_Water_Investigations.cfm)
- *Guidance Document for the Implementation of EPA Method 5035* (DTSC, 2004)
- *Advisory – Active Soil Gas Investigations* (DTSC/LARWQCB, 2003; update expected Spring 2009)
- *Guidance for the Evaluation and Mitigation of Vapor Intrusion to Indoor Air* (DTSC, 2005; update expected Summer 2009)
- *Vapor Intrusion Mitigation Advisory* (DTSC, pending; expected February 2009)

ATTACHMENT I

SUMMARY OF AMBIENT DATA SETS
NORTHERN AND SOUTHERN CALIFORNIA PAH STUDIES

(Note: Electronic copies of the data files are available on the DTSC Web-site.)

Final Data Set - Northern CA PAH Study

Site Owner	Site Name	Sample ID	Total PAHs (mg/kg wet weight)	Final 86 Sample Data Set Prior to Smoothing B(a)P Equivalent (mg/kg wet weight)	Final 86 Sample** Smoothed Data Set B(a)P Equivalent (mg/kg wet weight)
PG&E	Chico	DSS-CHI1-10	8.1693	0.5281	0.5281
PG&E	Chico	DSS-CHI1-6	46.5645	0.9209	0.9209
PG&E	Chico	DSS-CHI1-7	1.4790	0.0299	0.0299
PG&E	Chico	DSS-CHI1-8	5.5918	0.0755	0.0755
PG&E	Chico	DSS-CHI1-9	7.4574	0.4484	0.4484
PG&E	Colusa	DSS-COL-10	3.8003	0.3349	0.3349
PG&E	Colusa	DSS-COL-7	2.3472	0.2040	0.2040
PG&E	Colusa	DSS-COL-8	2.7454	0.0513	0.0513
PG&E	Colusa	DSS-COL-9	11.2570	0.2724	0.2724
PG&E	Colusa2000	CS-1	0.0805	0.0077	***0.0176***
PG&E	Colusa2000	CS-2	0.0575	0.0055	***0.0121***
PG&E	Colusa2000	CS-3	0.0880	0.0055	***0.0111***
PG&E	Colusa2000	CS-4	0.1075	0.0077	***0.0164***
PG&E	Colusa2000	CS-5	0.4970	0.0118	0.0118
PG&E	Eureka	SS-EKA-16	1.5087	0.0748	0.0748
PG&E	Eureka	SS-EKA-17	1.7804	0.0931	0.0931
PG&E	Fresno-1	DSS-8	1.3511	0.1350	0.1350
PG&E	Fresno-2	DSS-FRS2-8	1.9809	0.2613	0.2613
PG&E	Fresno-2	DSS-FRS2-9	1.4255	0.2192	0.2192
PG&E	Hollister	DSS-HOL-10	6.1829	0.5069	0.5069
PG&E	Hollister	DSS-HOL-11	0.8319	0.0710	0.0710
PG&E	Hollister	DSS-HOL-12	0.6104	0.0427	0.0427
PG&E	Hollister	DSS-HOL-8	0.6421	0.0368	0.0368
PG&E	Hollister	DSS-HOL-9	4.3980	0.1623	0.1623
PG&E	Marysville	DSS-MRY1-4	14.5480	1.6116	1.6116
PG&E	Marysville	DSS-MRY1-6	1.2488	0.0345	0.0345
PG&E	Marysville	DSS-MRY1-8	1.2315	0.0283	0.0283
Midway Village Public Housing	Midway-Bayshore	BS-5	0.4618	0.0142	0.0142
Midway Village Public Housing	Midway-Bayshore	BS-8	1.0171	0.0846	0.0846
San Mateo County Housing Authority	Midway Village2000	M101S	0.0403	0.0063	0.0063
San Mateo County Housing Authority	Midway Village2000	M140S	0.0225	0.0055	***0.0101***
San Mateo County Housing Authority	Midway Village2000	M70S	0.0225	0.0055	***0.0092***
San Mateo County Housing Authority	Midway Village2000	M95S	0.0225	0.0055	***0.0082***
PG&E	Monterey	DSS-MNT1-10	11.7284	1.5494	1.5494
PG&E	Monterey	DSS-MNT1-11	1.5183	0.2067	0.2067
PG&E	Monterey	DSS-MNT1-7	0.7374	0.1206	0.1206
PG&E	Monterey	DSS-MNT1-8	0.9022	0.0740	0.0740
PG&E	Monterey	DSS-MNT1-9	1.6533	0.2198	0.2198
U.S. Navy	Oak Knoll Medical	029-SEW-1	0.3761	0.0138	0.0138
PG&E	Oakdale	DSS-OKD-6	0.7318	0.0234	0.0234
PG&E	Oakdale	DSS-OKD-7	1.7476	0.0840	0.0840
PG&E	Oakdale	DSS-OKD-8	0.5567	0.0396	0.0396
PG&E	Oakdale	DSS-OKD-9	0.2458	0.0121	0.0121
PG&E	Oakland	DSS-OAK-10	1.3315	0.2312	0.2312
PG&E	Oakland	DSS-OAK-11	6.5249	1.3387	1.3387
PG&E	Oakland	DSS-OAK-7	3.3970	0.3588	0.3588
PG&E	Oakland	DSS-OAK-8	16.1145	0.5804	0.5804
PG&E	Petaluma	SS-PET-15	0.6434	0.0350	0.0350
PG&E	Potrero	BSS-POT-1	2.2723	0.2354	0.2354
PG&E	Potrero	BSS-POT-2	4.7292	0.2284	0.2284
PG&E	Potrero	BSS-POT-3	2.4169	0.1550	0.1550
PG&E	Redding	BG-14	2.9441	0.3285	0.3285

