SECTION 2.5

Construction Quality Assurance Plan

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1.0 Purpose and Scope

1.1 Purpose

The purpose of this Construction Quality Assurance Plan (CQA Plan) is to provide procedures to assure that landfill components of the Veolia ES Zion Landfill are constructed and documented in adherence to their design and regulatory requirements.

This plan has been prepared in accordance with the requirements of Title 35 Illinois Administrative Code Part 811 Subpart E and Appendix D to IEPA Landfill Permit Application Instructions Form No. LPC-PA2. This plan is intended to serve as a guide and can be modified to reflect current industry standards with regard to laboratory testing methods and requirements.

1.2 Scope

Construction components and facilities subject to this CQA Plan are as follows:

Construction Component	Applicable Sections*
Foundation and Subgrades	2.0 –5.0, 6.0, 8.0
Test Liner	2.0 –5.0, 6.0, 7.0, 8.0
Gradient Control Layer	2.0 –5.0, 14.0, 15.0
Compacted Low-Permeability Soil Liner	2.0 –5.0, 7.0, 8.0
Geomembrane Installation	2.0 –5.0, 11.0
Leachate Drainage and Collection System	2.0 –5.0, 10.0, 12.0, 13.0, 14.0,15.0
Final Cover System	2.0 –5.0, 7.0, 8.0, 9.0, 11.0, 12.0, 13.0, 14.0, 15.0
Surface Water Control Facilities	2.0 –5.0, 12.0, 15.0, 16.0
Gas Control and Leachate Recirculation Systems	2.0 –5.0, 17.0
Leachate Storage Tanks	2.0 –5.0, 19.0

* NOTE: Sections 2.0 through 5.0 are applicable to all landfill components.

Sections 2.0 through 5.0 discuss CQA requirements common to all the components of landfill construction. These common requirements include Roles, Responsibilities, and Qualifications (Section 2.0), Preconstruction Planning (Section 3.0), General Inspection and Documentation (Section 4.0), and the Construction Acceptance Report (Section 5.0).

Sections 6.0 through 19.0 discuss specific construction procedures, observation, sampling, testing, acceptance criteria, surveying and documentation requirements for each material utilized in construction of landfill components. Several sections will have to be referenced for landfill components constructed of multiple materials. For example, the final cover utilizes general fill (final protective layer), geocomposite or granular soil (drainage layer), geomembrane, and low-permeability soil (low-permeability layer).

2.0 Operator and CQA Roles, Responsibilities, and Qualification

2.1 Owner/Operator

For each component of landfill construction addressed by this CQA Plan, the owner/operator shall retain professional services of a third party other than the owner/operator or an employee of the operator to fulfill the requirements of the CQA Officer.

2.2 CQA Officer

The CQA Officer shall supervise and be responsible for all inspections, testing, and related construction documentation as described in this CQA Plan. The CQA Officer will be responsible for preparation of the construction acceptance report to certify substantial compliance with the engineering design. The CQA Officer shall be an Illinois Registered Professional Engineer.

The CQA Officer may delegate daily inspection, testing, and sampling duties to a qualified technician with experience in the assigned aspect of construction who will serve as the Resident Project Representative (RPR). Although these duties may be delegated, the CQA Officer will retain the responsibility for these activities.

When an RPR is designated, the CQA Officer shall visit the construction site periodically during active periods of construction to personally observe the construction and documentation procedures. Also, at a minimum, the CQA Officer shall personally observe, on at least one occasion, each of the following major elements of landfill construction:

- Compaction of the subgrade and foundation to design parameters;
- Installation/testing of the compacted low permeability soil liner;
- Installation/testing of the geomembrane;
- Installation/testing of the leachate drainage and collection system;
- Application/testing of the final cover;
- Installation/testing of gas control facilities; and
- Construction of the ponds, ditches, and berms.

The CQA Officer shall be readily available for consultation, as needed.

2.3 Resident Project Representative (RPR)

The RPR will carry out daily inspection, testing, and sampling duties under the direct supervision of the CQA Officer. The RPR shall be a qualified technician with experience in the assigned aspect of construction. The RPR will prepare daily summary and inspection reports and transmit these routinely to the CQA Officer. The RPR will immediately notify the CQA Officer of any problems or deviations from design plans and specifications. The RPR will not have authority to approve any design or specification changes without the consent of the CQA Officer.

2.4 CQA Officer-In-Absentia

In the event that the CQA Officer is unable to be present to perform the requirements of this CQA Plan, the CQA Officer will designate a person to fulfill the duties of the CQA Officer and exercise professional judgment in the role of CQA Officer-In-Absentia. The CQA Officer-In-Absentia will not necessarily be an Illinois Registered Professional Engineer. The Officer-in-Absentia provided in Section 21, or its equivalent, shall be completed in its entirety when a CQA Officer-In-Absentia is designated, and shall be included in the construction acceptance report.

2.5 Soils Testing Laboratory

The Soils Testing Laboratory shall have experience in testing soils in accordance with standards developed by the American Society of Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), United States Army Corp of Engineers (USCOE), and other applicable test standards. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. Final laboratory reports will be certified by the Soils Testing Laboratory and submitted to the CQA Officer.

2.6 Geosynthetic Testing Laboratory

The Geosynthetic Testing Laboratory will have experience in testing geosynthetics in accordance with standards developed by the American Society of Testing and Materials (ASTM), Geosynthetic Institute (GSI), International Standards Organization (ISO), and other applicable test standards. The selected laboratory will be required to be responsive to the project needs by providing test results within reasonable time frames. Final laboratory reports will be certified by the Geosynthetic Testing Laboratory and submitted to the CQA officer.

3.0 Preconstruction Meeting

Prior to construction commencing at the landfill facility, a preconstruction meeting shall be held. This meeting will include the parties involved in the construction, including the CQA Officer, RPR, construction and/or installation contractor, and operator.

