APPENDIX P
CQA PLAN

APPENDIX P.1	PHASE III CQA PLAN
APPENDIX P.2	FINAL CLOSURE CQA PLAN

APPENDIX P.1
PHASE III CQA PLAN

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CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN FOR LANDFILL UNIT B-18 PHASE III EXPANSION KETTLEMAN HILLS FACILITY KETTLEMAN CITY, CALIFORNIA

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ENGINEER'S CERTIFICATION

In accordance with the requirements of California Code of Regulations (CCR) Title 22 Section 66264.19, this Construction Quality Assurance (CQA) Plan has been developed under the direction of a Civil Engineer registered in the State of California.

I hereby certify that this CQA Plan was developed under my direct supervision.

REGISTERED PROFESSIONAL ENGINEER
RYAN HILLMAN
C 71988
Exp. 3-31-12
CIVIL
STATE OF CALIFORNIA

5-2-2011

Ryan Hillman, P.E. Date
RCE No. 071988 Expires: 03-31-2012

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the Construction Quality Assurance (CQA) procedures required during the Phase III expansion of Landfill Unit B-18 (B-18) at the Kettleman Hills Facility in Kettleman City, California. This CQA Plan establishes procedures to document that the construction is performed in accordance with the approved engineering standards and specifications, meets the appropriate regulatory requirements (i.e., California Code of Regulations Title 22 §66264.19 and Title 27 §20323 and §20324), and that the necessary documentation is developed for submittal to the regulators. This CQA Plan shall be implemented under the direction of a CQA Officer who is a registered Civil Engineer in the State of California.

This CQA Plan is a guidance document that contains general and specific work element requirements for monitoring construction. General requirements include the organization and responsibilities of CQA personnel, documentation control, and reporting procedures. Specific work elements include the following:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Subgrade Preparation;
- Earthfill;
- Compacted Clay Liner;
- Geomembranes;
- Geotextiles;
- Drainage Geocomposites;
- Operations Layer;
- Piping; and
- Culverts/Drainage Channels.

The CQA Consultant will prepare a Final CQA Report upon completion of construction. The Final CQA Report will include information generated through the CQA program and will document the extent to which construction was performed in accordance with the intent of the Contract Documents and design. The CQA Consultant will be required to submit the Final CQA Report within one week of substantial completion of construction.

1.2 CQA Consultant

The CQA Consultant has the primary responsibility of implementing and managing the CQA program described herein and will document to the appropriate regulatory agencies that construction of the facility was performed in accordance with the design and the Contract Documents. Specific responsibilities for the CQA Consultant's site personnel are presented in Section 2.2.

1.3 Project Organization

The project will be completed by Contractors performing earthworks construction, geosynthetic materials installation, and construction of associated ancillary facilities. The CQA Consultant will be independent of the Contractors and will report directly to the Owner's Project Manager.

1.4 Reference Documents

The latest editions of the following reference documents provide background information and support this CQA Plan:

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.02, Concrete and Aggregates.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.08, Soil and Rock(I), and Volume 04.09, Soil and Rock (II); Geosynthetics.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 8, Plastics, Volumes 08.01, Plastics (I), Volume 08.02, Plastics (II), and Volume 08.03, Plastics (III).

California Code of Regulations (CCR), Titles 22 (Social Security) and 27 (Environmental Protection).

Standard Specifications for Public Works Construction, Joint Cooperative Committee of the Southern California Chapter, American Public Works Association And Southern California Districts, Associated General Contractors of California, Building News.

1.5 Definitions

Whenever the terms listed below are used, the intent and meaning shall be interpreted as indicated.

ACI: American Concrete Institute.

AISC: American Institute of Steel Construction.

ASTM: American Society for Testing and Materials.

Construction Manager: The individual or firm responsible for administering the construction contract and providing overall construction management for the project. The construction manager is the primary contact on the project site representing the Owner.

Construction Quality Assurance (CQA): A planned and systematic pattern of procedures and documentation designed to provide confidence that items of work or services meet the requirements of the Contract Documents. Construction quality assurance includes verifying that the Contractor is performing the quality control requirements of the Specifications.

CQA Consultant: See Section 1.2

CQA Manager: Authorized representative of the CQA Consultant responsible for managing the CQA program.

CQA Monitors: Authorized representatives of the CQA Consultant responsible for observing and documenting activities related to CQA during construction.

CQA Officer: Authorized representative of the CQA Consultant and a California-Registered Civil Engineer responsible for certifying that construction was performed in accordance with the intent of the Contract Documents and design.

Construction Quality Control: Those actions which provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the Contract Documents. Quality control will be performed by the Contractor/Geosynthetics Contractor, except where designated in the Specifications.

Contract Drawings: The official plans, profiles, typical cross-sections, elevations, and details, as well as their amendments and supplemental drawings, that show the locations, character, dimensions, and details of the work to be performed. Contract Drawings are also referred to as the "Plans."

Contract Documents: The official set of documents issued by the Owner, which includes bidding requirements, contract forms, contract conditions, Specifications, Contract Drawings, addenda, and contract modifications.

Contractor: The person or persons, firm, partnership, corporation, or any combination of these or any combination of private, municipal, or public entities who, as an independent Contractor, has entered into a contract with the Owner and who is referred to throughout the Contract Documents by singular number and masculine gender.

Contract Specifications: The requirements for products, materials, and workmanship upon which the contract is based. Contract Specifications are also referred to as the "Specifications."

Design Engineer: The individuals or firms responsible for the project's design and preparation of the Plans and Specifications. The Design Engineer is also referred to as the "Designer" or "Engineer." The Design Engineer for the Phase III expansion of Landfill Unit B-18 is Golder Associates Inc. of Irvine, California.

Earthwork: A construction activity involving the use of soil materials as defined in the Specifications and Section 3 of this document.

Flexible Membrane Liner (FML): A synthetic lining material, also referred to as geomembrane, membrane, liner, or sheet.

Geosynthetics Contractor: Also referred to as the "Installer." The person or firm responsible for installation of geosynthetic components. This definition applies to any party installing geomembrane,

geotextile, geocomposite, geosynthetic clay liner, or any other geosynthetic material, even if it is not their primary function.

GRI: Geosynthetics Research Institute.

Non-Conformance: A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformance include, but are not limited to, physical defects, test failures, and inadequate documentation.

Owner: Waste Management, Inc. – Kettleman Hills Facility.

Owner's Project Manager: Authorized representative of the Owner responsible for planning, organizing, and control of the design and construction activities. Responsibilities include scheduling, cost control, engineering, procurement, and contracting functions. Referred to as the "Project Manager" in this document.

Panel: A unit area of the FML that is seamed in the field or in the fabricator's plant.

Procedure: A document that specifies or describes how an activity is to be performed.

Project Documents: Contractor submittals, Construction Drawings, Record Drawings, Specifications, shop drawings, construction quality control and quality assurance plans, health and safety plans, and project schedules.

Record Drawings: Drawings recording the constructed dimensions, details, and coordinates of the project. Also referred to as "as-builts."

SSPWC: Standard Specifications for Public Works Construction.

Testing: Verification that an item meets specified requirements by subjecting that item to a set of physical, chemical, environmental, or operating conditions.

Testing Laboratory: A laboratory capable of conducting the tests required by this CQA Plan and the Specifications.

2. GENERAL REQUIREMENTS

2.1 Meetings

In order to facilitate construction and to clearly define construction goals and activities, close coordination between the Owner, Design Engineer, CQA Consultant, and Contractor is essential. To meet this objective, pre-construction and progress meetings will be held.

2.1.1 Pre-Construction Meeting

Following the bid award, a pre-construction meeting will be held at the site. Attendees at this meeting will include the Owner, Contractor, Design Engineer, CQA Consultant, agencies, and others designated by the Owner. The primary purposes of the pre-construction meeting will be to:

- Review the Plans, Specifications, this CQA Plan, work area security, health and safety procedures, and related issues.
- Provide all parties with relevant project documents.
- Review responsibilities and qualifications of each party.
- Define lines of communication and authority.
- Establish reporting and documenting procedures.
- Review procedures for handling submittals.
- Review testing equipment and procedures.
- Review procedures for field directives and change orders.
- Establish testing protocols and procedures for correcting and documenting construction or non-conformance.
- Establish the weekly meeting schedule.
- Discuss work areas, stockpile areas, lay down areas, access roads, haul roads, and related items.
- Review the project schedule and critical path items.
- Review the Contractor's work plan.

The pre-construction meeting will be documented by the CQA Manager. Copies of the minutes and other pertinent material will be prepared and provided to the relevant parties.

2.1.2 Progress Meetings

Informal progress meetings will be held each morning before the start of work. At a minimum, these meetings will be attended by the CQA Monitor and Contractor. The purpose of these meetings will be to:

- Discuss problems and resolutions.
- Review test data.
- Discuss the Contractor's personnel and equipment assignments for the day.
- Review the previous day's activities and accomplishments.
- Resolve any outstanding problems or disputes.

2.1.3 Weekly Meetings

Throughout the duration of construction, scheduled weekly meetings will be held. The Project Manager, Construction Manager, CQA Manager, and Contractor will be present. These meetings will be held to discuss progress, problems, construction schedule, changes, test data, health and safety, environmental issues, and any other issues necessary. The Project Manager will prepare the agenda for each meeting and prepare meeting minutes for distribution to the relevant parties.

2.1.4 Other Meetings

As required, other meetings may be held to plan work items and/or to discuss problems or non-conformance. These meetings will be attended by parties as directed by the Owner. If the problem requires a design modification and subsequent change order, the Engineer and Project Manager should be present. These meetings will be documented as directed by the Project Manager.

2.2 Responsibilities of Construction Quality Assurance Staff

2.2.1 Communications with the Contractor

Only the individuals assigned to this project, as defined in this document, can communicate with the Contractor. Communications of an official nature must be clear, direct, and professional. When written communications are required, they must be documented on the appropriate forms. Formal letters to the Contractor should normally be signed by the CQA Manager and reviewed by the Owner.

2.2.2 Communications with the Owner

Only those individuals assigned to this project, as defined in this document, can communicate with representatives of the Owner. All communications must be through proper channels as defined during the project's pre-construction meeting. Communications of an official nature must be written, clear, direct, and professional.

2.2.3 Responsibilities of the CQA Manager

The CQA Manager administers the CQA program. CQA procedures and reports must be reviewed by the CQA Manager for compliance with this CQA Plan. The CQA Manager acts as an auditor to

monitor and document the proper and complete implementation of the CQA program. The CQA Manager has authority to identify deficiencies and implement corrective action to the CQA program. The CQA Manager collects, distributes, and addresses the disposition of Contractor submittals approved by the Design Engineer. The CQA Manager coordinates testing with independent testing laboratories and maintains the Record Drawings. The CQA Manager reports directly to the Construction Manager. The CQA Manager will aid in preparing the Final CQA Report for the project under the direction of the CQA Officer.

2.2.4 Responsibilities of the CQA Officer

The CQA Officer is responsible for documenting and certifying to the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB) that the construction was performed in accordance with the intent of the design and the Contract Documents. The CQA Officer may also be the CQA Manager.

2.2.5 Responsibilities of the Design Engineer

The Design Engineer is responsible for site engineering services related to the project's design. Those services include reviewing Contractor submittals, resolving technical issues related to construction, providing interpretation of the Plans and Specifications, and approving substantial design modifications and technical revisions.

2.2.6 Responsibilities of the CQA Monitors

The CQA Monitors implement the CQA program under the direction of the CQA Manager. The CQA Monitors perform the construction monitoring and construction materials testing. The CQA Monitors maintain the documentation and test data summaries related to construction monitoring and construction materials testing. The CQA Monitors report directly to the CQA Manager.

2.3 Control of Documents, Records, and Forms

2.3.1 Project Control of Contract Documents

The Contract Documents, including the Specifications, Plans, and change orders, are controlled by the Construction Manager. The Construction Manager maintains one or more copies of the most current set of Contract Documents for use by the CQA Consultant. Upon issuance of new copies or revisions, it is the responsibility of the Construction Manager to notify the Contractor of the revisions, provide revised Contract Documents, and order the recall of superseded copies of the Contract Documents. The Construction Manager also provides the latest revised set of Contract Documents to the CQA Consultant.

2.3.2 Project Control of As-Built Information

As-built information generated by the Contractor and CQA Consultant is controlled by the CQA Manager. During the progress of the work, the CQA Manager obtains as-built information provided from the CQA Monitors, Contractor, surveyors, or others and compiles the as-built data into one set of drawings. The as-built drawing set must be maintained on site and be clearly marked as "Record Drawings."

2.3.3 Project Control of Forms

Daily report forms, test report forms, and other project forms are controlled by the CQA Manager, who maintains a master of each form for copies. Upon issuance of a new form, the CQA Manager must recall and remove all superseded copies along with the master, notify the CQA Monitors, and provide new copies for their use.

2.3.4 Processing Daily Reports

The CQA Monitors write a daily record of work progress. These daily reports are reviewed by the CQA Manager for legibility, clarity, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Daily reports are submitted to the Construction Manager on a daily basis and are maintained at the site. A weekly summary construction report will be prepared by the CQA Manager and submitted on a weekly basis to the Construction Manager.

2.3.5 Processing Test Reports

A test report must be completed by the CQA Monitors whenever testing is performed. The test reports must be reviewed by the CQA Manager. The review includes a check for mathematical accuracy, conformance to test requirements, conformance to the Specifications, and for clarity, legibility, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Test reports (or summaries) from independent testing laboratories will also be transmitted to the CQA Manager for review.

2.3.6 Processing Project Records

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all of the blanks provided on the form, followed by the signature of the individual completing the form. All project records must be maintained at the site.

2.4 Documentation and Control of Non-Conformance

2.4.1 Observation of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Manager and CQA Monitors should first notify the Contractor's foreman/superintendent supervising the work in question. The CQA Manager should then notify the Construction Manager.

2.4.2 Determining Extent of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Consultant will determine the extent of the non-conformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate.

2.4.3 Documenting Non-Conformance

All non-conformance must be documented in writing on the daily records, logs, and elsewhere, as appropriate. This documentation must occur immediately upon determining the extent of the non-

conformance. For a non-conformance that is considered serious or complex in nature, or which requires an engineering evaluation, a Non-Conformance Report will be prepared and issued to the Construction Manager and Contractor.

2.4.4 Corrective Measures

For a straightforward or routine non-conformance, corrective measures will be determined by direction from the Specifications. If no direction exists in the Specifications, the Construction Manager, CQA Manager, and Contractor will discuss construction methods to correct the deficiency. For Non-Conformance Reports that require an engineering evaluation, the Design Engineer must determine corrective measures. A copy of the Non-Conformance Report, with the Design Engineer's corrective measure determination, will be forwarded to the Construction Manager, CQA Manager, and Contractor for implementation of the corrective action.