Final Data Set - Northern CA PAH Study

Site Owner	Site Name	Sample ID	Total PAHs (mg/kg wet weight)	Final 86 Sample Data Set Prior to Smoothing B(a)P Equivalent (mg/kg wet weight)	Final 86 Sample** Smoothed Data Set B(a)P Equivalent (mg/kg wet weight)
PG&E	Redding	BG-17	0.0400	0.0044	**0.0037**
PG&E	Redding	BG-9	0.2809	0.0146	0.0146
PG&E	Redding	REDSS3200	1.1087	0.0720	0.0720
PG&E	Redding	REDSS3300	0.8167	0.0500	0.0500
PG&E	Redding	SS-RED-5	1.5692	0.0900	0.0900
PG&E	Salinas	DSS-SAL-7	0.0760	0.0070	**0.0153**
PG&E	Salinas	DSS-SAL-9	2.3385	0.2703	0.2703
PG&E	San Luis Obispo	DSS-SLO1-10	0.6774	0.0785	0.0785
PG&E	San Luis Obispo	DSS-SLO1-11	2.0163	0.2024	0.2024
PG&E	San Luis Obispo	DSS-SLO1-9	1.2218	0.1688	0.1688
PG&E	Santa Cruz	LB-5	1.8627	0.0532	0.0532
PG&E	Santa Cruz	RS-6A	0.3971	0.0099	0.0099
PG&E	Santa Cruz	RS-6B	0.3505	0.0055	***0.0073***
PG&E	Santa Cruz	RS-6C	0.1173	0.0055	0.0055
PG&E	Santa Cruz	RS-8	0.1750	0.0055	***0.0064***
PG&E	Santa Cruz	RS-9A	0.0575	0.0055	***0.0055***
PG&E	Santa Cruz	RS-9B	0.0575	0.0055	***0.0046***
PG&E	St. Helena	DBS-STH-1	1.5159	0.0027	0.0027
PG&E	St. Helena	DBS-STH-2	1.2886	0.0878	0.0878
PG&E	St. Helena	DBS-STH-3	6.0314	0.0174	0.0174
PG&E	St. Helena	DBS-STH-4	3.7171	0.1026	0.1026
PG&E	St. Helena	DBS-STH-5	0.7691	0.0041	0.0041
PG&E	Stockton	SS-06	21.5224	2.8134	2.8134
PG&E	Stockton	SS-07	3.0248	0.3688	0.3688
PG&E	Stockton	SS-09	5.2757	0.6109	0.6109
PG&E	Watsonville	DSS-WAT1-6	2.3682	0.3437	0.3437
PG&E	Watsonville	DSS-WAT1-7	0.6525	0.0601	0.0601
PG&E	Watsonville	DSS-WAT1-8	0.5406	0.0338	0.0338
PG&E	Watsonville	DSS-WAT1-9	0.7146	0.0379	0.0379
PG&E	Willows	DSS-WIL-10	3.9783	0.0808	0.0808
PG&E	Willows	DSS-WIL-6	4.3379	0.4770	0.4770
PG&E	Willows	DSS-WIL-7	0.5568	0.0184	0.0184
PG&E	Willows	DSS-WIL-8	2.5340	0.0937	0.0937
PG&E	Willows	DSS-WIL-9	3.7446	0.0411	0.0411

Notes/Data Codes:

** - The only differences between the final 86 sample data set and the 86 sample data set prior to and after smoothing are the 13 smoothed results (highlighted data). As discussed in the text, these 13 samples were classified as censored samples.