The objectives of this meeting include construction planning and coordination of tasks; identification of potential problems that might cause difficulties and delays in construction; proper interpretation of design intent by contractor(s); and to present the CQA Plan to all the parties involved. It is very important that the rules regarding documentation, reporting, testing, repair, and acceptance be understood by each party to this plan.

Specific topics considered for this meeting include the following:

- ❑ Review the construction plans, construction specifications, and CQA Plan. Review all critical design details of the project.
- ❑ Review measures for surface and storm water control, including but not limited to storm water diversion, erosion control measures, pumping locations, storm water retention, and discharge requirements.
- ❑ Make appropriate modifications to the CQA Plan and develop any project-specific addenda.
- ❑ Review the responsibilities of each party.
- ❑ Review lines of authority and communication.
- ❑ Review methods for documenting, reporting, and distributing documents and reports.
- ❑ Review the testing requirements, locations, and frequency for the soil and geosynthetic components.
- ❑ Construction procedures for the compacted low-permeability soil layer, including compaction and water content requirement, precautions to be taken to maximize bonding between lifts of compacted low-permeability soil, method for splicing liner and cover, precautions to minimize desiccation cracking, surface preparation and approval prior to geomembrane placement.
- ❑ Establish rules for writing on the geomembrane (i.e., who is authorized to write, what can be written, and in which color). Outline procedures for packaging and storing archive samples.
- ❑ Review the time schedule for all operations and hours of operations.
- ❑ Establish procedures for deployment of materials over completed geosynthetics.
- ❑ Observe where the site survey benchmarks are located, and review methods for maintaining vertical and horizontal control.
- ❑ Review permit documentation requirements.
- ❑ Review the survey documentation tables and plans that identify the locations where survey documentation information is required.
- ❑ Conduct a site walk-around to review material storage locations and general conditions relative to construction.
- ❑ Review geomembrane panel and seam layout drawings and numbering systems.
- ❑ Establish procedures for use of the geomembrane welding apparatus, if applicable.

- ❑ Finalize field cutout sample sizes.
- ❑ Review repair procedures.
- ❑ Review procedures for working in areas containing waste.

The meeting will be documented by the CQA Officer, and minutes will be distributed to all parties involved in the construction project. A copy of the preconstruction meeting minutes may be included in the construction acceptance report.

4.0 General Construction Observation and Documentation

This section describes general documentation procedures to be implemented including use of forms, identification and resolution of problems or deficiencies, and photographic documentation.

4.1 Daily Reports

A daily construction report shall be prepared by the CQA Officer, or under direct supervision of the CQA Officer, for each day of activity. Each report shall contain the following information:

- Date, project name, location, and report preparer's name. Names of all inspectors on-site performing CQA under the supervision of the CQA Officer.
- Time work starts and ends each construction work day. Also identify the duration and reason for any work stoppages (i.e., weather delay, equipment shortage, labor shortage, unanticipated conditions encountered, etc.).
- Data on weather conditions including temperature, humidity, wind speed and direction, cloud cover, and precipitation.
- Construction contractor's work force, equipment in use, and materials delivered to or removed from job site.
- Chronological description of work in progress including locations and type of work performed.
- Summary of any meetings held and attendees.
- A description of all materials used and references or results of testing and documentation.
- Discussion of any problems/deficiencies identified and any corrective actions taken as described in Section 4.3 (Problem/Deficiency Identification and Corrective Action).
- Identification/list of laboratory samples collected, marked, and delivered to laboratories or clear reference to the document containing such information if samples were obtained.
- An accurate record of calibrations, recalibrations, or standardizations performed on field testing equipment, including any actions taken as a result of recalibrations. In addition, the results of other data recording such as geomembrane seaming temperatures shall be included or clearly referenced to the document containing such information, if applicable.
- Copies of each inspectors daily field data sheets

Field data sheets shall be prepared daily by the RPR and contain the following information:

- Test or sample location and elevation
- Type of inspection
- The procedures used
- Test data
- Test results
- Personnel involved in the inspection and sampling activities
- Name of the RPR

4.2 Forms, Checklists, and Data Sheets

Additional forms may be developed during the course of the project to provide specific needs such as geomembrane inspections or simply to improve efficiency of data collection. Any new forms shall be approved by the CQA Officer prior to their use.

4.3 Problem/Deficiency Identification and Corrective Action

Problem and/or deficiency identification and corrective action will be documented in the Daily Summary Report when any construction material or activity is observed or tested that does not meet the requirements set forth in this plan. The Summary Report should clearly reference any other report, photograph, or form that contains data or observations leading to the determination of a problem or deficiency. Problem/deficiency identification and corrective action documentation may include the following information:

- A description of the problem or deficiency, including reference to any supplemental data or observations responsible for determining the problem or deficiency.
- Location of the problem or deficiency, including how and when the problem or deficiency was discovered. In addition, an estimate of how long the problem or deficiency has existed should be included.
- A recommended corrective action for resolving the problem or deficiency. If the corrective action has already been implemented, then the observations and documentation to show that the problem or deficiency has been resolved should be included. If the problem or deficiency has not been resolved by the end of the day upon which it was discovered, then the report will clearly state that it is an unresolved problem or deficiency.

The CQA Officer and the RPR will discuss the necessary corrective actions with the Owner and the Construction Contractor and implement actions, as necessary, to resolve the problem or deficiency as soon as possible. A description of such problems or deficiencies and corrective actions implemented will be provided in the Construction Documentation Report.

The CQA Officer, working with the operator and construction contractor, will determine if the problem or deficiency is an indication of a situation that might require changes to the plans and specifications and/or the CQA Plan. Any revisions to the plans or specifications or the CQA Plan must be approved by the CQA Officer and the site operator.

4.4 Photographic Documentation

Photographs shall be taken of each major element of the CQA process to document observations, problems, deficiencies, corrective actions, and work in progress. The following information should be documented in the daily report or a log book for each photograph:

- Date and time.
- Location where photograph was taken, including information regarding the orientation of the photograph itself for proper viewing (i.e., looking south), if not apparent from the content of the photograph.
- Description of the subject matter.
- Unique identifying number for reference in other reports.
- Name and signature of photographer.