2.4.5 Verification of Corrective Measures

Upon notification by the Contractor that a corrective measure is complete, the CQA Manager will verify its completion. The verification must be accomplished by observations or re-testing and documented photographically. Written documentation of the corrective measures must be made by the CQA Manager on daily reports, logs, forms, and, if applicable, the Non-Conformance Report. Verification of corrective measures will be reviewed by the Construction Manager. Corrective action measures that require an engineering evaluation will be reviewed and verified by the Design Engineer.

2.5 Construction Monitoring

2.5.1 Monitoring Priorities

Before commencement of construction, the CQA Manager will establish a list of monitoring priorities. This list will include the various construction activities and the monitoring priority of those activities. The monitoring priorities may change during construction, based upon the Contractor's performance and/or the Owner's request. Changes in the monitoring priorities must be approved by the CQA Manager.

2.5.2 Discrepancies

CQA testing must be conducted in accordance with this CQA Plan. However, discrepancies that occur between this document and other construction documents must be resolved. The document that requires the most frequent tests or more stringent requirements will govern, unless otherwise specified by the Design Engineer and/or CQA Manager.

2.6 Materials Quality Verification

2.6.1 General

Material sources will be identified and samples tested to determine if the material meets the requirements of the Specifications. Definitions and requirements of materials are provided in the Specifications. Test samples will be obtained in accordance with applicable ASTM and GRI standards. Archive samples and test results of the test samples will be maintained and stored at the project site. The CQA Monitors will establish and maintain a materials quality verification list. This

list will include material sources, sample locations, testing requirements, test results, and verification action items.

2.6.2 Material Submittals

Material submittals may be used by the CQA Consultant to establish the acceptability of materials. When material sample submittals are required, they will be made available to the CQA Consultant by the Contractor. Acceptance and proper review of material submittals are the responsibility of the CQA Manager.

2.6.3 Certificates of Compliance and Conformance

Certificates of compliance and conformance may be used by the CQA Manager to establish the acceptability of materials. These certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. These certificates may be used for acceptance of a product before or in lieu of testing, if allowed by the Specifications.

2.7 Equipment Control

2.7.1 Equipment List

Before the start of construction, the CQA Manager will complete a list of all measuring, sampling, and testing equipment being used at the site. As new equipment becomes available during the course of the project, it must be added to the list. When more than one type of equipment is available, a unique number will be affixed to each piece to maintain identity. The equipment list will be maintained in the project files and contains the following information:

- Type of equipment;
- Serial number or identifying number;
- Date item received at site;
- Use of the equipment; and
- Date removed from service.

2.7.2 Calibration of Equipment and Materials

Before placing a piece of testing equipment into service, its accuracy must be established and calibrated by the CQA Manager or CQA Monitor. Types of equipment requiring calibration include: nuclear gauges, sand cone devices, sand to be used in sand cones, and scales. The calibration procedures and frequencies must be per the equipment manufacturer's instructions or ASTM standards. Whenever the equipment is suspect or is producing questionable results, it must be removed from service immediately and re-calibrated.

3. CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

3.1 General

This section describes CQA procedures for earthwork operations. The scope of earthwork and related CQA includes the following elements:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Structural Fill;
- Subgrade Preparation;
- Compacted Clay Liner;
- Operations Layer; and
- Trench Excavation and Backfill.

3.2 Earthwork Construction Testing

3.2.1 Test Standards

The latest editions of the following test standards apply as called out in this document or the Specifications:

Standard	Test Description
ASTM D422	Standard Test Method for Particle Size Analysis of Soils
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
ASTM D1557	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D1587	Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils
ASTM D2216	Standard Test Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3.2.2 Test Frequencies

Tables 3-1 and 3-2 establish the test frequencies for earthwork CQA. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any re-tests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

The Final CQA Report shall include tables similar to Tables 3-1 and 3-2 that document compliance with the testing frequencies and that document test results that comply with the Specifications.

TABLE 3-1
STRUCTURAL FILL CONFORMANCE
TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 10,000 CY or Each Material Type	1 Per Material Type
Atterberg Limits	D4318	1 Per 10,000 CY or Each Material Type	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests

Notes to Table 3-1:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.

TABLE 3-2
CLAY LINER CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 5,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 5,000 CY or Each Material Type	1 Per Material Type
Atterberg Limits	D4318	1 Per 5,000 CY or Each Material Type	1 Per Material Type
Hydraulic Conductivity	D5084	1 Per 5,000 CY or Each Material Type	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 500 CY or Per Lift, whichever is greater	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests
Hydraulic Conductivity	D5084	1 Per 1,000 CY or Per Lift, whichever is greater	1 Per 200 Linear Feet

Notes to Table 3-2:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.

3.2.3 Soil Sample Numbering

The CQA Monitor will maintain soil sample numbers in a master log to be maintained at the site. Sample numbers will begin at 001 and proceed upward. No sample number can be repeated and re-tests of a failing sample will be given the original number with a letter suffix (i.e., re-tests for a failing sample 021 would be: 021A, 021B, etc.). Information contained in the master log of test samples will include:

- Sample number;
- Test(s) to be performed;
- Dated sampled;
- CQA Monitor obtaining sample;
- Location sampled;
- Location of testing (on-site vs. off-site);

- Date sample sent off-site;
- Date test results received;
- Site testing CQA Monitor;
- Date testing completed at site; and
- Test results and remarks.

3.2.4 Soil Sample Tagging

The CQA Monitor is responsible for maintaining sample identification for all soil samples while on site, from the time of sampling through the completion of testing. The CQA Monitor must place a sample tag on the soil sample container immediately upon sampling. This tag must remain with the soil sample throughout processing. The tag will contain the following information:

- Sample number;
- Material type;
- Project name and project number;
- Sampling CQA Monitor;
- Date sampled; and
- Test(s) to be performed.

3.2.5 Soil Sample Processing

The CQA Monitor is responsible for the timely processing of soil test samples. The CQA Manager will determine which samples are tested on-site and which are tested off-site. This determination will be made based on available manpower, available equipment, complexity of testing, and the desired turnaround time for results. For expediency, samples to be tested off-site should be shipped the same day they are collected.

3.3 Field Density Tests

3.3.1 Test Numbering

The CQA Monitor is responsible for maintaining test numbers and results for field density tests performed using the nuclear gauge (ASTM D6938), sand cone (ASTM D1556), and drive cylinder (ASTM D2937). All other testing is identified through the sample number (Section 3.2.3). The CQA Monitor will maintain field books that identify soil segments, test data, the CQA Monitor performing the test, and the sequential test number. Each soil segment will have a unique series of numbers. No test number can be repeated for a given soil segment, and re-tests of failing tests must be given a letter suffix along with the original test number (i.e., re-tests for a failing test 1201 would be: 1201A, 1201B, etc.). Test data and results must be filled out on the field density test form.

3.3.2 Test Locations

The intent of the CQA program is to provide confidence that the earthwork materials and work conform to the requirements of the Specifications. To meet this intent, the CQA Monitor will perform density tests of earthfills during construction. Density tests must be located at various elevations and uniformly dispersed throughout the entire plan dimensions of the fill. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, density test locations will be plotted on a drawing by the CQA Monitor to document that no significant areas are left untested. This drawing will be included in the Final CQA Report.

3.4 Monitoring and Testing Requirements

Earthwork components of the construction are summarized in Section 3.1. Each component has specific construction requirements that must be monitored. The following sections list monitoring requirements for each type of earthwork.

3.4.1 Clearing, Grubbing, and Stripping

- Document that erosion and sediment control silt fences, straw bale barriers, and other measures are securely in place prior to initiating clearing, grubbing, and stripping operations in any area.
- Document that existing plant life designated to remain is protected against damage during construction.
- Document that clearing and stripping in areas required for site access and execution of the work is complete.
- Document that vegetation, roots, and highly organic soil within the work area are removed to the appropriate extent.

3.4.2 Stockpiling and Soil Management

- Review the Contractor's approved work plan submittal. Verify stockpile locations, stockpile dimensions, clay mixing areas, haul routes, material segregation procedures, and erosion, sediment, and drainage control measures. Determine and note corrective action items, if applicable.
- Document that stockpile locations have been cleared, grubbed, and stripped in accordance with Section 3.4.1 of this CQA Plan and the Specifications.
- Document that stockpile subgrades are surveyed prior to stockpiling.

The CQA Monitor will maintain a separate soil test data summary sheet for the specific purpose of soil classification of stockpiled materials.

- During excavation, hauling, and stockpiling operations, continually identify and verify material classifications in general accordance with ASTM D2487 (Unified Soil Classification System) and ASTM D2488 as necessary to characterize material stockpile designations.

- Observe that stockpiles are constructed with slopes no greater than 2H:1V (horizontal:vertical) and that the top surface maintains a minimum 5 percent grade. The Contractor shall include 15-foot-wide drainage benches every 50 vertical feet on all stockpiles.

3.4.3 Excavation

- Document that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.
- If applicable, document that the Contractor has notified Underground Service Alert to identify and locate underground utilities.
- Document that excavated materials are segregated into proper stockpiles.
- Coordinate with the Contractor to perform excavation verification surveys upon completion of excavating operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine limits of excavation for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.
- Document that unsuitable materials are removed from areas that will receive earthfill. Unsuitable materials include uncertified existing fills, disturbed soils, weak/highly compressible soils, and deleterious materials.
- Prepare a geologic map and geotechnical report of the subgrade for inclusion in the final certification report. Mapping shall be performed by a competent person under the supervision of a California Certified Engineering Geologist.

3.4.4 Structural Fill

- Monitor that subgrade for placement of soil is consistent with the Specifications.
- Monitor that construction staking is performed before the beginning of the work and that survey bench marks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2488) to verify that the material source is suitable for structural fill. Verify that the material is free of organic and oversized materials and perform classifications continually during excavation of borrow materials.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content for structural fill materials. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that structural fill materials are placed in loose lifts not exceeding 8-inches thick and are then properly compacted.
- Perform nuclear density-moisture tests (ASTM D6938) to document that each lift is compacted to the appropriate relative compaction, as stipulated in the Specifications. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that soil materials are kept within the specified moisture content range listed in the Specifications. Monitor that soil materials that are wet and over the optimum moisture content (as determined by ASTM D1557) are properly aerated and processed to

bring the moisture content of the material into the acceptable range. Monitor that soils that are dry and below the optimum moisture content (as determined by ASTM D1557) are properly moisture conditioned and processed to bring the moisture content into the acceptable range.

- Monitor that desiccated structural fills are properly repaired or removed before placing subsequent lifts.
- Monitor that final structural fill surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment run-off.
- During fill operations, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.
- Coordinate with the Contractor to perform verification surveys at the completion of structural fill placement. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine the limits of structural fill for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.5 Compacted Clay Liner

- Monitor that material borrow sources are suitable for compacted clay liner.
- Monitor that processing and moisture conditioning of the compacted clay liner are in conformance with the Specifications.
- Monitor that grade control construction staking is performed before the work.
- Monitor that the proper number of passes are made with an approved compactor.
- Monitor lift thickness and other construction procedures as covered in the Specifications and verify that test results are in accordance with the Specifications.
- Perform tests at the frequencies specified in Table 3-2.

3.4.6 Geosynthetics Subgrade Preparation

- Monitor that the subgrade is free of organic and oversized materials and meets the requirements of the Specifications.
- Monitor that grade control construction staking is performed prior to the work.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of subgrade materials.
- Monitor that angular or sharp rocks, rocks that protrude more than 0.5 inches, and other debris that could damage the overlying geomembrane are removed from the surface of the subgrade. Verify that the subgrade is free of irregularities and is steel drum rolled smooth prior to geomembrane placement.

- Monitor that the final surface provides continuous and intimate contact with the overlying geomembrane.

- Coordinate with the Contractor to perform subgrade verification surveys upon completion of the subgrade preparation. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the subgrade preparation for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.7 Operations Layer

- Monitor that the material source is suitable for the operations layer and is free of organic or other deleterious materials and free of oversized particles, as defined by the Specifications.

- Monitor that grade control construction staking is performed before the work.

- Verify that the operations layer and is placed in a manner that does not damage the underlying geosynthetic layers.

- Coordinate with the Contractor to perform operations layer verification surveys upon completion of placement operations. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the operations layer for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.

3.4.8 Trenching and Backfilling

- Monitor that construction staking is performed before the work and that survey bench marks with elevations are secured outside the work area.

- Monitor that trenches are excavated in accordance with the dimensional cross-sections and design elevations shown on the Plans.

- Monitor profile surveys conducted by the Contractor during trenching operations.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of soil materials that will be used as backfill.

- Perform nuclear density-moisture tests (ASTM D6938) to verify that backfill materials are moisture conditioned and compacted in accordance with the Specifications.

4. CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

4.1 General

The objectives of the geosynthetics CQA program are to assure that: (i) proper construction techniques and procedures are used, and (ii) the project is completed in accordance with the Plans and Specifications. The intents of the CQA program are to: (i) identify and define problems that may occur during construction, and (ii) document that these problems are corrected before construction is complete.

This section describes CQA procedures for the installation of geosynthetic components. The following geosynthetics will be utilized for this project:

- 60-mil HDPE geomembrane (textured on both sides);
- Non-woven geotextile; and
- Double-sided geocomposite.

CQA for the geosynthetics installations will be performed to monitor that geosynthetics are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Manager will: (i) review the Contractor's quality control submittals; (ii) perform material conformance testing; (iii) monitor construction testing; and (iv) monitor installations. Conformance testing refers to activities that take place before geosynthetics installation. Construction testing includes activities that occur during geosynthetics installation.

The CQA testing will be conducted in accordance with this CQA Plan and the project's Plans and Specifications. If a discrepancy exists in the testing requirements, the document that requires the most stringent testing will govern.

4.2 Geomembrane

4.2.1 Delivery, Storage, and Handling

Upon delivery of geomembrane, the CQA Monitor will:

- Observe geomembrane rolls for damage during shipping and handling, identify and mark any damaged materials, and document that damaged materials are set aside.
- Observe that the geomembrane is stored in accordance with the Specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Document that all manufacturing documentation required by the Specifications has been received.
- Complete the geosynthetics inventory form for all geomembrane materials received.

Damaged geomembrane may be rejected. If rejected, document that material is removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have

proper documentation from the manufacturer must be stored at a separate location until all documentation has been received, reviewed, and accepted.