= a smoothed result used to represent a censored data point.

Bold Italics = Indicates values obtained by smoothing and associated with censored samples for which the original values were tied. As discussed in the text, individual values obtained by smoothing, cannot be assigned to specific censored samples. It should be noted that it is appropriate to use these values to calculate summary statistics, but these values should not be used when evaluating the differences among subsets of background data (e.g., subsets defined by site or region). These values have been listed with specific samples for the sole purpose of keeping the table format consistent.

Bold Results = Indicates values obtained by smoothing and associated with censored samples for which the original values were not tied. Unlike the smoothed values associated with censored results which were tied, these results are not arbitrary and can be assigned to specific samples. For this reason, these values can be used when evaluating the differences among subsets of background data (e.g., subsets defined by site or region).

Table 4
Background Concentrations of Carcinogenic PAHs at Former MGP Sites, Total B(a)P Equivalents

Site Name	Sample	B(a)P Equivalent Concentration (mg/kg)[1]	Log Transformed (mg/kg)[1]
Alhambra	BK-1	0.0278	-3.5842
Alhambra	BK-11	0.0765	-2.5701
Alhambra	BK-13	0.0175	-4.0456
Alhambra	BK-14	0.0175	-4.0456
Alhambra	BK-19	0.0541	-2.9163
Alhambra	BK-20	0.2492	-1.3896
Alhambra	BK-25	0.0175	-4.0456
Alhambra	BK-26	0.0175	-4.0456
Alhambra	BK-27	0.0175	-4.0456
Alhambra	BK-32	0.0209	-3.8680
Alhambra	BK-33	0.0399	-3.2211
Alhambra	BK-35	0.0726	-2.6233
Alhambra	BK-36	0.0723	-2.6267
Alhambra	BK-38	0.0189	-3.9686
Alhambra	BK-39	0.0329	-3.4146
Alhambra	BK-4	0.0175	-4.0456
Alhambra	BK-43	0.0175	-4.0456
Alhambra	BK-44	0.0351	-3.3484
Alhambra	BK-45	0.1121	-2.1883
Alhambra	BK-51	0.0263	-3.6370
Alhambra	BK-52	0.0220	-3.8176
Alhambra	BK-54	0.0175	-4.0456
Alhambra	BK-55	0.0175	-4.0456
Alhambra	BK-57	0.0926	-2.3793
Alhambra	BK-60	0.1854	-1.6851
Alhambra	BK-62	0.1083	-2.2232
Alhambra	BK-64	0.1197	-2.1229
Alhambra	BK-69	0.0388	-3.2483
Alhambra	BK-7	0.0175	-4.0456
Alhambra	BK-70	0.1644	-1.8053
Alhambra	BK-71	0.2229	-1.5010
Alhambra	BK-72	0.3992	-0.9182
Alhambra	BK-73	0.0889	-2.4199
Alhambra	BK-75	0.0175	-4.0456
Alhambra	BK-76	0.0175	-4.0456
Alhambra	BK-77	0.0836	-2.4814
Alhambra	BK-78	0.0541	-2.9166
Alhambra	BK-79	0.0240	-3.7305
Alhambra	BK-8	0.0516	-2.9641
Alhambra	BK-80	0.0175	-4.0456
Beaumont	BS-10	0.0054	-5.2258
Beaumont	BS-6	0.1424	-1.9492
Beaumont	BS-7	0.0083	-4.7944
Beaumont	BS-8	0.0177	-4.0359
Beaumont	BS-9	0.0026	-5.9600
Colton	CLT-BK-01	0.0177	-4.0342
Colton	CLT-BK-02	0.0175	-4.0456
Colton	CLT-BK-03	0.0296	-3.5196
Colton	CLT-BK-04	0.0180	-4.0174
Colton	CLT-BK-05	0.0312	-3.4680
Colton	CLT-BK-06	0.0175	-4.0456
Colton	CLT-BK-07	0.0176	-4.0399
Colton	CLT-BK-08	0.0351	-3.3510
Colton	CLT-BK-09	0.0339	-3.3843
Colton	CLT-BK-10	0.0579	-2.8496
Corona	A	0.0037	-5.6103
Corona	B	0.0084	-4.7795
Corona	BG-1	0.1348	-2.0039
Corona	BG-2	0.1223	-2.1011
Corona	BG-3	0.0651	-2.7315
Corona	BG-5	0.0138	-4.2849
Corona	BG-7	0.0958	-2.3452
Corona	BG-8	0.0217	-3.8307
Corona	BG-9	0.0219	-3.8228
Covina	BCK-1	0.0310	-3.4738
Covina	BCK-2	0.1615	-1.8233
Covina	BCK-3	0.5901	-0.5275
Covina	BCK-4	0.1608	-1.8276
Covina	TTOS-E	0.0345	-3.3668
Covina	TTOS-N	0.0177	-4.0342
Covina	TTOS-NE	0.3274	-1.1166
Covina	TTOS-NW	0.1305	-2.0364
Covina	TTOS-S	0.1497	-1.8991
Covina	TTOS-SE	0.0175	-4.0456
Covina	TTOS-SW	0.3331	-1.0993
Covina	TTOS-W	1.4284	0.3566
Dinuba	BG-1-B	0.0357	-3.3336
Dinuba	BG-2-B	1.6772	0.5171
Dinuba	BG-3-B	0.0476	-3.0442
Dinuba	BG-4-B	0.0419	-3.1723