4.5 Surveying

Documentation surveying requirements for each major landfill component are described in Sections 6.0 through 19.0. All required surveying will be performed under the direct supervision of the CQA Officer. All surveys will be based on survey control monuments to be established according to Part 811.104. The location of all field tests and samples will be recorded. Generally, these locations can be determined by reference to nearby construction stakes or markings; however, if such convenient reference is not readily available, the CQA Officer or the designated RPR is responsible to provide or request survey control.

5.0 Construction Acceptance Report

Following completion of construction of each major phase, a Construction Acceptance Report will be prepared including certification by the CQA Officer that construction was completed in substantial conformance with the engineering design and applicable approvals. The report will be submitted to the IEPA, as required for operation approval.

The report will include the following information, at a minimum:

5.1 Narrative

A narrative description in chronological order for each of the major construction elements listed in Section 1.0. The narrative will include discussion of the following items:

- A physical description of the subject construction and a description of the construction procedures used.
- A comparison of testing requirements, as specified by the CQA Plan, to the testing actually performed.
- A comparison of acceptance criteria specified by the CQA Plan to the testing results actually achieved. Summaries of all test data (including sample and test locations) will be provided as well as copies of pertinent laboratory testing reports such as grain-size distribution curves, hydraulic conductivity test data, moisture-density curves, and geosynthetic test data.
- A comparison of surveying requirements specified by the CQA Plan to those performed, and an evaluation of conformance to specified thicknesses, lines, and grades. Survey data will be summarized and/or represented by drawings of record.
- Any deviation from the design plan or from the agency approval will be discussed including the reason and justification for the change.
- Any pertinent correspondence related to the construction will be referenced in the narrative and included in appendices.

5.2 Photographic Documentation

Photographic documentation will be included in an appendix. A sufficient number of photos will be included to provide a visual concept of each major component of landfill construction. Photographs may also depict testing and sampling procedures and construction procedures.

5.3 Summary Reports

Copies of all Daily Summary Reports will be provided in an appendix.

5.4 Drawings of Record

Drawings of Record for the construction may include the following Plan Sheets and contents, as applicable. When practical, each of these record drawings should show where samples are collected and/or tests were conducted, with a reference to test/ sample identification:

- Title Sheet - Project name, date, site location, preparer, owner/operator, certification, and drawing index.

- Subgrade Grades - Surveyed subgrade grade spot elevations, and locations of any areas requiring stabilization.
- Liner Grades - Surveyed top of liner grade spot elevations.
- Liner Geomembrane - Panel and seam locations, anchor trench locations, any pertinent testing locations, and penetration locations, including repairs.
- Leachate Drainage and Collection System - Surveyed top of drainage layer grade spot elevations, or measured thickness, location and slopes of leachate collection pipes, anti-seep collars, manholes, tanks, and loading facilities.
- Gas Control and Leachate Recirculation System – Surveyed locations of wells, laterals, and header piping with spot elevations as necessary, locations of air lines and condensate forcemain piping, locations of tanks, condensate collection points, and tie-in locations.
- Surface Water Drainage Facilities - Lines, grades, and spot elevations of surface water control facilities. Pipe locations, elevations, and any control devices will also be shown. If possible, this information may be incorporated into another Plan Sheet.
- Final Cover Low-Permeability Soil Layer - Surveyed top of low-permeability soil cover spot elevations.
- Final Cover Geomembrane - Panel and seam locations, any pertinent testing locations, and penetration locations, including repairs.
- Final Cover Drainage Layer: Surveyed top of granular layer, or limits of geocomposite if geosynthetic material is used.
- Final Cover Protective Layer - Top of protective layer grade spot elevations. Any surface water drainage or diversion facilities associated with the final cover.
- Details - Detail Plan Sheets will depict any necessary components, as necessary, to clearly document construction. Details may include, but may not be limited to: plan and profiles of manholes, tanks, piping and pump controls, liner penetrations, gas control and leachate recirculation system structures, and drainage structure controls.

6.0 Subgrade and Foundation

The liner subgrade will be established by excavating overburden soils to the designed subgrade grades.

6.1 Procedures and Observation

- Upon attainment of subgrade grades by excavation, the RPR will observe subgrade conditions and document unexpected conditions such as wet or unstable areas, or permeable lenses.
- Any unstable areas, permeable lenses, joints, or fractures encountered will be excavated at least 1 feet in depth and replaced with low-permeability soil. If required, dewatering, placement of geosynthetics, or placement of crushed stone to stabilize the subgrade undercut below 1 feet shall be at the direction of the CQA Officer.
- In the event that groundwater is encountered during excavation, the following procedures will be followed:
  - Excavating in the area will cease until the area can be assessed and mitigation measures implemented.
  - Veolia ES Zion Landfill will be notified by the contractor immediately.
  - The CQA Officer and an experienced geotechnical engineer will be notified immediately.
  - Based on recommendations by the geotechnical engineer, mitigation measures will be implemented (mitigation measures may include, but not be limited to perimeter dewatering, horizontal drains, and or drainage ditches).
  - Upon stabilization of the uplift forces, subgrade grade excavation will be completed and the low-permeability soil liner will be placed.
  - Mitigation measures will be maintained during waste placement operations until sufficient overburden materials are in place in order to counteract hydrostatic uplift forces.
- Any corrective actions taken under this section should be documented using the methods in Section 4.3.

6.2 Excavation

The following procedures will be followed prior to and during construction.

- All available geologic information, including boring logs and geologic cross sections, will be reviewed prior to excavation.
- Meetings will be scheduled on a regular basis between the owner, contractor, and CQA Officer to discuss elevations of the subgrade.
- Excavation depths will be monitored continuously to ensure subgrade grades are not over excavated.

6.3 Sampling Requirements and Acceptance Criteria

- As discussed above, subgrade stability will be determined by visual observations of surface conditions under proof rolling with a loaded haul truck or scraper, with rutting less than four inches considered acceptable.
- Any subgrade areas requiring placement of compacted low-permeability soil for stabilization should follow the Quality Assurance requirements.