4.2.2 Conformance Testing

Geomembrane Material Tests. Geomembrane samples will be obtained for conformance testing in accordance with Table 4-1. The material will be sampled at the site by the CQA Monitor or at the manufacturing plant under the direction of the CQA Consultant. The samples will be forwarded to an independent testing laboratory for the following conformance tests:

TABLE 4-1
HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency[6]
Thickness (min. avg.)	ASTM D5994	1 per 250,000 sf
Asperity Height (min. avg.)[1]	GRI GM 12	1 per 250,000 sf
Melt Flow Index	ASTM 1238	1 per 250,000 sf
Sheet Density (min avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Tensile Properties[2] (min. avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	1 per 250,000 sf
Puncture Resistance (min. avg.)	ASTM D4833	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603[3]	1 per 250,000 sf
Carbon Black Dispersion[4]	ASTM D2663 ASTM D5596	1 per 250,000 sf
Interface Shear Strength[5] • geocomposite / geomembrane • clay liner / geomembrane	ASTM D6243	1 per project

Notes to Table 4-1:
(1) Applies only to textured geomembranes. Alternate the measurement side for double-sided textured sheets.
(2) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens in each direction:
- Yield elongation is calculated using a gage length of 1.3 inches.
- Break elongation is calculated using a gage length of 2.0 inches.

(3) Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
(5) Interface shear strength tests shall be tested at normal loads of 1,000; 4,000; 8,000; and 15,000 pounds per square foot. Results of the testing shall be forwarded to the Engineer for review and approval. Test reports shall include peak and large-displacement (2.5 inches) shear stress values.
(6) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-1 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be taken across the entire roll width. Samples may be cut for shipping purposes, but a minimum of five square feet must be sent to the testing laboratory. Samplers must mark the machine direction and the manufacturer's roll identification number on the sample (each piece). Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.2.3 Geomembrane Installation

Surface Preparation. The soil surface must be prepared in accordance with the Specifications. Before geomembrane installation, the subgrade will be inspected by the CQA Monitor and Geosynthetics Contractor. The CQA Monitor must check the following:

- All lines and grades for the soil surface have been verified by the Contractor.
- The soil surface has been rolled/compacted and is free of surface irregularities, loose soil, and protrusions.
- The soil surface is firm and does not contain stones or other objects that could damage the geomembrane.
- The anchor trench dimensions have been checked and the trenches are free of sharp objects and stones.
- There are no excessively soft areas.
- The soil surface is not saturated and no standing water is present.
- The soil surface is not desiccated.
- All construction stakes, if utilized, have been removed and accounted for and there is no debris, rocks, or any other objects in or on the soil surface.
- The Geosynthetics Contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Before installing any of the geomembrane, the Geosynthetics Contractor must submit drawings in accordance with the Specifications. These drawings will show the proposed layout of the panels, including panel identification numbers, field seams, and any other details that do not conform to the Plans.

The CQA Monitor will maintain an up to date panel layout drawing that shows the following: (i) roll numbers; (ii) panel numbers; (iii) seam numbers; (iv) test locations; (v) repair locations; and, (vi) non-destructive testing information.

During panel placement operations, the CQA Monitor will:

- Record panel numbers and dimensions on the panel/seam log.

- Observe the panel surface as it is deployed and record all panel defects and defect corrective actions (panel rejected, patch installed, extrudate placed over the defect, etc.) on the repair sheet. Verify that corrective actions are made in accordance with the Specifications.

- Monitor that equipment used during deployment operations does not damage the geomembrane. Verify that equipment used on the geomembrane does not leak hydrocarbons onto the geomembrane or that corrective measures are taken to prevent leakage.

- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance. Verify that no stones, construction debris, or other items are beneath the geomembrane that could damage the geomembrane.

- Monitor that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.

- Record weather conditions including temperature, wind speed and direction, and humidity. Verify that the geomembrane is not deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, verify that the geomembrane is not placed when the air temperature is less than 40° F or when standing water or frost is on the ground.

- Monitor that crews working on the geomembrane do not smoke, do not wear shoes that could damage the liner, and do not engage in activities that could damage the geomembrane.

- Monitor that methods used to deploy the geomembrane minimize wrinkles and that panels are anchored to prevent movement by the wind. Verify that the Geosynthetics Contractor corrects any damage resulting to or from windblown geomembrane.

- Monitor that no more panels are deployed than can be seamed on the same day.

- The CQA Monitor must inform both the Geosynthetics Contractor and the CQA Manager if any of the above conditions are not met.

Field Seaming. Before the start of geomembrane welding and during welding operations, each welder and welding apparatus will be tested in accordance with the Specifications to verify that the equipment is functioning properly. One trial weld will be taken before the start of work and one at mid-shift. The trial weld sample will be at least 42-inches-long and 12-inches-wide, with the seam centered lengthwise. The CQA Monitor will observe all welding operations and verify that the Geosynthetics Contractor quantitatively tests each trial weld for peel adhesion and bonded seam strength (ASTM D6392). (Peel adhesion tests will be referred to as "peel" and bonded seam strength tests will be referred to as "shear" in this document.) The main purposes of the trial weld tests are to evaluate seam strength and to confirm that each welding machine is working properly. Shear tests measure the continuity of tensile strength through the seam and into the parent material. Peel tests measure the strength of the bond created by the welding process.

The results of the peel and shear tests on trial welds will be recorded on the trial weld form. Trial welds must be completed under conditions similar to those under which the panels will be welded.

Trial welds must meet specified requirements for peel and shear and the failure must be ductile or a film tearing bond (FTB) for a wedge weld. An FTB failure occurs when the test specimen breaks at the edge of the outside of the seam but not within that seam. If at any time the CQA Monitor believes that a welding machine is not functioning properly, a trial weld by that machine must be performed and tested. If there are wide changes in temperature (> 30° F), humidity, or wind speed, another trial weld must be performed and tested. The trial weld must be allowed to cool to ambient temperature before it is tested.

During geomembrane welding operations, the CQA Monitor will:

- Monitor that the Geosynthetics Contractor has an appropriate number of welding machines and spare parts necessary to perform the work.
- Monitor that equipment used for welding will not damage the geomembrane.
- Monitor that extrusion welders are purged before beginning a weld so that all heat-degraded extrudate is removed from the nozzle of the extrusion welder.
- Monitor that seam grinding is completed less than 1 hour before seam welding and that the upper sheet is beveled (extrusion welding only).
- Monitor that the ambient temperature measured 6-inches above the geomembrane surface is between 40° F and 110° F.
- Monitor that the ends of extrusion welds that are more than 5 minutes old are ground to expose new material before restarting a weld.
- Monitor that contact surfaces of the panels are clean and free of dust, grease, dirt, debris, and moisture before welding.
- Monitor that welds are free of dust, rocks, and other debris.
- Monitor that cross seams are ground to a smooth incline before welding (fusion welding only).
- Monitor that all seams are overlapped a minimum of 3 inches or in accordance with the manufacturer's recommendations, whichever is more stringent.
- Monitor that solvents or adhesives are not present in the seam area.
- Monitor that procedures used to temporarily hold the panels together do not damage the panels and do not preclude CQA testing.
- Monitor that strips of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, are placed below the geomembrane. These strips may be as long as the seam itself or shorter and moved with the seaming equipment. If necessary, a firm material such as a flat board or similar hard surface may be placed directly under the weld overlap to achieve firm support.
- Monitor that panels are being welded in accordance with the Plans and Specifications.

- Monitor that there is no free moisture in the weld area.
- Measure surface temperature of the panels every 2 hours.

4.2.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive geomembrane seam testing is to detect discontinuities or holes in the seams. Nondestructive geomembrane seam tests include vacuum box and air pressure testing. Nondestructive testing must be performed over the entire length of each seam.

It is the Geosynthetics Contractor's responsibility to perform all nondestructive testing as part of their quality control (QC) program. The CQA Monitor's responsibility is to observe and document that the Geosynthetics Contractor's QC testing is in compliance with the Specifications and to document seam defects and repairs.

Nondestructive seam testing procedures are described below:

- For welds tested by the vacuum box method, the weld is placed under suction utilizing a vacuum box constructed with rigid sides, a transparent top for viewing the seams, a neoprene rubber gasket attached to the bottom of the rigid sides, a vacuum gauge on the inside, and a valve assembly attached to a vacuum hose connection. The box is placed over a seam section which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom of the box must fit snugly against the soaped seam section of the panel to ensure a leak-tight seal.

- A vacuum pump is energized and the vacuum box pressure reduced to approximately 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than 10 seconds.

- Air pressure testing is used to test double wedge seams that have an enclosed air channel between them. Both ends of the air channel must be sealed. A pressure feed device, usually a hollow needle equipped with a pressure gauge, is inserted into one end of the channel. Air is then pumped into the channel to a minimum pressure of 25 to 30 psi. The air channel must sustain this pressure for 5 minutes without losing more than 2 psi. Following the 5-minute hold time, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if it does not return to zero a blockage is likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive seam testing, the CQA Monitor will:

- Review the Specifications regarding test procedures.
- Monitor that equipment operators are fully trained and qualified to perform their work.
- Monitor that test equipment meets the Specifications.
- Monitor that the entire length of each seam is tested in accordance with the Specifications.

- Observe testing and record results on the panel/seam log and the panel layout drawing.
- Identify any failed areas by marking the area with a waterproof marker compatible with the geomembrane, inform the Geosynthetics Contractor of any required repairs, and record the repair on the panel/seam log.
- Monitor that all repairs are completed and tested in accordance with the Specifications.
- Record all completed and tested repairs on a repair sheet and the panel layout drawing.

Destructive Seam Sampling Procedures and Field Testing. Destructive seam samples will be taken at intervals of at least one per 500 linear feet of geomembrane seam. However, additional samples will be taken if the CQA Monitor suspects that a seam does not meet the Specification's requirements. Reasons for taking additional samples may include, but are not limited to:

1. Wrinkling in the seam area.
2. Excess crystallinity.
3. Suspect seaming equipment or techniques.
4. Weld contamination.
5. Insufficient overlap.
6. Adverse weather conditions.
7. Failing tests.

The CQA Monitor will select the locations from where seam samples will be cut for destructive laboratory testing as follows:

- A minimum of one test per 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals. The testing frequency will be increased if welding operations are conducted in temperatures below 40° F. This increase will be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor.
- A maximum frequency must be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor at the pre-construction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the CQA Manager. Samples taken as the result of failed tests do not count toward the total number of required tests.

The CQA Monitor will not inform the Geosynthetics Contractor in advance of selecting the destructive sample locations.

The Geosynthetics Contractor will remove the destructive samples at locations identified by the CQA Monitor and field test the specimens for peel and shear before the samples are shipped off-site for laboratory testing. During sampling procedures the CQA Monitor will:

- Observe sample cutting.
- Mark each specimen and sample with an identifying number which contains the seam number, destructive sample test number, welder, and date and time welded.
- Record sample locations on the panel layout drawing and panel-seam logs.

- Record the sample locations, weather conditions, and reasons samples were taken (e.g., random sample, visual appearance, result of a previous failure, etc.) in the destructive seam test form.

At each location, obtain two seam specimens that are 44-inches apart. The specimens should be 1-inch wide and 12-inches long with the weld centered across the length of the specimen. The Geosynthetics Contractor must test these samples to failure in the field using a tensiometer capable of quantitatively measuring shear and peel strengths. For double wedge welding, the Geosynthetics Contractor must test both welds. The CQA Monitor will observe the tests. Geomembrane seam specimens pass when the break is a ductile FTB and the seam strength meets the specified values.

If one or both of the 1-inch specimens fails in either peel or shear, the Geosynthetics Contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations; or (2) take another test sample 10 feet from the point of the failed test and repeat this procedure. If the second test passes, the Geosynthetics Contractor can either reconstruct or cap strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly and that appropriate corrective action must be taken immediately.

Once the field test specimens have passed, a sample must be recovered for laboratory testing from between the passing field specimen locations. The sample must be 42-inches long and 12-inches wide, with the weld centered along the length of the sample. The sample must be divided into three sections: one 12-inch by 12-inch section for the Geosynthetics Contractor, one 12-inch by 18-inch section for laboratory testing, and one 12-inch by 12-inch section for the Owner to archive. Record the results of field testing on the destructive seam test form and the panel/seam log.

Third Party Laboratory Testing. The CQA destructive seam samples can be shipped to the testing laboratory to verify seam quality. The laboratory will test five specimens from each sample in both shear and peel modes of failure. Minimum required test values are presented in the Specifications. The testing laboratory must provide verbal test results within 24 hours to the CQA Manager and written certified test results within 5 days.

The CQA Manager must immediately notify the Construction Manager and Geosynthetics Contractor in the event of failed seam test results.

If a laboratory test fails in either peel or shear, the Geosynthetics Contractor must either reconstruct the entire seam or recover additional samples at least 10 feet on either side of the failed sample for retesting. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

4.2.5 Repairs

Portions of geomembrane panels and seams that contain: (1) a flaw; (2) a destructive test; or (3) nondestructive test cuts or holes must be repaired in accordance with the Specifications. The CQA Monitor must locate and record all repairs on the repair sheet and panel layout drawing. Acceptable repair techniques include the following:

- Patching: used to repair large holes, tears, large panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

- Extrusion: used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 2-inches in the largest dimension.

- Capping: used to repair failed welds or to cover seams where welds cannot be nondestructively tested.

- Removal: used to replace areas with large defects where preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than 1 hour before the repair.

- Clean and dry all surfaces at the time of repair.

- Monitor acceptance of the repair procedures, materials, and techniques by the CQA Monitor in advance of the specific repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches before extrusion welding.

4.2.6 Folded Material

Geomembrane with excessive folding (i.e., creased), as determined by the CQA Consultant, must be removed.

4.2.7 Geomembrane Anchor Trench

The geomembrane anchor trench should be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

4.2.8 Geomembrane Acceptance

The Contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Contractor is responsible for placing cover over the geomembrane, the Contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the completed installation will be walked by the CQA Monitor and Contractor. Any damage or defects found during this inspection will be repaired by the Geosynthetics Contractor. The installation will not be accepted until it meets the requirements of both parties. In addition, the geomembrane will be recommended for acceptance by the CQA Manager only when the following have been completed:

- The installation is finished.

- All seams have been inspected and verified to be acceptable and all required laboratory and field tests have been completed and reviewed.

- All required Contractor-supplied documentation has been received and reviewed.

- All as-built drawings have been reviewed and verified by the CQA Manager to show the true panel dimensions, the locations of all seams, trenches, pipes, appurtenances, and destructive test locations.

4.2.9 Qualifications

Proper layout, seaming, and testing of the geomembrane requires skill and experience. As such, the integrity of the geomembrane is dependent upon the installers. In order to assure a minimum level of experience and expertise, the following experience standards have been established in the Specifications:

Manufacturer/Fabricator/Installer. The Specifications list the required qualifications for the geomembrane manufacturer / fabricator / installer companies. The CQA Manager must verify qualifications of the manufacturer, fabricator, and installer through review of Engineer-approved project submittals.