Table 4
Background Concentrations of Carcinogenic PAHs at Former MGP Sites, Total B(a)P Equivalents

Site Name	Sample	B(a)P Equivalent Concentration (mg/kg)[1]	Log Transformed (mg/kg)[1]
Alhambra	BK-82	0.0766	-2.5689
Alhambra	BK-83	0.0501	-2.9945
Alhambra	BK-85	0.0412	-3.1898
Alhambra	BK-87	0.1536	-1.8734
Alhambra	BK-9	0.0175	-4.0456
Alhambra	BK-90	0.0213	-3.8490
Alhambra	BK-95	0.0373	-3.2883
Dinuba	C-1105	0.0614	-2.7909
Dinuba	C-145	0.0078	-4.8484
Dinuba	C-323	0.0033	-5.7254
Dinuba	C-348	0.0438	-3.1285
Dinuba	C-396	0.0044	-5.4241
Dinuba	C-456	0.0088	-4.7361
Dinuba	C-518	0.0174	-4.0498
Dinuba	C-599	0.0313	-3.4638
Dinuba	C-624	0.0722	-2.6287
Dinuba	C-696	0.1098	-2.2091
Dinuba	C-7	0.6085	-0.4968
Dinuba	C-770	0.0100	-4.6087
Dinuba	C-843	0.0364	-3.3134
Dinuba	DHS-BG-1-1B	0.0252	-3.6809
Dinuba	DHS-BG-1-2B	0.0069	-4.9698
Dinuba	DHS-BG-2-1B	0.0012	-6.7309
Dinuba	DHS-BG-2-2B	0.0012	-6.7309
Dinuba	DL3-D1	0.1970	-1.6247
Elsinore	UG No. 1	0.0211	-3.8594
Elsinore	UG No. 2	0.0211	-3.8594
Elsinore	UG No. 3	0.5291	-0.6366
Former Ontario	Background A	0.0240	-3.7301
Former Ontario	Background B	0.0145	-4.2351
Fullerton	B-1	0.2985	-1.2090
Fullerton	B-2	0.1198	-2.1221
Fullerton	B-3	0.0564	-2.8757
Fullerton	B-4	0.2224	-1.5034
Hemet	HSB-1	0.0096	-4.6485
Hemet	HSB-2	0.0167	-4.0930
Hemet	HSB-3	0.0102	-4.5864
Hemet	HSB-4	0.0132	-4.3238
Hemet	HSB-5	0.0884	-2.4260
Ingelwood	B-1-NS	0.0175	-4.0456
LA Alameda	LA-BK-1	0.0683	-2.6836
Dinuba	BG-5-B	0.0607	-2.8015
Dinuba	BG-6-B	0.0008	-7.1784
Dinuba	C-1018	0.1932	-1.6442
Dinuba	C-1020	0.0196	-3.9309
Dinuba	C-1047	0.2700	-1.3093
Dinuba	C-1052	0.1210	-2.1116
Dinuba	C-1102	0.0167	-4.0953
Pomona	PBG-4	0.1798	-1.7160
Pomona	PBG-5	0.0348	-3.3574
Redlands	RS-10	0.0934	-2.3709
Redlands	RS-6	0.3126	-1.1628
Redlands	RS-7	0.1727	-1.7561
Redlands	RS-8	0.2295	-1.4718
Redlands	RS-9	0.0154	-4.1748
Riverside	RVB1	0.0455	-3.0900
San Pedro	B-10-1A	0.0523	-2.9499
San Pedro	B-11-1A	0.0077	-4.8614
San Pedro	B-12-1A	0.0244	-3.7128
San Pedro	B-13-1A	0.0347	-3.3599