6.4 Surveying

Subgrade elevations will be surveyed on a 100-foot grid pattern at a minimum and any additional locations required to depict breaks in grade, toe, and top of sideslopes. In the alignment of undercuts for leachate collection lines, subgrade elevations will be surveyed at 50-foot intervals. The subgrade grades shall be equal to or lower in elevation than the design subgrade grades.

The limits of any subgrade stabilization or permeable lense removal and backfill will be surveyed and depicted on the Subgrade Grades record drawing plan sheet. The location of all field tests and samples will be recorded.

7.0 Test Liner

Prior to construction of the full-scale compacted low-permeability soil liner, a test liner will be constructed and evaluated in accordance with the requirements of Part 811.507. The RPR will observe its construction and perform the required testing and sampling. The CQA officer will inspect the construction and testing of the test liner to ensure that the requirements of Part 811.507(a) are met following the construction of the test liner. The CQA Officer will prepare a documentation report of test liner construction and testing results for IEPA submittal prior to full-scale low-permeability soil liner construction. Test liner construction, testing, and evaluation have been completed using the soil materials typically available on-site. Additional test liner(s) will be constructed if the properties of the borrow source change or there is a significant change in equipment or construction procedure.

7.1 Test Liner Design

The test liner dimensions will be 100 feet in length by 50 feet in width and 5 feet thick. The liner will be constructed with a 2 percent slope across its width, and the final surface will be elevated approximately 0.5 foot above the existing ground surface to promote runoff. The widest piece of equipment to be used in liner construction is approximately 12 feet. The scraper, being the longest piece of equipment, is approximately 40 feet in length. The scraper will already be in motion when it approaches the test liner and operates at very low speeds when depositing soil; therefore, the testing area of the liner has been determined by establishing a buffer for edge effects equal to one half the length of a scraper and one half the width of equipment. This provides a testing area with dimensions of 38 feet by 60 feet.

7.2 Procedures and Observation

- A shallow excavation, 1.5 to 2.5 feet in depth, will be made to remove topsoil and simulate subgrade conditions. The subgrade will be proof-rolled and quantitatively evaluated for acceptance using the methods in Section 6.3.
- Low-permeability soil for construction of the test liner will be obtained from the same borrow source(s) for the full-scale liner.
- The RPR will confirm the source and uniformity of the borrow source.
- The construction contractor will segregate and/or remove unsuitable soils as discussed in Subsection 8.1 (Low-Permeability Soils). Contractor methods will be evaluated for removal of stones which may cause damage to the liner or are greater than 2 inches in diameter within 6 inches of the final test liner surface.
- Low-permeability soil will be placed in loose lifts using scrapers or dozers. The effectiveness of scrapers performing this task will be evaluated by measuring loose lift thickness. The equipment will spread each lift to an approximate 9-inch thickness prior to compaction. Then, the compactor speed and number of passes required to achieve specified compaction will be evaluated. The test liner documentation report will discuss construction methods and propose a method for construction of the full scale liner.
- The final surface of the test liner will be compacted with a smooth drum roller. Then, the suitability of the surface relative to geomembrane placement will be evaluated.
- Moisture conditioning may be implemented at the direction of the CQA officer to protect the completed test liner surface from desiccation, particularly if the in-field hydraulic conductivity testing has not been completed.

- ❑ The test liner will be abandoned following completion of all data collection upon notice by the CQA officer.
- ❑ The low permeability soil material used for the construction of the test liner may be incorporated in the full-scale liner construction.

7.3 Sampling Requirements and Acceptance Criteria

Due to the relative size of the test liner, sampling frequencies are intensified solely for the purpose of demonstrating repeatability of results. The RPR will perform field tests and collect soil samples for laboratory analysis.

Field Testing

Parameter	Method
Moisture Content	ASTM D6938
Soil Density	ASTM D6938
Hydraulic conductivity	ASTM D6391

Field density and moisture content will be performed on each 1 foot lift thickness of soil placed. A nuclear density-moisture gauge will be used for field moisture and density determination.

In-field hydraulic conductivity testing will be performed on the test liner at a minimum of three locations. Tests will be conducted using the two-stage borehole permeameter or other accepted test method. At least one hand-carved block (test diameter greater than 150 mm) will be collected from the test liner and also tested for hydraulic conductivity for comparison purposes.

Field Testing Acceptance Criteria

Acceptance criteria for density and moisture content will require soil compaction to a minimum of 95 percent of the standard Proctor maximum dry density at a moisture content equal to or greater than optimum.

Field hydraulic conductivity will be required to be no greater than 1 x 10-7 cm/s.

Laboratory Testing

Undisturbed Sample Analysis

Samples for determining in-place properties will be collected by an appropriate method for obtaining intact, undisturbed samples. Two undisturbed samples per lift will be obtained. An undisturbed sample will be obtained on the final lift so each in-field hydraulic conductivity test can be compared to laboratory hydraulic conductivity results. The following laboratory analysis will be performed on each undisturbed sample:

Parameter	Test Method
Moisture Content and Dry Density	ASTM D2216

Atterberg limits	ASTM D4318
Grain Size Analysis	ASTM D422
Hydraulic conductivity	ASTM D5084

Representative Sample Analysis

A single representative (grab) sample will be obtained from the low-permeability soil borrow source and analyzed prior to construction. This will confirm soil characteristics and provide the maximum dry density value for compaction testing. A single sample will be adequate as only 740 cubic yards of in-place low-permeability soil will be required to construct the test liner.