Installation Superintendent. The installation field superintendent must have been responsible for the completed installation of a minimum of 5,000,000 square feet of polyethylene geomembrane in the past 5 years utilizing the type of seaming techniques and apparatus proposed for use on this project. A resume with references and phone numbers of satisfactory installations is required. Any superintendent proposed for this project must be present whenever geomembrane is installed.

Master Seamer and Other Welders. The master seamer must have demonstrated expertise on previous geomembrane installations. The master seamer must have successfully welded a minimum of 1,000,000 square feet of polyethylene geomembrane within the past 3 years. A resume for this work, with references and phone numbers, is required. Other welders are required to have welded a minimum of 100,000 square feet of geomembrane within the past 3 years. Resumes for all welders, with references and phone numbers, are required. Personnel that have welded less than 100,000 square feet of geomembrane within the past 3 years will only be allowed to weld under the direct supervision of either the master seamer or the installation superintendent.

CQA Manager Qualifications. The CQA Manager must have provided CQA services on a minimum of 1,000,000 square feet of polyethylene installations or be level II certified in geosynthetics installations by National Institute for Certification in Engineering Technologies (NICET). The CQA Manager must provide verification of this experience by references in a current resume.

4.3 Geotextiles

4.3.1 Delivery, Storage, and Handling

During delivery of geotextiles the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geotextile.
- Monitor that rolls are wrapped in impermeable and opaque protective covers.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Log this information on the geosynthetic inventory form.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Monitor that rejected material is removed from the site and stored at a location separate from accepted rolls. Geotextile rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.3.2 Conformance Testing

Geotextile Material Tests. The CQA Manager will arrange to obtain geotextile conformance test samples as indicated in Table 4-2. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-2
NON-WOVEN GEOTEXTILE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency(1)
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Apparent Opening Size[2] (max.)	ASTM D4751	1 per project
Grab Strength (min. avg.)	ASTM D4632	1 per 250,000 sf
Permittivity[2] (min.)	ASTM D4491	1 per project
Puncture Strength (min. avg.)	ASTM D4833	1 per 250,000 sf

Notes to Table 4-2:

(1) Minimum testing frequency shall be one sample per lot.
(2) AOS and permittivity shall only be tested for geotextiles used in filter applications.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-2 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.3.3 Geotextile Installation

Surface Preparation. Before geotextile installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the subgrade has been prepared in accordance with the Specifications and that the geomembrane installation and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geotextile.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geotextile.

Geotextile Placement and Seaming. During geotextile placement and seaming operations, the CQA Monitor will:

- Observe the geotextile as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.
- Monitor that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Monitor that crews working on the geotextile do not smoke, do not wear shoes that could damage the geotextile, and do not engage in activities that could damage the geotextile.
- Monitor that the geotextile is securely anchored in an anchor trench and is temporarily anchored to prevent movement by the wind.
- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.
- Monitor that the geotextile is not exposed to direct sunlight for more than 5 days.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.3.4 Repairs

Repair procedures include:

- Patching: used to repair large holes, tears, and small defective areas.
- Removal: used to replace large defective areas where the preceding method is not appropriate.

4.4 Geocomposite

4.4.1 Delivery, Storage, and Handling

During delivery of geocomposite the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geocomposite.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Record this information on the geosynthetic inventory log.
- Monitor that the geosynthetic inventory log is completed.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Verify that rejected material is removed from the site or stored at a location separate from accepted rolls. Geocomposite rolls that do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.4.2 Conformance Testing

Geocomposite Material Tests. The CQA Manager will arrange to obtain geocomposite conformance test samples as indicated in Table 4-3. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-3
GEOCOMPOSITE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency
Density (min. avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Thickness (min. avg.)	ASTM D751 or ASTM D5199	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603	1 per 250,000 sf
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Peel Strength (min. avg.)	GRI GC7	1 per 250,000 sf
Transmissivity(1) (min. avg.)	ASTM D4716	1 per project

Note to Table 4-3:

(1) Transmissivity shall be measured in a 12-inch by 12-inch box between steel plates under a normal stress of 15,000 psf and a hydraulic gradient of 0.1. A seating time of 15 minutes shall be used.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager.

The Final CQA Report shall include a table similar to Table 4-3 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.4.3 Geocomposite Installation

Surface Preparation. Before geocomposite installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the geomembrane has been prepared in accordance with the Specifications and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geocomposite.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geocomposite.
- Observe that all construction stakes have been removed.
- Monitor that all aspects of surface preparation have been performed according to the Specifications.

Geocomposite Placement. During geocomposite placement, the CQA Monitor will:

- Observe the geocomposite as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.

- Monitor that equipment used does not damage the geocomposite by handling, equipment transit, leakage of hydrocarbons, or other means.

- Monitor that crews working on the geocomposite do not smoke, do not wear shoes that could damage the geocomposite, and do not engage in activities that could damage the geocomposite.

- Monitor that the geocomposite is securely anchored to prevent movement by the wind.

- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.

- Examine the geocomposite after installation to ensure that no potentially harmful foreign objects are present.

The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.4.4 Repairs

Repair procedures for geocomposite include:

- Patching: used to repair large holes, tears, and small defective areas.

- Removal: used to replace large defective areas where the preceding method is not appropriate.

5. CONSTRUCTION QUALITY ASSURANCE FOR HDPE PIPE

5.1 General

This section describes CQA procedures for HDPE pipe installations. Solid HDPE pipe will be utilized to construct the LCRS riser extensions.

CQA for the HDPE pipe installations will be performed to verify that HDPE pipe systems are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

All construction testing will be conducted in accordance with the Specifications.

5.2 Construction Monitoring

The following sections list monitoring requirements during HDPE pipe operations.

5.2.1 Delivery, Handling, and Storage

- Monitor that chains, end hooks, cable slings, or any other devices that may scar the pipe are not used to handle pipe. Wide nylon web slings are recommended to handle the pipe.
- Monitor that the pipe is not damaged during handling operations and that damaged pipe is separated from accepted pipe.
- Monitor that pipe out-of-roundness will not occur due to excessive stacking heights when the pipe is stored at the site.
- Monitor that the pipe is not damaged by sharp rocks or excessive abrasion when the pipe is pulled into place during fusion welding and installation operations.

5.2.2 Fusion Welding

- Before pipe fusion welding operations and installations, verify that solid pipe, perforated pipe, fittings, and flanged couplings comply with the product requirements of the Specifications.
- Monitor that certified fusion welding operators will be performing the welding.
- Monitor that caution is taken to prevent water from coming in contact with the pipe and heater plates during welding operations. A shelter may be required for the fusion welding machine to allow operations to continue in adverse weather conditions.
- Monitor that heater plate surface temperatures are maintained between 375°F and 400°F for both coated plates and uncoated plates. Monitor that the operator checks the heater plate surface temperatures with a pyrometer.
- Monitor that inside and outside of pipe ends are cleaned to remove dirt, water, grease, and other foreign material.

- Monitor that pipe ends are squarely faced with the facing tool of the fusion welding machine.

- Monitor that pipe ends line up in the fusion welding machine and that the pipe ends meet squarely and completely over the entire surface to be welded. Monitor at this point that the pipe is securely clamped into place so that the pipe does not move during the fusion welding process.

- Monitor that the heater plate is clean and maintains the appropriate temperature. Monitor that the heater plate is inserted between the aligned pipe ends and that the pipe ends are firmly brought into contact with the heater plate. NO PRESSURE should be applied to achieve the melt pattern.

- Monitor that the pipe ends are allowed to heat and soften. As the pipe heats and softens a melt bead begins to roll back from the contact point of the heater plate and the pipe ends.

- Monitor that the heater plate is removed quickly and cleanly when the appropriate melt bead is achieved and that no melted pipe material sticks to the heater plate. If melted material sticks to the heater plate, Monitor that this joint is discontinued, the heater plate is cleaned, the pipe ends are re-faced, and that the joint is re-started.

- Monitor that the melted pipe ends are rapidly joined together and that enough pressure is applied to the joint to form a melt bead 1/8-inch to 3/16-inch in diameter around the entire circumference of the pipe. Pressure is critical to cause the heated material of each pipe end to flow together.

- Monitor that the joint is allowed to cool and solidify properly before the pipe is released from the fusion welding machine. Cooling and solidification is completed when a person's finger can remain comfortably on the bead.

- Examine the joint when the pipe is released from the fusion welding machine to verify that the weld is completely around the entire circumference of the pipe.

5.2.3 Slip Joints

- Monitor that all joints extend to the minimum overlap and comply with the requirements of the Plans and Specifications.

- Monitor that there is a snug fit with zero air gaps surrounding the connection.

6. CONSTRUCTION QUALITY ASSURANCE FOR EROSION CONTROL

6.1 Introduction

This section describes CQA procedures for temporary and permanent erosion control installations.

CQA for the temporary and permanent erosion control measures will be performed to verify that the Contractor complies with the requirements of the project's Stormwater Pollution Prevention Plan (SWPPP) and that the permanent erosion control measures are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals, and (2) monitor installations.

6.2 Construction Monitoring

6.2.1 Temporary Erosion Control

- Monitor that the Contractor implements temporary erosion control measures in compliance with the project's SWPPP.

6.2.2 Permanent Erosion Control Measures

Straw Wattles

- Review the Contractor's submittals for the straw wattles and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the straw wattles at the locations indicated on the Plans.
- Monitor that the Contractor installs the straw wattles in accordance with the manufacturer's recommendations.

7. CONSTRUCTION QUALITY ASSURANCE FOR DRAINAGE FACILITIES

7.1 Introduction

This section describes CQA procedures for the surface water drainage facilities. The drainage facilities consist of various types of drainage channels, drop inlets, culverts, and diversion berms.

CQA for the drainage facilities installation will be performed to verify that these facilities are constructed in accordance with the Plans and Specifications. To monitor compliance, the CQA program will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

Construction testing will be conducted in accordance with the Specifications.

7.2 Construction Monitoring

7.2.1 Drainage Channels

- Monitor that grade control construction staking for the drainage channels is performed before the work.
- Monitor that the drainage channels are constructed in accordance with the Drawings and Specifications.
- Monitor that the subgrades of the drainage channels are dry, firm, and unyielding and do not have loose or extraneous material.
- Document that drainage ditches are graded and sloped in accordance with the Plans and Specifications. Review verification surveys and notify the Contractor of areas needing repair. Submit copies of verification surveys to the Construction Manager.

7.2.2 Drop Inlets and Culverts

- Review the Contractor's submittals for the piping and drop inlets for compliance with the Specifications.
- Monitor that the Contractor has excavated pipe trenches to the proper depth.
- Monitor that the Contractor has graded the slope of the pipe trenches to uniform gradient.
- Monitor that the pipe subgrades are firm and unyielding and do not have loose or extraneous material.
- Monitor and test backfilling of pipe trenches.
- Verify that inlets to drainage structures are smooth and prevent ponding.

7.2.3 Diversion Berms

- Monitor that the material used to construct the diversion berms complies with the Specifications for structural fill.

8. DOCUMENTATION

This CQA Plan requires thorough monitoring and documentation of the construction activities. The CQA Manager will document that the CQA requirements have been addressed and satisfied. Documentation will consist of daily record keeping, testing and installation reports, non-conformance reports (if necessary), progress reports, photographic records, design and Specification revisions, and a Final CQA Report.

8.1 Daily Record Keeping

At a minimum, daily records will consist of a daily record of construction progress, daily construction report, observation and test data sheets, and, as needed, non-conformance/corrective measure reports. All forms will have peer review.

8.1.1 Daily Record of Construction Progress

The daily field report will summarize ongoing construction and discussions with the Contractor and will be prepared by the CQA Manager and CQA Monitor. At a minimum, the report will include the following:

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data.
4. A description of ongoing construction for the day in the area of the CQA Monitor's responsibility.
5. An inventory of equipment utilized by the Contractor.
6. Significant items of discussion and names of parties involved in these discussions.
7. A brief description of tests and observations, identified as passing or failing, or, in the event of failure, a retest.
8. Areas of non-conformance/corrective actions, if any (non-conformance/corrective action form to be attached).
9. Summary of materials received and quality control documentation.
10. Follow-up information on previously reported problems or deficiencies.
11. Record of site visitors involved with the project.
12. Signature of CQA Manager and/or CQA Monitor.
13. Signature of the peer reviewer.

8.1.2 Observation and Test Data Sheets

Observation and test data sheets should include the following information as is appropriate for the form being used.

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data, as applicable.
4. A reduced scale site plan showing sample and test locations.
5. Test equipment calibrations, if applicable.
6. A summary of test results identified as passing, failing, or, in the event of a failed test, retest.
7. Completed calculations.
8. Signature of the CQA Manager and/or CQA Monitor.
9. Signature of the peer reviewer.

8.1.3 Non-Conformance Reports

In the event of a non-conformance event, a non-conformance verification report form will be included with the daily report. Procedures for implementing and resolving any non-conformities to the Contract Documents are outlined in Section 2.4 of this CQA Plan.

8.2 Weekly Progress Reports

The CQA Manager will prepare weekly progress reports summarizing construction and CQA activities. These reports will contain, at a minimum, the following information:

- The date, project name, project number, and location.
- A summary of work activities completed in the last week and those expected to be performed in the next week.
- A summary of deficiencies and/or defects and resolutions.
- Ongoing summary of changes and/or change orders to the work.
- The signature of the CQA Manager.
- On the fourth week of each month the report will include a summary of on-site and third party laboratory test results.

8.3 Photographs

Construction activities will be photographed. Photographs will show any significant problems encountered and corrective actions and will document the construction progress. The photographs will be identified by location, date, and photographer. The photographer should document the subject or the photograph, either on the back of the picture or in a photograph log.

8.4 Design and Specification Changes

Design and Specification changes may be required during construction. Design and Specification changes will only be made with the written agreement of the Design Engineer, Owner, and Contractor. Design and specification changes which affect the containment system or environmental controls shall also require approval of the Regional Water Quality Control Board (RWQCB). These changes will be made by change order to the contract. When change orders are issued, they will be prepared by the Construction Manager. The Construction Manager will distribute change orders for signature and execution to the required parties.

8.5 Final Construction Quality Assurance Report

The CQA Manager and CQA Officer shall submit two Final CQA Reports for Phase III: one report for the Phase IIIA construction and one report for the Phase IIIB construction. These reports shall be submitted at the completion of construction of each Phase and shall document that the work for each Phase has been performed in compliance with the Plans and Specifications.

At a minimum, each Final CQA Report will contain:

- Daily Field Reports per Section 8.1.1.
- Inspection data sheets that contain observations and a record of field and laboratory tests per Section 8.1.2.
- A summary of the construction activities.
- A tabular summary of the laboratory and field test results demonstrating construction is in compliance with the Specifications.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A list of changes from the Plans and Specifications and the justifications for these changes.
- As-built (record) drawings.
- A statement of compliance with the Contract Documents and design intent that is signed and stamped by the CQA Officer.