San Pedro	B-14-1A	0.1064	-2.2410
Santa Ana	BG-1-	0.0688	-2.6762
Santa Ana	BG-8-	0.0476	-3.0440
Santa Ana	BG-9-	0.1206	-2.1156
Santa Ana	SBG-1	2.4386	0.8914
Santa Ana	SBG-2	0.0180	-4.0171
Santa Ana	SBG-3	0.0720	-2.6304
Santa Barbara	02-BKG-104	0.1531	-1.8770
Santa Barbara	02-BKG-118	0.0174	-4.0539
Santa Barbara	02-BKG-129	0.9540	-0.0471
Santa Barbara	02-BKG-160	4.0520	1.3992
Santa Barbara	02-BKG-26	0.2810	-1.2694
Santa Barbara	02-BKG-33	0.1561	-1.8573
Santa Barbara	02-BKG-60	0.7610	-0.2731
Santa Barbara	02-BKG-65	0.0342	-3.3743
Santa Barbara	02-BKG-69	0.1142	-2.1698
Santa Barbara	02-BKG-78	1.0050	0.0050
Santa Barbara	02-BKG-83	0.2189	-1.5191
Santa Barbara	02-BKG-92	0.0798	-2.5277
Visalia	BACK-1	0.8173	-0.2017
Visalia	BACK-2	0.3432	-1.0694
Visalia	BACK-3	0.1800	-1.7148

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Background Concentrations of Carcinogenic PAHs at Former MGP Sites, Total B(a)P Equivalents

Site Name	Sample	B(a)P Equivalent Concentration (mg/kg)[1]	Log Transformed (mg/kg)[1]
LA Alameda	LA-BK-2	0.1212	-2.1099
LA Alameda	LA-BK-3	0.0235	-3.7490
LA Alameda	LA-BK-4	0.0568	-2.8675
LA Main St.	BG-1	0.0195	-3.9373
LA Main St.	BG-2	0.0388	-3.2493
LA Main St.	BG-3	0.0259	-3.6535
Monrovia	MBG-1	0.3458	-1.0619
Monrovia	MBG-2	0.0357	-3.3319
Monrovia	MBG-4	1.5412	0.4326
Monrovia	MBG-5	0.0302	-3.4986
Pomona	PBG-1	0.0357	-3.3326
Pomona	PBG-2	0.1184	-2.1335
Pomona	PBG-3	0.1306	-2.0354
Visalia	BACK-4	0.4773	-0.7396
Visalia	BACK-5	0.0243	-3.7173
Visalia	BACK-6	0.0654	-2.7280
Visalia	BACK-7	0.0175	-4.0456
Visalia	BACK-8	0.0175	-4.0456
Visalia	BACK-9	0.0175	-4.0456
Whittier	WH-BK-1	0.0316	-3.4546
Whittier	WH-BK-2	0.0271	-3.6082
Whittier	WH-BK-3	0.0179	-4.0230
Whittier	WH-BK-4	0.3246	-1.1251

Notes:

1 Shaded results indicate samples in which no CPAHs were detected. Since no CPAHs were detected in these samples, the actual B(a)P equivalent concentrations associated with these samples are unknown; in statistical terms, these samples were classified as censored samples.