The following laboratory analysis will be performed on the representative sample:

Parameter	Test Method
Moisture Density Relationship using	
Standard Proctor Compaction	ASTM D698
Atterberg limits	ASTM D4318
Grain Size Analysis	ASTM D422
Soil Classification	ASTM D2487
Remolded Hydraulic Conductivity at 95 percent Compaction and wet of optimum water content per Standard Proctor Method (ASTM D698)	ASTM D5084

Laboratory Testing Acceptance Criteria

- Hydraulic conductivity shall be no greater than 1 x 10-7 cm/s (low-permeability soil liner only).
- Percent passing No. 200 sieve shall be at least 50%.
- Plasticity index shall be at least 4%, as long as hydraulic conductivity is no greater than 1 x 10-7 cm/s (low-permeability soil liner only).
- Atterberg Limits and Grain Size Analysis will be used to classify soils per the USCS. Low-permeability soils with USCS classification as CH, CL, or CL-ML are acceptable.

7.4 Surveying

Top and bottom of low-permeability soil liner elevations will be surveyed on a grid system with 25-foot intervals across the width of the test liner and 50-foot intervals across its length. The minimum acceptable liner thickness will be 5 feet. The location and elevation of all samples will be recorded.

8.0 Low-Permeability Soils

Low-permeability soil refers to the compacted low-permeability soil components of the composite liner and of the composite cover designs. The composite liner design consists of a 5-foot thick compacted low-permeability soil layer overlain with a 60-mil HDPE geomembrane. The composite cover design consists of (from bottom to top) a 2-foot-thick compacted low-permeability soil layer, a 40-mil LLDPE geomembrane, a geocomposite drainage layer, and a 3-foot-thick vegetative protective layer.

8.1 Procedures and Observation

The RPR will observe all compacted low-permeability soil liner and low-permeability soil cover construction activities and document relevant observations to support certification of the following requirements:

- Compaction equipment similar to that used in the test fill shall be used in the actual, full-scale compacted low-permeability soil liner and low-permeability soil cover.
- The same compaction procedures employed in the test fill shall be utilized for the actual liner and low-permeability soil cover, such as the number of passes, speed, and uniformity of coverage.
- The RPR will confirm the source and uniformity of the low-permeability borrow soils. Soil excavation and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type, color, texture, and moisture content. Additional characterization and testing will be completed if borrow soils for the conditions anticipated during design change from those used in the test pad.
- The construction contractor will segregate and/or remove unsuitable materials such as granular soils, silty or sandy clays not meeting acceptance criteria, boulders, cobbles, and organic material. Additionally, the construction contractor will remove any stones greater than 2 inches in diameter observed in the low-permeability soil liner and low-permeability soil cover placed within 6 inches of the geomembrane liner. Prior to compaction of the final lift of low-permeability soil, the material will be checked for the presence of sharp objects and angular stones by visual inspection.

Following compaction of the final lift, the material will be checked again for the presence of sharp objects and angular stones by visual inspection. Any stones observed will be removed.

- The RPR will measure field densities and moisture contents, to document that the compacted low-permeability soil liner is in substantial conformance with the placement specifications and that soil placement has been conducted in a manner to achieve a uniform, homogeneous mass.
- Any areas of unacceptable compaction density or moisture content will be documented by the RPR. Corrective action will consist of moisture conditioning of the soil and/or additional compactive effort as necessary. Following corrective actions, such areas will be retested. Rework and testing will continue until satisfactory conditions have been achieved.
- Loose lift thicknesses for low-permeability soil compaction will not exceed 9 inches. If soil is deposited in thickness exceeding 9 inches, dozers will be used to spread the soil to a 9-inch thickness prior to compaction. This will assure adequate reduction of clod size and provide a thin enough layer to achieve required compaction throughout the lift.
- If necessary, surfaces of liner to receive successive lifts of low-permeability soil will be moisture conditioned either by scarification and addition of water where desiccated, or by discing and air drying where too wet to promote effective bonding of lifts. Water will be applied with a spray bar applicator by a tank truck or equivalent methods to achieve uniform distribution following scarification.

- Low-permeability soil compaction will be performed in a manner to achieve continuous and complete keying together of all segments of low-permeability soil liner and cover construction. Stepped joints will be utilized to connect any lateral segments of low-permeability soil liner and cover construction.
- Preconstruction planning will be done to sequence construction activities which minimizes the length of time any completed low-permeability soil liner and cover surfaces are exposed prior to receiving protective cover. Protective cover will be provided by installation of the geomembrane. Surfaces will be maintained until protective cover is placed
- No frozen soils will be used for low-permeability soil liner or cover construction. Any frozen soils in the compaction work area will be removed.
- The final surface of the low-permeability soil liner and low-permeability soil cover will be compacted with a smooth drum roller to provide a level surface for installation of the geomembrane liner. Preconstruction planning will be done to minimize the need for traffic over the completed liner surface. Heavy trucking of materials and cleated equipment will not be allowed directly on completed liner surfaces. If this is unavoidable, an evaluation will be made upon termination of the haul route to determine if the liner should be reconstructed or repaired in such areas. Floatation-type all-terrain vehicles will be used to assist in deployment of the geomembrane liner to avoid disruption of the completed low-permeability soil liner surface.
- When the completed compacted low-permeability soil liner is exposed prior to geomembrane deployment, moisture conditioning of the liner surface will be employed as necessary to prevent desiccation.

8.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed. This section describes required analysis, methods, sample frequency, and acceptance limits. The RPR will perform field tests and collect soil samples for laboratory analysis.

Field Testing

The following field testing methods will be used by the RPR during construction:

Parameter	Method
Moisture Content	ASTM D6938
Soil Density	ASTM D6938

Field density and moisture content tests will be performed at a minimum frequency of five tests per acre per six-inch lift. At a minimum, at least one field density/moisture content test will be conducted per lift and at least one test per day of compacted low-permeability soil construction. A nuclear density-moisture gauge will be used for field moisture and density determination.

Field Testing Acceptance Criteria

Acceptance criteria for field density and moisture content will require soil compaction to a minimum of 95 percent of the Standard Proctor maximum dry density at a moisture content equal to or greater than optimum. The acceptance criteria for field density and moisture content of the low-permeability cover may be modified as described below under Representative Sample Analysis.