The as-built drawings will accurately show the constructed location of the work items, including the location of piping, anchor trenches, etc. All surveying and base maps required for the development of the as-built drawings will be prepared by the Contractor. The CQA Manager will review and verify that the as-builts are correct.

APPENDIX P.2
FINAL CLOSURE CQA PLAN

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CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN FOR LANDFILL UNIT B-18 FINAL CLOSURE KETTLEMAN HILLS FACILITY KETTLEMAN CITY, CALIFORNIA

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ENGINEER'S CERTIFICATION

In accordance with the requirements of California Code of Regulations (CCR) Title 22 Section 66264.19, this Construction Quality Assurance (CQA) Plan has been developed under the direction of a Civil Engineer registered in the State of California.

I hereby certify that this CQA Plan was developed under my direct supervision.

REGISTERED PROFESSIONAL ENGINEER
SCOTT G. SUMNER
No. C049769
EXP. 9-30-10
CIVIL
STATE OF CALIFORNIA

11-17-08

Scott G. Sumner, P.E. Date
RCE No. 049769 Expires: 09-30-2010

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the Construction Quality Assurance (CQA) procedures required during the final closure construction of Landfill Unit B-18 (B-18) at the Kettleman Hills Facility in Kettleman City, California. This CQA Plan establishes procedures to document that the construction is performed in accordance with the approved engineering standards and specifications, meets the appropriate regulatory requirements (i.e., California Code of Regulations Title 22 §66264.19 and Title 27 §20323 and §20324), and that the necessary documentation is developed for submittal to the regulators. This CQA Plan shall be implemented under the direction of a CQA Officer who is a registered Civil Engineer in the State of California.

This CQA Plan is a guidance document that contains general and specific work element requirements for monitoring construction. General requirements include the organization and responsibilities of CQA personnel, documentation control, and reporting procedures. Specific work elements include the following:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Subgrade Preparation;
- Earthfill;
- Geomembranes;
- Geotextiles; and
- Culverts/Drainage Channels.

The CQA Consultant will prepare a Final CQA Report upon completion of construction. The Final CQA Report will include information generated through the CQA program and will document the extent to which construction was performed in accordance with the intent of the Contract Documents and design. The CQA Consultant will be required to submit the Final CQA Report within one week of substantial completion of construction.

1.2 CQA Consultant

The CQA Consultant has the primary responsibility of implementing and managing the CQA program described herein and will document to the appropriate regulatory agencies that construction of the facility was performed in accordance with the design and the Contract Documents. Specific responsibilities for the CQA Consultant's site personnel are presented in Section 2.2.

1.3 Project Organization

The project will be completed by Contractors performing earthworks construction, geosynthetic materials installation, and construction of associated ancillary facilities. The CQA Consultant will be independent of the Contractors and will report directly to the Owner's Project Manager.

1.4 Reference Documents

The latest editions of the following reference documents provide background information and support this CQA Plan:

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.02, Concrete and Aggregates.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 4, Construction, Volume 04.08, Soil and Rock(I), and Volume 04.09, Soil and Rock (II); Geosynthetics.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards, Section 8, Plastics, Volumes 08.01, Plastics (I), Volume 08.02, Plastics (II), and Volume 08.03, Plastics (III).

California Code of Regulations (CCR), Titles 22 (Social Security) and 27 (Environmental Protection).

Standard Specifications for Public Works Construction, Joint Cooperative Committee of the Southern California Chapter, American Public Works Association And Southern California Districts, Associated General Contractors of California, Building News.

1.5 Definitions

Whenever the terms listed below are used, the intent and meaning shall be interpreted as indicated.

ACI: American Concrete Institute.

AISC: American Institute of Steel Construction.

ASTM: American Society for Testing and Materials.

Construction Manager: The individual or firm responsible for administering the construction contract and providing overall construction management for the project. The construction manager is the primary contact on the project site representing the Owner.

Construction Quality Assurance (CQA): A planned and systematic pattern of procedures and documentation designed to provide confidence that items of work or services meet the requirements of the Contract Documents. Construction quality assurance includes verifying that the Contractor is performing the quality control requirements of the Specifications.

CQA Consultant: See Section 1.2

CQA Manager: Authorized representative of the CQA Consultant responsible for managing the CQA program.

CQA Monitors: Authorized representatives of the CQA Consultant responsible for observing and documenting activities related to CQA during construction.

CQA Officer: Authorized representative of the CQA Consultant and a California-Registered Civil Engineer responsible for certifying that construction was performed in accordance with the intent of the Contract Documents and design.

Construction Quality Control: Those actions which provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the Contract Documents. Quality control will be performed by the Contractor/Geosynthetics Contractor, except where designated in the Specifications.

Contract Drawings: The official plans, profiles, typical cross-sections, elevations, and details, as well as their amendments and supplemental drawings, that show the locations, character, dimensions, and details of the work to be performed. Contract Drawings are also referred to as the "Plans."

Contract Documents: The official set of documents issued by the Owner, which includes bidding requirements, contract forms, contract conditions, Specifications, Contract Drawings, addenda, and contract modifications.

Contractor: The person or persons, firm, partnership, corporation, or any combination of these or any combination of private, municipal, or public entities who, as an independent Contractor, has entered into a contract with the Owner and who is referred to throughout the Contract Documents by singular number and masculine gender.

Contract Specifications: The requirements for products, materials, and workmanship upon which the contract is based. Contract Specifications are also referred to as the "Specifications."

Design Engineer: The individuals or firms responsible for the project's design and preparation of the Plans and Specifications. The Design Engineer is also referred to as the "Designer" or "Engineer." The Design Engineer for the Final Closure of Landfill Unit B-18 is Golder Associates Inc. of Irvine, California.

Earthwork: A construction activity involving the use of soil materials as defined in the Specifications and Section 3 of this document.

Flexible Membrane Liner (FML): A synthetic lining material, also referred to as geomembrane, membrane, liner, or sheet.

Geosynthetics Contractor: Also referred to as the "Installer." The person or firm responsible for installation of geosynthetic components. This definition applies to any party installing geomembrane, geotextile, geocomposite, geosynthetic clay liner, or any other geosynthetic material, even if it is not their primary function.

GRI: Geosynthetics Research Institute.

Non-Conformance: A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformance include, but are not limited to, physical defects, test failures, and inadequate documentation.

Owner: Waste Management, Inc. – Kettleman Hills Facility.

Owner's Project Manager: Authorized representative of the Owner responsible for planning, organizing, and control of the design and construction activities. Responsibilities include scheduling, cost control, engineering, procurement, and contracting functions. Referred to as the "Project Manager" in this document.

Panel: A unit area of the FML that is seamed in the field or in the fabricator's plant.

Procedure: A document that specifies or describes how an activity is to be performed.

Project Documents: Contractor submittals, Construction Drawings, Record Drawings, Specifications, shop drawings, construction quality control and quality assurance plans, health and safety plans, and project schedules.

Record Drawings: Drawings recording the constructed dimensions, details, and coordinates of the project. Also referred to as "as-builts."

SSPWC: Standard Specifications for Public Works Construction.

Testing: Verification that an item meets specified requirements by subjecting that item to a set of physical, chemical, environmental, or operating conditions.

Testing Laboratory: A laboratory capable of conducting the tests required by this CQA Plan and the Specifications.

2. GENERAL REQUIREMENTS

2.1 Meetings

In order to facilitate construction and to clearly define construction goals and activities, close coordination between the Owner, Design Engineer, CQA Consultant, and Contractor is essential. To meet this objective, pre-construction and progress meetings will be held.

2.1.1 Pre-Construction Meeting

Following the bid award, a pre-construction meeting will be held at the site. Attendees at this meeting will include the Owner, Contractor, Design Engineer, CQA Consultant, agencies, and others designated by the Owner. The primary purposes of the pre-construction meeting will be to:

- Review the Plans, Specifications, this CQA Plan, work area security, health and safety procedures, and related issues.
- Provide all parties with relevant project documents.
- Review responsibilities and qualifications of each party.
- Define lines of communication and authority.
- Establish reporting and documenting procedures.
- Review procedures for handling submittals.
- Review testing equipment and procedures.
- Review procedures for field directives and change orders.
- Establish testing protocols and procedures for correcting and documenting construction or non-conformance.
- Establish the weekly meeting schedule.
- Discuss work areas, stockpile areas, lay down areas, access roads, haul roads, and related items.
- Review the project schedule and critical path items.
- Review the Contractor's work plan.

The pre-construction meeting will be documented by the CQA Manager. Copies of the minutes and other pertinent material will be prepared and provided to the relevant parties.

2.1.2 Progress Meetings

Informal progress meetings will be held each morning before the start of work. At a minimum, these meetings will be attended by the CQA Monitor and Contractor. The purpose of these meetings will be to:

- Discuss problems and resolutions.
- Review test data.
- Discuss the Contractor's personnel and equipment assignments for the day.
- Review the previous day's activities and accomplishments.
- Resolve any outstanding problems or disputes.

2.1.3 Weekly Meetings

Throughout the duration of construction, scheduled weekly meetings will be held. The Project Manager, Construction Manager, CQA Manager, and Contractor will be present. These meetings will be held to discuss progress, problems, construction schedule, changes, test data, health and safety, environmental issues, and any other issues necessary. The Project Manager will prepare the agenda for each meeting and prepare meeting minutes for distribution to the relevant parties.

2.1.4 Other Meetings

As required, other meetings may be held to plan work items and/or to discuss problems or non-conformance. These meetings will be attended by parties as directed by the Owner. If the problem requires a design modification and subsequent change order, the Engineer and Project Manager should be present. These meetings will be documented as directed by the Project Manager.

2.2 Responsibilities of Construction Quality Assurance Staff

2.2.1 Communications with the Contractor

Only the individuals assigned to this project, as defined in this document, can communicate with the Contractor. Communications of an official nature must be clear, direct, and professional. When written communications are required, they must be documented on the appropriate forms. Formal letters to the Contractor should normally be signed by the CQA Manager and reviewed by the Owner.

2.2.2 Communications with the Owner

Only those individuals assigned to this project, as defined in this document, can communicate with representatives of the Owner. All communications must be through proper channels as defined during the project's pre-construction meeting. Communications of an official nature must be written, clear, direct, and professional.

2.2.3 Responsibilities of the CQA Manager

The CQA Manager administers the CQA program. CQA procedures and reports must be reviewed by the CQA Manager for compliance with this CQA Plan. The CQA Manager acts as an auditor to

monitor and document the proper and complete implementation of the CQA program. The CQA Manager has authority to identify deficiencies and implement corrective action to the CQA program. The CQA Manager collects, distributes, and addresses the disposition of Contractor submittals approved by the Design Engineer. The CQA Manager coordinates testing with independent testing laboratories and maintains the Record Drawings. The CQA Manager reports directly to the Construction Manager. The CQA Manager will aid in preparing the Final CQA Report for the project under the direction of the CQA Officer.

2.2.4 Responsibilities of the CQA Officer

The CQA Officer is responsible for documenting and certifying to the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB) that the construction was performed in accordance with the intent of the design and the Contract Documents. The CQA Officer may also be the CQA Manager.

2.2.5 Responsibilities of the Design Engineer

The Design Engineer is responsible for site engineering services related to the project's design. Those services include reviewing Contractor submittals, resolving technical issues related to construction, providing interpretation of the Plans and Specifications, and approving substantial design modifications and technical revisions.

2.2.6 Responsibilities of the CQA Monitors

The CQA Monitors implement the CQA program under the direction of the CQA Manager. The CQA Monitors perform the construction monitoring and construction materials testing. The CQA Monitors maintain the documentation and test data summaries related to construction monitoring and construction materials testing. The CQA Monitors report directly to the CQA Manager.

2.3 Control of Documents, Records, and Forms

2.3.1 Project Control of Contract Documents

The Contract Documents, including the Specifications, Plans, and change orders, are controlled by the Construction Manager. The Construction Manager maintains one or more copies of the most current set of Contract Documents for use by the CQA Consultant. Upon issuance of new copies or revisions, it is the responsibility of the Construction Manager to notify the Contractor of the revisions, provide revised Contract Documents, and order the recall of superseded copies of the Contract Documents. The Construction Manager also provides the latest revised set of Contract Documents to the CQA Consultant.

2.3.2 Project Control of As-Built Information

As-built information generated by the Contractor and CQA Consultant is controlled by the CQA Manager. During the progress of the work, the CQA Manager obtains as-built information provided from the CQA Monitors, Contractor, surveyors, or others and compiles the as-built data into one set of drawings. The as-built drawing set must be maintained on site and be clearly marked as "Record Drawings."

2.3.3 Project Control of Forms

Daily report forms, test report forms, and other project forms are controlled by the CQA Manager, who maintains a master of each form for copies. Upon issuance of a new form, the CQA Manager must recall and remove all superseded copies along with the master, notify the CQA Monitors, and provide new copies for their use.

2.3.4 Processing Daily Reports

The CQA Monitors write a daily record of work progress. These daily reports are reviewed by the CQA Manager for legibility, clarity, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Daily reports are submitted to the Construction Manager on a daily basis and are maintained at the site. A weekly summary construction report will be prepared by the CQA Manager and submitted on a weekly basis to the Construction Manager.

2.3.5 Processing Test Reports

A test report must be completed by the CQA Monitors whenever testing is performed. The test reports must be reviewed by the CQA Manager. The review includes a check for mathematical accuracy, conformance to test requirements, conformance to the Specifications, and for clarity, legibility, traceability, and completeness. The review must be evidenced by a signature of the reviewer. Test reports (or summaries) from independent testing laboratories will also be transmitted to the CQA Manager for review.

2.3.6 Processing Project Records

Project records are completed as needed. Use of the project records is limited to the scope for which they are intended. The record must be completed by filling in all of the blanks provided on the form, followed by the signature of the individual completing the form. All project records must be maintained at the site.

2.4 Documentation and Control of Non-Conformance

2.4.1 Observation of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Manager and CQA Monitors should first notify the Contractor's foreman/superintendent supervising the work in question. The CQA Manager should then notify the Construction Manager.

2.4.2 Determining Extent of Non-Conformance

Whenever a non-conformance is discovered or observed in the construction process, product, job-related materials, documentation, or elsewhere, the CQA Consultant will determine the extent of the non-conformance. The extent of the deficiency may be determined by additional sampling, testing, observations, review of records, or any other means deemed appropriate.

2.4.3 Documenting Non-Conformance

All non-conformance must be documented in writing on the daily records, logs, and elsewhere, as appropriate. This documentation must occur immediately upon determining the extent of the non-

conformance. For a non-conformance that is considered serious or complex in nature, or which requires an engineering evaluation, a Non-Conformance Report will be prepared and issued to the Construction Manager and Contractor.