Laboratory Testing

Routine laboratory testing of the compacted low-permeability soil liner or cover soils will be performed on samples from the low-permeability soil borrow area and in-place low-permeability soils collected by the RPR. Samples for determining in-place properties will be collected by an appropriate method for obtaining intact, undisturbed samples. Soil characteristics will be determined from representative samples.

Undisturbed Sample Analysis

At a minimum, one undisturbed sample will be taken for every 5,000 cubic yards of low-permeability soil placed and submitted to the Soils Testing Laboratory.

The following analysis will be performed on all undisturbed samples obtained:

Parameter	**Test Method**
Moisture Content and Dry Density	ASTM D2216
Atterberg Limits	ASTM D4318
Grain Size Analysis	ASTM D422

One of every two undisturbed samples will also be analyzed for hydraulic conductivity as follows:

Hydraulic conductivity	ASTM D5084

At the discretion of the CQAO, the hydraulic conductivity testing frequency may be increased if borrow sources change.

Representative Sample Analysis

Representative (grab) samples will be obtained on the basis of three criteria. First, an initial sample will be obtained from the low-permeability soil borrow source and analyzed prior to construction. This will confirm soil characteristics and provide an initial maximum dry density value for compaction testing. The representative sample obtained for the test liner may be used to satisfy this initial sample requirement. Second, routine samples will be obtained for every 5,000 cubic yards placed. Third, in the event that changes in physical appearance or soil characteristics are observed, a sample will be obtained and analyzed. The maximum dry density value used for compaction testing may be adjusted during the course of liner construction based on the results of the above sampling.

The following laboratory analyses will be performed on <u>all</u> representative samples obtained:

Parameter	**Test Method**
Moisture-Density Relationship	ASTM D698
Atterberg Limits	ASTM D4318
Grain Size Analysis	ASTM D422

Soil Classification	ASTM D2487

Representative samples collected for the first and third criteria above (initial confirming sample and samples due to changes in appearance or characteristics) will be analyzed for remolded hydraulic conductivity at 95 percent of maximum dry density as determined by ASTM D698 in accordance with ASTM D5084.

Representative samples of low-permeability cover soils collected for the first criteria above (initial confirming sample) may have multiple remolded hydraulic conductivity tests performed in order to determine an acceptable window of moisture/density relationships that will achieve the required hydraulic conductivity. The increased testing may demonstrate that a hydraulic conductivity of 1 x 10-6 cm/sec or less may be achieved at moisture/density conditions other than 95 percent of the Standard Proctor maximum dry density and moisture content equal to or greater than optimum. As approved by the CQAO, the acceptable window of moisture/density conditions defined this way can be used to modify the acceptance criteria for field testing of moisture and density of the low-permeability cover.

Laboratory Testing Acceptance Criteria

- Hydraulic conductivity shall be no greater than 1 x 10-7 cm/s for low-permeability liner.
- Hydraulic conductivity shall be no greater than 1 x 10-5 cm/s for detention basin sidewalls as required by stormwater detention basin design details.
- Hydraulic conductivity shall be not greater than 1 x 10-6 cm/s for low-permeability cover.
- Percent passing No. 200 sieve shall be at least 50% for low-permeability liner.
- Percent passing No. 200 sieve shall be at least 20% for low-permeability cover.
- Plasticity index shall be at least 4% for low-permeability liner, as long as hydraulic conductivity is no greater than 1 x 10-7 cm/s.
- Plasticity index shall be at least 4% for stormwater detention basin sidewalls, as long as hydraulic conductivity is no greater than 1 x 10-5 cm/s.
- Plasticity index shall be at least 4% for low-permeability cover. PI less than 4% may be acceptable, as long as hydraulic conductivity is no greater than 1 x 10-6 cm/s.
- Atterberg Limits and Grain Size Analysis will be used to classify soils per the USCS. Clay soils with USCS classification as CH, CL, or CL-ML are acceptable for low-permeability liner material. Soils with USCS classification as CH, CL, CL-ML, ML, SC, or SM/SC are acceptable for low-permeability cover material, provided they meet the hydraulic conductivity specification.

8.3 Surveying

The top of low-permeability soil liner and low-permeability soil cover grades will be surveyed on the same 100-foot grid pattern and other locations surveyed for subgrade grades. Other locations include breaks in grade, toe of slope, and top of sideslopes. In the alignment of undercuts for leachate collection lines, top of liner elevations will be surveyed at 50-foot intervals. Vertical survey tolerance will be 0.0 to +0.1 foot, and horizontal tolerance will be 0.5 foot. The low-permeability soil liner thickness will be determined at all surveyed locations and reported in table fashion. The minimum acceptable liner thickness will be 5 feet perpendicular to the slope. The location and elevation of all samples will be recorded. Settlement plates or similar devices may be employed to document low-permeability soil cover thickness.

9.0 General Soils

General soils will be used for construction of the final cover protective layer and for any areas for the final cover low-permeability soil layer that may require stabilization or fill to attain proper grade. General soils may be any inorganic soil, except rock, and will be obtained from on-site stockpiles or directly from the subgrade excavation. Generally, these soils will consist of segregated excavation soils that do not meet the low-permeability soil liner soil specifications. Seeding, fertilizing, and mulching of general soils for establishment of vegetation is discussed in Section 18.0.

9.1 Procedures and Observation

The RPR will observe general soil placement activities and document relevant observations to support certification of the following requirements:

- The RPR will confirm the source and uniformity of general soils used. Soil excavation and placement will be monitored for segregation and removal of unsuitable material and for changes in soil type that may affect maximum dry density values used for determining percent compaction.
- The construction contractor will segregate and/or remove unsuitable materials such as boulders and organic material.
- General soils used for general/structural fill will be compacted to achieve the required density. The RPR will perform field testing and sampling.
- Any general fill areas not meeting the density requirement will be recompacted and retested until acceptable. Loose lift thickness for subgrade general fill placement shall not exceed 12 inches.
- General soils used for the final cover protective layer construction shall not be compacted; however, loose lift thickness shall not exceed 36 inches.
- No frozen soils will be used for general fill construction.
- Prior to seeding, the final protective layer will be worked to prepare a suitable seed bed.
- Fertilizing, seeding, and mulching will be performed in a timely manner.

9.2 Sampling Requirements and Acceptance Criteria

Field and laboratory sampling frequencies are based on proportionate sampling of construction areas or volume of material placed. This section describes required analysis, methods, sample frequency, and acceptance limits. The RPR will perform field tests and collect soil samples for laboratory analysis. As general soils placed for the final cover protective layer are not to be compacted, field testing, sampling, and laboratory analysis apply only to general soils used for structural fill.

Field Testing

The following field testing methods will be used by the RPR during construction:

Parameter	Method
Soil Density	ASTM D6938

Field density tests will be performed on every 5,000 cubic yards placed. At a minimum, at least one field density test will be conducted per lift, and at least one test per day of structural general fill placement. A nuclear density-moisture gauge will be used for field density determination.

Field Testing Acceptance Criteria

Acceptance criteria for field density will require soil compaction to a minimum of 95 percent of the Standard Proctor maximum dry density.

Laboratory Testing

Laboratory testing of the structural general fill soils will be performed on representative samples from the general fill source and on representative samples of in-place fill collected by the RPR.

Representative Sample Analysis

Representative (grab) samples will be obtained on the basis of three criteria. First, an initial sample will be obtained from the general fill source and analyzed prior to construction. This will provide an initial maximum dry density value for compaction testing. Second, routine samples will be obtained for every 20,000 cubic yards placed. Third, in the event that changes in physical appearance or soil characteristics are observed, a sample will be obtained and analyzed. The maximum dry density value used for compaction testing may be adjusted during the course of general fill placement based on the results of the above sampling. Laboratory testing of representative samples of general fill soils may be eliminated if low-permeability soils are used for general fill.

The following laboratory analyses will be performed on all representative samples obtained:

Parameter	Test Method
Moisture-Density Relationship	ASTM D698

Laboratory Testing Acceptance Criteria

Acceptance criteria is not applicable as laboratory data only will be used to establish the moisture-density relationship and determine maximum dry density for compaction testing.

9.3 Surveying

The top of the protective cover grades will be surveyed on the same 100-foot grid pattern and other locations surveyed for top of low-permeability soil cover grades. Other locations include breaks in grade and toe, and top of sideslopes. Vertical survey tolerance will be 0.0 to +0.1 foot, and horizontal tolerance will be 0.5 foot. The protective cover thickness will be determined at all surveyed locations and reported in table fashion. The minimum acceptable protective cover thickness will be 3 feet normal to the slope. Settlement plates or similar devices may be employed to document protective cover thickness.

10.0 Granular Soils

Granular soils refer to materials to be used as the granular drainage layer on the landfill base overlying the geomembrane, the optional granular drainage layer in place of the lower 12 inches of the final cover protective layer overlying the geomembrane, and stone to be used for transmission of leachate and structural support of leachate collection pipes. Limestone and dolomite stone shall not be used in the leachate collection system unless no other suitable material is reasonably available. The stone should be rounded to subangular.

10.1 Procedures and Observation

The RPR will observe granular soil placement activities and document relevant observations to support certification of the following requirements:

- The RPR shall periodically observe loads of granular soils for general conformance to material specifications and may randomly sample questionable loads. The RPR will perform routine conformance sampling.
- No tracked or rubber-tired equipment will travel directly on the geomembrane. Only low-ground pressure equipment may operate over the geomembrane when there is a 12-inch minimum layer of granular drainage material in-place. Procedures for deployment of pipe, sand, stone, and/or geotextiles overlying any placed geomembranes will be planned at the Pre-Construction Meeting. No equipment shall apply a ground pressure greater than 5 psi on the geomembrane. Any special requirements for geomembrane protection and equipment necessary to deploy materials must be approved by the CQA Officer.
- A geotextile cushion will be placed between the geomembrane and stone placed in leachate collection lines. A geotextile cushion will also be placed between the geomembrane and the granular drainage layer if stone drainage blanket is used in lieu of sand. A geotextile filter will be placed on top of the granular drainage layer to minimize the entry of fines into the leachate collection system.
- A minimum of 6 inches of stone shall be placed under leachate collection pipes prior to pipe placement, and a minimum of 6 inches of stone shall be placed over the top of leachate collection pipes.
- If granular soils are stockpiled on-site prior to use, measures should be taken to minimize contamination by fines such as wind-blown particles and surface soils during loading operations.

10.2 Sampling Requirements and Acceptance Criteria

Field sampling and laboratory testing frequencies are based on proportionate sampling of construction areas or volume of material placed. This section describes the required analysis, methods, sampling frequency, and acceptance limits. The RPR will collect soil samples for laboratory analysis.

Field Testing

No field testing will be required for granular soils. However, as stated in 10.1 above, the RPR will perform visual inspection of granular soils for conformance to material specifications and may randomly sample questionable loads.

Laboratory Testing

Representative (grab) samples will be obtained from the proposed granular soil source prior to the delivery of any material. The source sampling frequency will be dependent on the apparent uniformity of the source and must be approved by the CQA Officer.

Grab samples of granular soils placed will be collected and analyzed as follows:

Soil Type	Frequency	Parameter	Test Method
Drainage Layer Material	1/5,000 CY	Grain size	ASTM D422
Drainage Layer Material	1/5,000 CY	Hydraulic conductivity	ASTM D2434
Drainage Layer Material	1/5,000 CY	Soil Classification per USCS	ASTM D2487
Pipe Bedding Material	1/3,000 CY	Grain size	ASTM D422
Pipe Bedding Material	1/3,000 CY	Soil Classification per USCS	ASTM D2487

Laboratory Testing Acceptance Criteria

The drainage layer material will contain no more than 5 percent of fines passing the 200 sieve and a hydraulic conductivity greater than 1 x 10-3 cm/s remolded at the anticipated field density. The pipe bedding material will contain no more than 5 percent of fines passing the 200 sieve, and have a maximum particle diameter of 2½ inches.