2.4.4 Corrective Measures

For a straightforward or routine non-conformance, corrective measures will be determined by direction from the Specifications. If no direction exists in the Specifications, the Construction Manager, CQA Manager, and Contractor will discuss construction methods to correct the deficiency. For Non-Conformance Reports that require an engineering evaluation, the Design Engineer must determine corrective measures. A copy of the Non-Conformance Report, with the Design Engineer's corrective measure determination, will be forwarded to the Construction Manager, CQA Manager, and Contractor for implementation of the corrective action.

2.4.5 Verification of Corrective Measures

Upon notification by the Contractor that a corrective measure is complete, the CQA Manager will verify its completion. The verification must be accomplished by observations or re-testing and documented photographically. Written documentation of the corrective measures must be made by the CQA Manager on daily reports, logs, forms, and, if applicable, the Non-Conformance Report. Verification of corrective measures will be reviewed by the Construction Manager. Corrective action measures that require an engineering evaluation will be reviewed and verified by the Design Engineer.

2.5 Construction Monitoring

2.5.1 Monitoring Priorities

Before commencement of construction, the CQA Manager will establish a list of monitoring priorities. This list will include the various construction activities and the monitoring priority of those activities. The monitoring priorities may change during construction, based upon the Contractor's performance and/or the Owner's request. Changes in the monitoring priorities must be approved by the CQA Manager.

2.5.2 Discrepancies

CQA testing must be conducted in accordance with this CQA Plan. However, discrepancies that occur between this document and other construction documents must be resolved. The document that requires the most frequent tests or more stringent requirements will govern, unless otherwise specified by the Design Engineer and/or CQA Manager.

2.6 Materials Quality Verification

2.6.1 General

Material sources will be identified and samples tested to determine if the material meets the requirements of the Specifications. Definitions and requirements of materials are provided in the Specifications. Test samples will be obtained in accordance with applicable ASTM and GRI standards. Archive samples and test results of the test samples will be maintained and stored at the project site. The CQA Monitors will establish and maintain a materials quality verification list. This

list will include material sources, sample locations, testing requirements, test results, and verification action items.

2.6.2 Material Submittals

Material submittals may be used by the CQA Consultant to establish the acceptability of materials. When material sample submittals are required, they will be made available to the CQA Consultant by the Contractor. Acceptance and proper review of material submittals are the responsibility of the CQA Manager.

2.6.3 Certificates of Compliance and Conformance

Certificates of compliance and conformance may be used by the CQA Manager to establish the acceptability of materials. These certificates generally state that the material is in compliance or conformance with a particular code, standard, or specification. These certificates may be used for acceptance of a product before or in lieu of testing, if allowed by the Specifications.

2.7 Equipment Control

2.7.1 Equipment List

Before the start of construction, the CQA Manager will complete a list of all measuring, sampling, and testing equipment being used at the site. As new equipment becomes available during the course of the project, it must be added to the list. When more than one type of equipment is available, a unique number will be affixed to each piece to maintain identity. The equipment list will be maintained in the project files and contains the following information:

- Type of equipment;
- Serial number or identifying number;
- Date item received at site;
- Use of the equipment; and
- Date removed from service.

2.7.2 Calibration of Equipment and Materials

Before placing a piece of testing equipment into service, its accuracy must be established and calibrated by the CQA Manager or CQA Monitor. Types of equipment requiring calibration include: nuclear gauges, sand cone devices, sand to be used in sand cones, and scales. The calibration procedures and frequencies must be per the equipment manufacturer's instructions or ASTM standards. Whenever the equipment is suspect or is producing questionable results, it must be removed from service immediately and re-calibrated.

3. CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

3.1 General

This section describes CQA procedures for earthwork operations. The scope of earthwork and related CQA includes the following elements:

- Clearing, Grubbing, and Stripping;
- Stockpiling and Soil Management;
- Excavation;
- Structural Fill/Foundation Layer;
- Subgrade Preparation;
- Vegetative Cover Soil; and
- Trench Excavation and Backfill.

3.2 Earthwork Construction Testing

3.2.1 Test Standards

The latest editions of the following test standards apply as called out in this document or the Specifications:

Standard	Test Description
ASTM D422	Standard Test Method for Particle Size Analysis of Soils
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
ASTM D1557	Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D1587	Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils
ASTM D2216	Standard Test Method of Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D5084	Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3.2.2 Test Frequencies

Tables 3-1 and 3-2 establish the test frequencies for earthwork CQA. The test frequencies listed establish a minimum number of required tests. Extra testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Extra testing may also be performed to provide additional data for engineering evaluation. Any re-tests performed as a result of a failing test do not contribute to the total number of tests performed in satisfying the minimum test frequency.

The Final CQA Report shall include tables similar to Tables 3-1 and 3-2 that document compliance with the testing frequencies and that document test results that comply with the Specifications.

TABLE 3-1
STRUCTURAL FILL AND FOUNDATION LAYER CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency (Structural Fill and Foundation Layer)	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
Sieve Analysis	D422	1 Per 30,000 CY or Each Material Type	-
Atterberg Limits	D4318	1 Per 30,000 CY or Each Material Type	-
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests
Test Pit to Confirm Cover Thickness (for existing Interim Cover Only)	-	1 per 100,000 SF	-
Hydraulic Conductivity (Foundation Layer Only)[4]	D5084	1 per 100,000 SF	-

Notes to Table 3-1:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.
4. Hydraulic conductivity tests shall be conducted on relatively undisturbed samples obtained using a thin-walled sampler (i.e., Shelby tube) with a minimum diameter of 3 inches.

TABLE 3-2
VEGETATIVE COVER SOIL CONFORMANCE TESTING FREQUENCIES

ASTM Test Method	ASTM Designation	Frequency	Frequency (Bench Fill/Trench)
Prior to Placement:			
Moisture-Density Relationship[1]	D1557	1 Per 10,000 CY or Each Material Type (minimum of 2)	1 Per Material Type
During / After Placement:			
Nuclear Water Content and Density[2]	D6938	1 Per 1,000 CY Per 1.5 Vertical Feet	1 Per Lift Per 200 Linear Feet
Sand Cone Test or Drive Cylinder Test[3]	D1556 D2937	1 Per 20 Nuclear Density Tests	1 Per 10 Nuclear Density Tests

Notes to Table 3-2:

1. Perform a Check Point (one point selected at near optimum and compared to the ASTM D1557 curve) at least once for every 10,000 cubic yards of material placed.
2. Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to ensure testing for each lift of soil placed.
3. Drive cylinder tests may be performed on clay or silt samples only.

3.2.3 Soil Sample Numbering

The CQA Monitor will maintain soil sample numbers in a master log to be maintained at the site. Sample numbers will begin at 001 and proceed upward. No sample number can be repeated and re-tests of a failing sample will be given the original number with a letter suffix (i.e., re-tests for a failing sample 021 would be: 021A, 021B, etc.). Information contained in the master log of test samples will include:

- Sample number;
- Test(s) to be performed;
- Dated sampled;
- CQA Monitor obtaining sample;
- Location sampled;
- Location of testing (on-site vs. off-site);
- Date sample sent off-site;
- Date test results received;
- Site testing CQA Monitor;
- Date testing completed at site; and

- Test results and remarks.

3.2.4 Soil Sample Tagging

The CQA Monitor is responsible for maintaining sample identification for all soil samples while on site, from the time of sampling through the completion of testing. The CQA Monitor must place a sample tag on the soil sample container immediately upon sampling. This tag must remain with the soil sample throughout processing. The tag will contain the following information:

- Sample number;
- Material type;
- Project name and project number;
- Sampling CQA Monitor;
- Date sampled; and
- Test(s) to be performed.

3.2.5 Soil Sample Processing

The CQA Monitor is responsible for the timely processing of soil test samples. The CQA Manager will determine which samples are tested on-site and which are tested off-site. This determination will be made based on available manpower, available equipment, complexity of testing, and the desired turnaround time for results. For expediency, samples to be tested off-site should be shipped the same day they are collected.

3.3 Field Density Tests

3.3.1 Test Numbering

The CQA Monitor is responsible for maintaining test numbers and results for field density tests performed using the nuclear gauge (ASTM D6938), sand cone (ASTM D1556), and drive cylinder (ASTM D2937). All other testing is identified through the sample number (Section 3.2.3). The CQA Monitor will maintain field books that identify soil segments, test data, the CQA Monitor performing the test, and the sequential test number. Each soil segment will have a unique series of numbers. No test number can be repeated for a given soil segment, and re-tests of failing tests must be given a letter suffix along with the original test number (i.e., re-tests for a failing test 1201 would be: 1201A, 1201B, etc.). Test data and results must be filled out on the field density test form.

3.3.2 Test Locations

The intent of the CQA program is to provide confidence that the earthwork materials and work conform to the requirements of the Specifications. To meet this intent, the CQA Monitor will perform density tests of earthfills during construction. Density tests must be located at various elevations and uniformly dispersed throughout the entire plan dimensions of the fill. Density test locations must be chosen without bias; however, additional testing can be performed in any areas that are suspect, marginal, or appear to be of poor quality. During the progress of the work, density test

locations will be plotted on a drawing by the CQA Monitor to document that no significant areas are left untested. This drawing will be included in the Final CQA Report.

3.4 Monitoring and Testing Requirements

Earthwork components of the construction are summarized in Section 3.1. Each component has specific construction requirements that must be monitored. The following sections list monitoring requirements for each type of earthwork.

3.4.1 Clearing, Grubbing, and Stripping

- Document that erosion and sediment control silt fences, straw bale barriers, and other measures are securely in place prior to initiating clearing, grubbing, and stripping operations in any area.
- Document that existing plant life designated to remain is protected against damage during construction.
- Document that clearing and stripping in areas required for site access and execution of the work is complete.
- Document that vegetation, roots, and highly organic soil within the work area are removed to the appropriate extent.

3.4.2 Stockpiling and Soil Management

- Review the Contractor's approved work plan submittal. Verify stockpile locations, stockpile dimensions, haul routes, material segregation procedures, and erosion, sediment, and drainage control measures. Determine and note corrective action items, if applicable.
- Document that stockpile locations have been cleared, grubbed, and stripped in accordance with Section 3.4.1 of this CQA Plan and the Specifications.
- Document that stockpile subgrades are surveyed prior to stockpiling.

The CQA Monitor will maintain a separate soil test data summary sheet for the specific purpose of soil classification of stockpiled materials.

- During excavation, hauling, and stockpiling operations, continually identify and verify material classifications in general accordance with ASTM D2487 (Unified Soil Classification System) and ASTM D2488 as necessary to characterize material stockpile designations.
- Observe that stockpiles are constructed with slopes no greater than 2H:1V (horizontal:vertical) and that the top surface maintains a minimum 5 percent grade. The Contractor shall include 15-foot-wide drainage benches every 50 vertical feet on all stockpiles.

3.4.3 Excavation

- Document that construction staking is performed before work and that survey bench marks with elevations are secured outside the work area.
- If applicable, document that the Contractor has notified Underground Service Alert to identify and locate underground utilities.
- Document that excavated materials are segregated into proper stockpiles.
- Coordinate with the Contractor to perform excavation verification surveys upon completion of excavating operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine limits of excavation for measurement and payment applications. Submit a copy of verification surveys to the Construction Manager.
- Document that unsuitable materials are removed from areas that will receive earthfill. Unsuitable materials include uncertified existing fills, disturbed soils, weak/highly compressible soils, and deleterious materials.

3.4.4 Structural Fill/Foundation Layer

- Monitor that subgrade for placement of soil is consistent with the Specifications.
- Monitor that construction staking is performed before the beginning of the work and that survey bench marks with elevations are secured outside the work area.
- Perform visual and manual soil classifications (ASTM D2488) to verify that the material source is suitable for structural fill. Verify that the material is free of organic and oversized materials and perform classifications continually during excavation of borrow materials.
- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content for structural fill/foundation layer materials. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that structural fill materials are placed in loose lifts not exceeding 8-inches thick and are then properly compacted.
- Perform nuclear density-moisture tests (ASTM D6938) to document that each lift is compacted to the appropriate relative compaction, as stipulated in the Specifications. Perform tests at the testing frequencies specified in Table 3-1.
- Monitor that soil materials are kept within the specified moisture content range listed in the Specifications. Monitor that soil materials that are wet and over the optimum moisture content (as determined by ASTM D1557) are properly aerated and processed to bring the moisture content of the material into the acceptable range. Monitor that soils that are dry and below the optimum moisture content (as determined by ASTM D1557) are properly moisture conditioned and processed to bring the moisture content into the acceptable range.

- Monitor that desiccated structural fills are properly repaired or removed before placing subsequent lifts.

- Monitor that final structural fill/foundation layer surfaces are free of ruts, gouges, and other features that might contribute to erosion and sediment run-off.

- During fill operations, field-verify lines, grades, and dimensions using hand-held levels, range poles, and measuring tapes.

- Coordinate with the Contractor to perform verification surveys at the completion of structural fill/foundation layer operations. Verify corrective action measures as determined by verification surveys. Verification surveys will also be used to determine the limits of structural fill/foundation layer for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.5 Geosynthetics Subgrade Preparation

- Monitor that the subgrade is free of organic and oversized materials and meets the requirements of the Specifications.

- Monitor that grade control construction staking is performed prior to the work.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of subgrade materials.

- Monitor that angular or sharp rocks, rocks that protrude more than 0.5 inches, and other debris that could damage the overlying geomembrane are removed from the surface of the subgrade. Verify that the subgrade is free of irregularities and is steel drum rolled smooth prior to geomembrane placement.

- Monitor that the final surface provides continuous and intimate contact with the overlying geomembrane.

- Coordinate with the Contractor to perform subgrade verification surveys upon completion of the subgrade preparation. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the subgrade preparation for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.6 Vegetative Cover Soil

- Monitor that the material source is suitable for the vegetative cover soil layer and is free of organic or other deleterious materials and free of over-sized particles as described in the Specifications.

- Monitor that grade control construction staking is performed before the work.

- Verify that the vegetative cover soil is placed in a manner that does not damage the underlying geosynthetic layers.

- Coordinate with the Contractor to perform vegetative cover soil verification surveys upon completion of placement operations. Verify corrective action measures as determined by the verification surveys. Verification surveys will also be used to determine the limits of the vegetative cover soil for measurement and payment applications. Submit copies of verification surveys to the Construction Manager.

3.4.7 Trenching and Backfilling

- Monitor that construction staking is performed before the work and that survey bench marks with elevations are secured outside the work area.

- Monitor that trenches are excavated in accordance with the dimensional cross-sections and design elevations shown on the Plans.

- Monitor profile surveys conducted by the Contractor during trenching operations.

- Perform moisture-density relationship testing (ASTM D1557) to determine the maximum dry density and optimum moisture content of soil materials that will be used as backfill.

- Perform nuclear density-moisture tests (ASTM D6938) to verify that backfill materials are moisture conditioned and compacted in accordance with the Specifications.

4. CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

4.1 General

The objectives of the geosynthetics CQA program are to assure that: (i) proper construction techniques and procedures are used, and (ii) the project is completed in accordance with the Plans and Specifications. The intents of the CQA program are to: (i) identify and define problems that may occur during construction, and (ii) document that these problems are corrected before construction is complete.

This section describes CQA procedures for the installation of geosynthetic components. The following geosynthetics will be utilized for this project:

- Non-woven geotextile; and
- 40-mil HDPE geomembrane (textured on both sides).

CQA for the geosynthetics installations will be performed to monitor that geosynthetics are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Manager will: (i) review the Contractor's quality control submittals; (ii) perform material conformance testing; (iii) monitor construction testing; and (iv) monitor installations. Conformance testing refers to activities that take place before geosynthetics installation. Construction testing includes activities that occur during geosynthetics installation.

The CQA testing will be conducted in accordance with this CQA Plan and the project's Plans and Specifications. If a discrepancy exists in the testing requirements, the document that requires the most stringent testing will govern.

4.2 Geomembrane

4.2.1 Delivery, Storage, and Handling

Upon delivery of geomembrane, the CQA Monitor will:

- Observe geomembrane rolls for damage during shipping and handling, identify and mark any damaged materials, and document that damaged materials are set aside.
- Observe that the geomembrane is stored in accordance with the Specifications and is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, direct sunlight, and other damage.
- Document that all manufacturing documentation required by the Specifications has been received.
- Complete the geosynthetics inventory form for all geomembrane materials received.

Damaged geomembrane may be rejected. If rejected, document that material is removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper documentation from the manufacturer must be stored at a separate location until all documentation has been received, reviewed, and accepted.

4.2.2 Conformance Testing

Geomembrane Material Tests. Geomembrane samples will be obtained for conformance testing in accordance with Table 4-1. The material will be sampled at the site by the CQA Monitor or at the manufacturing plant under the direction of the CQA Consultant. The samples will be forwarded to an independent testing laboratory for the following conformance tests:

TABLE 4-1
HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency[6]
Thickness (min. avg.)	ASTM D5994	1 per 250,000 sf
Asperity Height (min. avg.)[1]	GRI GM 12	1 per 250,000 sf
Melt Flow Index	ASTM 1238	1 per 250,000 sf
Sheet Density (min avg.)	ASTM D792 or ASTM D1505	1 per 250,000 sf
Tensile Properties[2] (min. avg.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	1 per 250,000 sf
Puncture Resistance (min. avg.)	ASTM D4833	1 per 250,000 sf
Carbon Black Content (range)	ASTM D1603[3]	1 per 250,000 sf
Carbon Black Dispersion[4]	ASTM D2663 ASTM D5596	1 per 250,000 sf
Interface Shear Strength[5] • cover soil / geotextile • geotextile / geomembrane • geomembrane / foundation layer	ASTM D6243	1 per project

Notes to Table 4-1:
(1) Alternate the measurement side for double sided textured sheets.
(2) Machine direction (MD) and cross machine direction (XMD) average values shall be on the basis of 5 test specimens in each direction:
- Yield elongation is calculated using a gage length of 1.3 inches.
- Break elongation is calculated using a gage length of 2.0 inches.

(3) Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views.
(5) Interface shear strength tests shall be tested at normal loads of 200; 500; 1,000; and 2,000 pounds per square foot. Results of the testing shall be forwarded to the Engineer for review and approval. Test reports shall include peak and large-displacement (2.5 inches) shear stress values.
(6) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-1 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be taken across the entire roll width. Samples may be cut for shipping purposes, but a minimum of five square feet must be sent to the testing laboratory. Samplers must mark the machine direction and the manufacturer's roll identification number on the sample (each piece). Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.2.3 Geomembrane Installation

Surface Preparation. The soil surface must be prepared in accordance with the Specifications. Before geomembrane installation, the subgrade will be inspected by the CQA Monitor and Geosynthetics Contractor. The CQA Monitor must check the following:

- All lines and grades for the soil surface have been verified by the Contractor.
- The soil surface has been rolled/compacted and is free of surface irregularities, loose soil, and protrusions.
- The soil surface is firm and does not contain stones or other objects that could damage the geomembrane.
- The anchor trench dimensions have been checked and the trenches are free of sharp objects and stones.
- There are no excessively soft areas.
- The soil surface is not saturated and no standing water is present.
- The soil surface is not desiccated.
- All construction stakes, if utilized, have been removed and accounted for and there is no debris, rocks, or any other objects in or on the soil surface.
- The Geosynthetics Contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Before installing any of the geomembrane, the Geosynthetics Contractor must submit drawings in accordance with the Specifications. These drawings will show the proposed layout of the panels, including panel identification numbers, field seams, and any other details that do not conform to the Plans.

The CQA Monitor will maintain an up to date panel layout drawing that shows the following: (i) roll numbers; (ii) panel numbers; (iii) seam numbers; (iv) test locations; (v) repair locations; and, (vi) non-destructive testing information.

During panel placement operations, the CQA Monitor will:

- Record panel numbers and dimensions on the panel/seam log.
- Observe the panel surface as it is deployed and record all panel defects and defect corrective actions (panel rejected, patch installed, extrudate placed over the defect, etc.)

on the repair sheet. Verify that corrective actions are made in accordance with the Specifications.

- Monitor that equipment used during deployment operations does not damage the geomembrane. Verify that equipment used on the geomembrane does not leak hydrocarbons onto the geomembrane or that corrective measures are taken to prevent leakage.

- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance. Verify that no stones, construction debris, or other items are beneath the geomembrane that could damage the geomembrane.

- Monitor that the geomembrane is not dragged across an unprotected surface. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, if necessary.

- Record weather conditions including temperature, wind speed and direction, and humidity. Verify that the geomembrane is not deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, verify that the geomembrane is not placed when the air temperature is less than 40° F or when standing water or frost is on the ground.

- Monitor that crews working on the geomembrane do not smoke, do not wear shoes that could damage the liner, and do not engage in activities that could damage the geomembrane.

- Monitor that methods used to deploy the geomembrane minimize wrinkles and that panels are anchored to prevent movement by the wind. Verify that the Geosynthetics Contractor corrects any damage resulting to or from windblown geomembrane.

- Monitor that no more panels are deployed than can be seamed on the same day.

- The CQA Monitor must inform both the Geosynthetics Contractor and the CQA Manager if any of the above conditions are not met.

Field Seaming. Before the start of geomembrane welding and during welding operations, each welder and welding apparatus will be tested in accordance with the Specifications to verify that the equipment is functioning properly. One trial weld will be taken before the start of work and one at mid-shift. The trial weld sample will be at least 42-inches-long and 12-inches-wide, with the seam centered lengthwise. The CQA Monitor will observe all welding operations and verify that the Geosynthetics Contractor quantitatively tests each trial weld for peel adhesion and bonded seam strength (ASTM D6392). (Peel adhesion tests will be referred to as "peel" and bonded seam strength tests will be referred to as "shear" in this document.) The main purposes of the trial weld tests are to evaluate seam strength and to confirm that each welding machine is working properly. Shear tests measure the continuity of tensile strength through the seam and into the parent material. Peel tests measure the strength of the bond created by the welding process.

The results of the peel and shear tests on trial welds will be recorded on the trial weld form. Trial welds must be completed under conditions similar to those under which the panels will be welded. Trial welds must meet specified requirements for peel and shear and the failure must be ductile or a film tearing bond (FTB) for a wedge weld. An FTB failure occurs when the test specimen breaks at

the edge of the outside of the seam but not within that seam. If at any time the CQA Monitor believes that a welding machine is not functioning properly, a trial weld by that machine must be performed and tested. If there are wide changes in temperature (> 30° F), humidity, or wind speed, another trial weld must be performed and tested. The trial weld must be allowed to cool to ambient temperature before it is tested.

During geomembrane welding operations, the CQA Monitor will:

- Monitor that the Geosynthetics Contractor has an appropriate number of welding machines and spare parts necessary to perform the work.
- Monitor that equipment used for welding will not damage the geomembrane.
- Monitor that extrusion welders are purged before beginning a weld so that all heat-degraded extrudate is removed from the nozzle of the extrusion welder.
- Monitor that seam grinding is completed less than 1 hour before seam welding and that the upper sheet is beveled (extrusion welding only).
- Monitor that the ambient temperature measured 6-inches above the geomembrane surface is between 40° F and 110° F.
- Monitor that the ends of extrusion welds that are more than 5 minutes old are ground to expose new material before restarting a weld.
- Monitor that contact surfaces of the panels are clean and free of dust, grease, dirt, debris, and moisture before welding.
- Monitor that welds are free of dust, rocks, and other debris.
- Monitor that cross seams are ground to a smooth incline before welding (fusion welding only).
- Monitor that all seams are overlapped a minimum of 3 inches or in accordance with the manufacturer's recommendations, whichever is more stringent.
- Monitor that solvents or adhesives are not present in the seam area.
- Monitor that procedures used to temporarily hold the panels together do not damage the panels and do not preclude CQA testing.
- Monitor that strips of geomembrane, wide enough and long enough to protect the hot wedge welder from running on the subgrade, are placed below the geomembrane. These strips may be as long as the seam itself or shorter and moved with the seaming equipment. If necessary, a firm material such as a flat board or similar hard surface may be placed directly under the weld overlap to achieve firm support.
- Monitor that panels are being welded in accordance with the Plans and Specifications.
- Monitor that there is no free moisture in the weld area.

- Measure surface temperature of the panels every 2 hours.

4.2.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive geomembrane seam testing is to detect discontinuities or holes in the seams. Nondestructive geomembrane seam tests include vacuum box and air pressure testing. Nondestructive testing must be performed over the entire length of each seam.

It is the Geosynthetics Contractor's responsibility to perform all nondestructive testing as part of their quality control (QC) program. The CQA Monitor's responsibility is to observe and document that the Geosynthetics Contractor's QC testing is in compliance with the Specifications and to document seam defects and repairs.

Nondestructive seam testing procedures are described below:

- For welds tested by the vacuum box method, the weld is placed under suction utilizing a vacuum box constructed with rigid sides, a transparent top for viewing the seams, a neoprene rubber gasket attached to the bottom of the rigid sides, a vacuum gauge on the inside, and a valve assembly attached to a vacuum hose connection. The box is placed over a seam section which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom of the box must fit snugly against the soaped seam section of the panel to ensure a leak-tight seal.

- A vacuum pump is energized and the vacuum box pressure reduced to approximately 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than 10 seconds.

- Air pressure testing is used to test double wedge seams that have an enclosed air channel between them. Both ends of the air channel must be sealed. A pressure feed device, usually a hollow needle equipped with a pressure gauge, is inserted into one end of the channel. Air is then pumped into the channel to a minimum pressure of 25 to 30 psi. The air channel must sustain this pressure for 5 minutes without losing more than 2 psi. Following the 5-minute hold time, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if it does not return to zero a blockage is likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive seam testing, the CQA Monitor will:

- Review the Specifications regarding test procedures.

- Monitor that equipment operators are fully trained and qualified to perform their work.

- Monitor that test equipment meets the Specifications.

- Monitor that the entire length of each seam is tested in accordance with the Specifications.

- Observe testing and record results on the panel/seam log and the panel layout drawing.

- Identify any failed areas by marking the area with a waterproof marker compatible with the geomembrane, inform the Geosynthetics Contractor of any required repairs, and record the repair on the panel/seam log.

- Monitor that all repairs are completed and tested in accordance with the Specifications.

- Record all completed and tested repairs on a repair sheet and the panel layout drawing.

Destructive Seam Sampling Procedures and Field Testing. Destructive seam samples will be taken at intervals of at least one per 500 linear feet of geomembrane seam. However, additional samples will be taken if the CQA Monitor suspects that a seam does not meet the Specification's requirements. Reasons for taking additional samples may include, but are not limited to:

1. Wrinkling in the seam area.
2. Excess crystallinity.
3. Suspect seaming equipment or techniques.
4. Weld contamination.
5. Insufficient overlap.
6. Adverse weather conditions.
7. Failing tests.

The CQA Monitor will select the locations from where seam samples will be cut for destructive laboratory testing as follows:

- A minimum of one test per 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals. The testing frequency will be increased if welding operations are conducted in temperatures below 40° F. This increase will be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor.

- A maximum frequency must be agreed to by the Construction Manager, CQA Manager, and Geosynthetics Contractor at the pre-construction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the CQA Manager. Samples taken as the result of failed tests do not count toward the total number of required tests.

The CQA Monitor will not inform the Geosynthetics Contractor in advance of selecting the destructive sample locations.

The Geosynthetics Contractor will remove the destructive samples at locations identified by the CQA Monitor and field test the specimens for peel and shear before the samples are shipped off-site for laboratory testing. During sampling procedures the CQA Monitor will:

- Observe sample cutting.

- Mark each specimen and sample with an identifying number which contains the seam number, destructive sample test number, welder, and date and time welded.

- Record sample locations on the panel layout drawing and panel-seam logs.

- Record the sample locations, weather conditions, and reasons samples were taken (e.g., random sample, visual appearance, result of a previous failure, etc.) in the destructive seam test form.

At each location, obtain two seam specimens that are 44-inches apart. The specimens should be 1-inch wide and 12-inches long with the weld centered across the length of the specimen. The Geosynthetics Contractor must test these samples to failure in the field using a tensiometer capable of quantitatively measuring shear and peel strengths. For double wedge welding, the Geosynthetics Contractor must test both welds. The CQA Monitor will observe the tests. Geomembrane seam specimens pass when the break is a ductile FTB and the seam strength meets the specified values.

If one or both of the 1-inch specimens fails in either peel or shear, the Geosynthetics Contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations; or (2) take another test sample 10 feet from the point of the failed test and repeat this procedure. If the second test passes, the Geosynthetics Contractor can either reconstruct or cap strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly and that appropriate corrective action must be taken immediately.

Once the field test specimens have passed, a sample must be recovered for laboratory testing from between the passing field specimen locations. The sample must be 42-inches long and 12-inches wide, with the weld centered along the length of the sample. The sample must be divided into three sections: one 12-inch by 12-inch section for the Geosynthetics Contractor, one 12-inch by 18-inch section for laboratory testing, and one 12-inch by 12-inch section for the Owner to archive. Record the results of field testing on the destructive seam test form and the panel/seam log.

Third Party Laboratory Testing. The CQA destructive seam samples can be shipped to the testing laboratory to verify seam quality. The laboratory will test five specimens from each sample in both shear and peel modes of failure. Minimum required test values are presented in the Specifications. The testing laboratory must provide verbal test results within 24 hours to the CQA Manager and written certified test results within 5 days.

The CQA Manager must immediately notify the Construction Manager and Geosynthetics Contractor in the event of failed seam test results.

If a laboratory test fails in either peel or shear, the Geosynthetics Contractor must either reconstruct the entire seam or recover additional samples at least 10 feet on either side of the failed sample for retesting. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

4.2.5 Repairs

Portions of geomembrane panels and seams that contain: (1) a flaw; (2) a destructive test; or (3) nondestructive test cuts or holes must be repaired in accordance with the Specifications. The CQA Monitor must locate and record all repairs on the repair sheet and panel layout drawing. Acceptable repair techniques include the following:

- Patching: used to repair large holes, tears, large panel defects, undispersed raw materials, welds, contamination by foreign matter, and destructive sample locations.

- Extrusion: used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 2-inches in the largest dimension.

- Capping: used to repair failed welds or to cover seams where welds cannot be nondestructively tested.

- Removal: used to replace areas with large defects where preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal shall be patched or capped.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than 1 hour before the repair.

- Clean and dry all surfaces at the time of repair.

- Monitor acceptance of the repair procedures, materials, and techniques by the CQA Monitor in advance of the specific repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches before extrusion welding.

4.2.6 Folded Material

Geomembrane with excessive folding (i.e., creased), as determined by the CQA Consultant, must be removed.

4.2.7 Geomembrane Anchor Trench

The geomembrane anchor trench should be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the liner placement. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

4.2.8 Geomembrane Acceptance

The Contractor retains all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Contractor is responsible for placing cover over the geomembrane, the Contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete and the cover material is placed. After panels are placed, seamed, tested successfully, and repairs made, the completed installation will be walked by the CQA Monitor and Contractor. Any damage or defects found during this inspection will be repaired by the Geosynthetics Contractor. The installation will not be accepted until it meets the requirements of both parties. In addition, the geomembrane will be recommended for acceptance by the CQA Manager only when the following have been completed:

- The installation is finished.

- All seams have been inspected and verified to be acceptable and all required laboratory and field tests have been completed and reviewed.
- All required Contractor-supplied documentation has been received and reviewed.
- All as-built drawings have been reviewed and verified by the CQA Manager to show the true panel dimensions, the locations of all seams, trenches, pipes, appurtenances, and destructive test locations.

4.2.9 Qualifications

Proper layout, seaming, and testing of the geomembrane requires skill and experience. As such, the integrity of the geomembrane is dependent upon the installers. In order to assure a minimum level of experience and expertise, the following experience standards have been established in the Specifications:

Manufacturer/Fabricator/Installer. The Specifications list the required qualifications for the geomembrane manufacturer / fabricator / installer companies. The CQA Manager must verify qualifications of the manufacturer, fabricator, and installer through review of Engineer-approved project submittals.

Installation Superintendent. The installation field superintendent must have been responsible for the completed installation of a minimum of 5,000,000 square feet of polyethylene geomembrane in the past 5 years utilizing the type of seaming techniques and apparatus proposed for use on this project. A resume with references and phone numbers of satisfactory installations is required. Any superintendent proposed for this project must be present whenever geomembrane is installed.

Master Seamer and Other Welders. The master seamer must have demonstrated expertise on previous geomembrane installations. The master seamer must have successfully welded a minimum of 1,000,000 square feet of polyethylene geomembrane within the past 3 years. A resume for this work, with references and phone numbers, is required. Other welders are required to have welded a minimum of 100,000 square feet of geomembrane within the past 3 years. Resumes for all welders, with references and phone numbers, are required. Personnel that have welded less than 100,000 square feet of geomembrane within the past 3 years will only be allowed to weld under the direct supervision of either the master seamer or the installation superintendent.

CQA Manager Qualifications. The CQA Manager must have provided CQA services on a minimum of 1,000,000 square feet of polyethylene installations or be level II certified in geosynthetics installations by National Institute for Certification in Engineering Technologies (NICET). The CQA Manager must provide verification of this experience by references in a current resume.

4.3 Geotextiles

4.3.1 Delivery, Storage, and Handling

During delivery of geotextiles the CQA Monitor will:

- Monitor that equipment used to unload the rolls does not damage the geotextile.
- Monitor that rolls are wrapped in impermeable and opaque protective covers.
- Monitor that care is used to unload the rolls.
- Monitor that all documentation required by the Specifications has been received.
- Monitor that each roll is marked or tagged with the following information: manufacturer's name; project identification; lot number; roll number; and roll dimensions. Log this information on the geosynthetic inventory form.
- Monitor that materials are stored in a location that will protect the rolls from ultraviolet light exposure, precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls may be rejected. Monitor that rejected material is removed from the site and stored at a location separate from accepted rolls. Geotextile rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

4.3.2 Conformance Testing

Geotextile Material Tests. The CQA Manager will arrange to obtain geotextile conformance test samples as indicated in Table 4-2. These samples will be sent to the testing laboratory for the following conformance tests:

TABLE 4-2
NON-WOVEN GEOTEXTILE CONFORMANCE TESTING FREQUENCIES

Property	Test Method	Conformance Test Frequency(1)
Mass/Unit Area (min. avg.)	ASTM D5261	1 per 250,000 sf
Apparent Opening Size (max.)	ASTM D4751	1 per project
Grab Strength (min. avg.)	ASTM D4632	1 per 250,000 sf
Permittivity (min.)	ASTM D4491	1 per project
Puncture Strength (min. avg.)	ASTM D4833	1 per 250,000 sf

Note to Table 4-2:
(1) Minimum testing frequency shall be one sample per lot.

The CQA Manager will review all conformance test results and report any non-conformance to the Construction Manager and Contractor.

The Final CQA Report shall include a table similar to Table 4-2 documenting compliance with the testing frequencies and results documenting compliance with the Specifications.

Sampling Procedure. Samples will be obtained across the entire roll width and will be 3-feet long. Samplers must mark the manufacturer's roll identification number and the machine direction on the sample. Samplers will also assign a conformance test number to the sample and mark the sample with that number.

4.3.3 Geotextile Installation

Surface Preparation. Before geotextile installation, the CQA Monitor will:

- Monitor that all lines and grades have been verified by the Contractor.
- Monitor that the subgrade has been prepared in accordance with the Specifications and that the geomembrane installation and all associated documentation has been completed.
- Monitor that soil or geomembrane surfaces do not contain stones that could damage the geotextile.
- Monitor that there are no excessively soft areas in soil surfaces that could damage the geotextile.

Geotextile Placement and Seaming. During geotextile placement and seaming operations, the CQA Monitor will:

- Observe the geotextile as it is deployed and record all defects and defect corrective actions (panel rejected, patch installed, etc.). Verify that corrective actions are performed in accordance with the Specifications.
- Monitor that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Monitor that crews working on the geotextile do not smoke, do not wear shoes that could damage the geotextile, and do not engage in activities that could damage the geotextile.
- Monitor that the geotextile is securely anchored in an anchor trench and is temporarily anchored to prevent movement by the wind.
- Monitor that adjacent panels are overlapped and seamed in accordance with the Specifications.
- Monitor that the geotextile is not exposed to direct sunlight for more than 5 days.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- The CQA Monitor must inform both the CQA Manager and Contractor if the above conditions are not met.

4.3.4 Repairs

Repair procedures include:

- Patching: used to repair large holes, tears, and small defective areas.
- Removal: used to replace large defective areas where the preceding method is not appropriate.

5. CONSTRUCTION QUALITY ASSURANCE FOR EROSION CONTROL

5.1 Introduction

This section describes CQA procedures for temporary and permanent erosion control installations.

CQA for the temporary and permanent erosion control measures will be performed to verify that the Contractor complies with the requirements of the project's Stormwater Pollution Prevention Plan (SWPPP) and that the permanent erosion control measures are installed in accordance with the design. Construction must be conducted in accordance with the Plans and Specifications. To monitor compliance, the CQA Consultant will: (1) review the Contractor's quality control submittals, and (2) monitor installations.

5.2 Construction Monitoring

5.2.1 Temporary Erosion Control

- Monitor that the Contractor implements temporary erosion control measures in compliance with the project's SWPPP.

5.2.2 Permanent Erosion Control Measures

Erosion Mats

- Review the Contractor's submittals for the erosion mats and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the erosion mats at the locations indicated on the Plans.
- Monitor that the Contractor installs the erosion mats prior to revegetation of the final cover.
- Monitor that the Contractor installs the erosion mats in accordance with the manufacturer's recommendations.

Straw Wattles

- Review the Contractor's submittals for the straw wattles and verify that the material complies with the manufacturer's recommendations and the Specifications.
- Monitor that the Contractor installs the straw wattles at the locations indicated on the Plans.
- Monitor that the Contractor installs the straw wattles prior to revegetation of the final cover.
- Monitor that the Contractor installs the straw wattles in accordance with the manufacturer's recommendations.

Revegetation

- Review the Contractor's submittals for the hydroseed mix design and straw mulch for compliance with the Specifications.
- Monitor that the Contractor evenly and uniformly distributes the hydroseed mixture over the final cover and that there are no bare spots.
- Monitor that the Contractor evenly and uniformly distributes the straw mulch in accordance with the Specifications.
- Monitor that the Contractor irrigates the revegetated areas during construction.

6. CONSTRUCTION QUALITY ASSURANCE FOR DRAINAGE FACILITIES

6.1 Introduction

This section describes CQA procedures for the surface water drainage facilities. The drainage facilities consist of various types of drainage channels, drop inlets, culverts, and diversion berms.

CQA for the drainage facilities installation will be performed to verify that these facilities are constructed in accordance with the Plans and Specifications. To monitor compliance, the CQA program will: (1) review the Contractor's quality control submittals; (2) monitor construction testing; and (3) monitor installations.

Construction testing will be conducted in accordance with the Specifications.

6.2 Construction Monitoring

6.2.1 Drainage Channels

- Monitor that grade control construction staking for the drainage channels is performed before the work.
- Monitor that the drainage channels are constructed in accordance with the Drawings and Specifications.
- Monitor that the subgrades of the drainage channels are dry, firm, and unyielding and do not have loose or extraneous material.
- Document that drainage ditches are graded and sloped in accordance with the Plans and Specifications. Review verification surveys and notify the Contractor of areas needing repair. Submit copies of verification surveys to the Construction Manager.

6.2.2 Drop Inlets and Culverts

- Review the Contractor's submittals for the piping and drop inlets for compliance with the Specifications.
- Monitor that the Contractor has excavated pipe trenches to the proper depth.
- Monitor that the Contractor has graded the slope of the pipe trenches to uniform gradient.
- Monitor that the pipe subgrades are firm and unyielding and do not have loose or extraneous material.
- Monitor and test backfilling of pipe trenches.
- Verify that inlets to drainage structures are smooth and prevent ponding.

6.2.3 Diversion Berms

- Monitor that the material used to construct the diversion berms complies with the Specifications for structural fill.

7. DOCUMENTATION

This CQA Plan requires thorough monitoring and documentation of the construction activities. The CQA Manager will document that the CQA requirements have been addressed and satisfied. Documentation will consist of daily record keeping, testing and installation reports, non-conformance reports (if necessary), progress reports, photographic records, design and Specification revisions, and a Final CQA Report.

7.1 Daily Record Keeping

At a minimum, daily records will consist of a daily record of construction progress, daily construction report, observation and test data sheets, and, as needed, non-conformance/corrective measure reports. All forms will have peer review.

7.1.1 Daily Record of Construction Progress

The daily field report will summarize ongoing construction and discussions with the Contractor and will be prepared by the CQA Manager and CQA Monitor. At a minimum, the report will include the following:

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data.
4. A description of ongoing construction for the day in the area of the CQA Monitor's responsibility.
5. An inventory of equipment utilized by the Contractor.
6. Significant items of discussion and names of parties involved in these discussions.
7. A brief description of tests and observations, identified as passing or failing, or, in the event of failure, a retest.
8. Areas of non-conformance/corrective actions, if any (non-conformance/corrective action form to be attached).
9. Summary of materials received and quality control documentation.
10. Follow-up information on previously reported problems or deficiencies.
11. Record of site visitors involved with the project.
12. Signature of CQA Manager and/or CQA Monitor.
13. Signature of the peer reviewer.

7.1.2 Observation and Test Data Sheets

Observation and test data sheets should include the following information as is appropriate for the form being used.

1. Date, project name, project number, and location.
2. A unique number for cross-referencing and document control.
3. Weather data, as applicable.
4. A reduced scale site plan showing sample and test locations.
5. Test equipment calibrations, if applicable.
6. A summary of test results identified as passing, failing, or, in the event of a failed test, retest.
7. Completed calculations.
8. Signature of the CQA Manager and/or CQA Monitor.
9. Signature of the peer reviewer.

7.1.3 Non-Conformance Reports

In the event of a non-conformance event, a non-conformance verification report form will be included with the daily report. Procedures for implementing and resolving any non-conformities to the Contract Documents are outlined in Section 2.4 of this CQA Plan.

7.2 Weekly Progress Reports

The CQA Manager will prepare weekly progress reports summarizing construction and CQA activities. These reports will contain, at a minimum, the following information:

- The date, project name, project number, and location.
- A summary of work activities completed in the last week and those expected to be performed in the next week.
- A summary of deficiencies and/or defects and resolutions.
- Ongoing summary of changes and/or change orders to the work.
- The signature of the CQA Manager.
- On the fourth week of each month the report will include a summary of on-site and third party laboratory test results.

7.3 Photographs

Construction activities will be photographed. Photographs will show any significant problems encountered and corrective actions and will document the construction progress. The photographs will be identified by location, date, and photographer. The photographer should document the subject or the photograph, either on the back of the picture or in a photograph log.

7.4 Design and Specification Changes

Design and Specification changes may be required during construction. Design and Specification changes will only be made with the written agreement of the Design Engineer, Owner, and Contractor. These changes will be made by change order to the contract. When change orders are issued, they will be prepared by the Construction Manager. The Construction Manager will distribute change orders for signature and execution to the required parties.

7.5 Final Construction Quality Assurance Report

At the completion of the project, the CQA Manager and CQA Officer will submit a Final CQA Report. This report will document that the work has been performed in compliance with the Plans and Specifications.

At a minimum, the Final CQA Report will contain:

- Daily Field Reports per Section 7.1.1.
- Inspection data sheets that contain observations and a record of field and laboratory tests per Section 7.1.2.
- A summary of the construction activities.
- A tabular summary of the laboratory and field test results demonstrating construction is in compliance with the Specifications.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- A list of changes from the Plans and Specifications and the justifications for these changes.
- As-built (record) drawings.
- A statement of compliance with the Contract Documents and design intent that is signed and stamped by the CQA Officer.

The as-built drawings will accurately show the constructed location of the work items, including the location of piping, anchor trenches, etc. All surveying and base maps required for the development of the as-built drawings will be prepared by the Contractor. The CQA Manager will review and verify that the as-builts are correct.