10.3 Surveying/Thickness Determination

The finished elevation of the granular drainage layer will be documented by one of two methods to verify its thickness: survey on the same 100 foot grid as the final low-permeability soil liner surface, or physical measurement of the in-place thickness on a maximum 100 foot grid. Stone placed along leachate collection pipe alignments will be surveyed for elevation prior to pipe placement and following pipe backfilling at 50-foot intervals to document the thickness of stone placed below pipe inverts and above the top of pipe.

11.0 Geomembranes

This section of the Construction Quality Assurance Plan applies to the high density polyethylene (HDPE) geomembrane used in the composite liner and the linear low density polyethylene (LLDPE) geomembrane used in the final cover system.

The geomembrane will be supplied to the site in factory rolls. No factory seams will be used to prepare larger panels of geomembrane for delivery to the site. This plan, therefore, does not contain any QA/QC requirements for factory seaming.

This section is divided into four major subheadings which cover the QA requirements for the Pre-Installation (includes resin manufacturers and geomembrane manufacturers), Installation, Field Seaming, and Post-Installation (includes the final examination of the geomembranes prior to placing the appropriate material above the geomembrane). The terms Pre-Installation, Installation, Field Seaming, and Post-Installation are applicable only to the geomembrane installation and do not apply to the overall construction of the landfill facility.

11.1 Pre-Installation

This section describes the quality control measures that are applicable to the polyethylene (PE) resin manufacturers, geomembrane manufacturers, and finished geomembrane roll delivery to the site prior to installation.

The geomembranes must be fabricated from polyethylene resin, and the fabricated geomembrane must be classified as Type III Class C Category 4 or 5 as defined by ASTM D1248. (Note: these classifications are based on tests performed on the finished product, not the polyethylene resin used to fabricate the geomembrane.)

Manufacturing

Material Specifications

The following list specifies the required geomembrane materials for liner and final cover construction:

Base liner sideslopes 3:1	60-mil HDPE-Textured
Base liner	60-mil HDPE
Final cover sideslopes 4:1 or 3:1	40-mil LLDPE-Textured
Final cover top and sideslopes 10:1	40-mil LLDPE

The CQA Officer will confirm that the geomembrane utilized has adequate interface fiction properties based upon the actual materials/products that are used for construction.

Quality Control Requirements

Prior to the delivery of any geomembrane rolls to the site, the Geomembrane Manufacturer will provide the CQA Officer with the following information:

- The resin supplier, location of supplier's production plant(s), and resin brand name and lot number.
- Any test results conducted by the Geomembrane Manufacturer and/or the Resin Manufacturer testing laboratories to document the quality of the resin used in fabricating the geomembrane.
- The Quality Control Plan that the Geomembrane Manufacturer will be using for the geomembrane being supplied.
- Every roll of geomembrane for delivery to the site must be manufactured and inspected by the Geomembrane Manufacturer according to the following requirements:
  - First quality polyethylene resin must be used.
  - The geomembrane must contain no more than a maximum of 1 percent by weight of additives, fillers, or extenders, excluding carbon black.
  - The geomembrane must have no striations, roughness (except for where the textured geomembrane is specified), or bubbles on the surface.
  - The geomembrane must be free of holes, blisters, undispersed raw materials, or any other sign of contamination by foreign matter.

The Geomembrane Manufacturer will routinely perform specific gravity (ASTM D792) tests on the raw resin to document the quality of the resins used to manufacturer the geomembrane rolls designated to this project. The results will be submitted to the CQA Officer.

Manufacturer's Certification

The Geomembrane Manufacturer will provide certification, based on tests performed in accordance with Tables 2.5-1, 2.5-2, 2.5-4 and 2.5-5 (see Section 20) by either the Geomembrane Manufacturer's laboratory or other outside laboratory contracted by the Geomembrane Manufacturer, that the geomembrane supplied under this plan will meet the specifications listed in Tables 2.5-1, 2.5-2, 2.5-4 and 2.5-5. Additionally, the manufacturer shall provide certification that the manufacturer's Quality Control Plan was (or will be) fully implemented for the geomembrane material supplied under this plan. The manufacturer shall provide documentation to verify results of the manufacturer's Quality Control Plan implementation if requested by the CQA officer.

Delivery, Handling, and Storage of Geomembrane Roles

The geomembrane will be protected during shipment from excessive heat or cold, puncture, cutting, or other damaging or deleterious conditions. The geomembrane rolls will be stored on-site in a designated area and will be protected from long-term ultraviolet exposure prior to actual installation.

Each geomembrane roll will be marked by the Geomembrane Manufacturer with the following information on a durable gummed label, or equivalent, on inside of core:

- Name of manufacturer
- Product type and identification number (if any)
- Batch lot number

- Nominal product thickness
- Date of manufacture
- Roll number
- Roll length and width

When cores are required for preparing geomembranes for shipment, the contractor shall require the manufacturer to use cores with sufficient crushing strength to avoid collapse or other damage while in use.

The following practices should be used as a minimum in receiving and storing geomembrane rolls in the designated storage area at the job site:

- While unloading or transferring the geomembrane rolls from one location to another, prevent damage to the geomembrane itself. The preferred method involves use of a spreader-bar, straps, and a loader. Do not drag rolls.
- Store the geomembrane rolls to ensure that they are adequately protected from the following:
  - Equipment damage
  - Strong oxidizing chemicals, acids, or bases
  - Flames including welding sparks
  - Temperatures in excess of 160°F
  - Soiling

The RPR will observe and document, throughout the pre-installation, installation, and post-installation periods that the Installer provides adequate handling equipment for moving geomembrane rolls and that the equipment and the handling methods used do not pose unnecessary risk of damage. The Installer is responsible for means and methods to implement the work.

The Installer will be responsible for assuring that all materials installed meet specifications. The RPR will maintain a log of geomembrane roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- Date of receipt of delivery at job-site
- For each geomembrane roll the following information will be noted:
  - Roll number
  - Batch lot number

11.2 Installation

This section includes discussions of geomembrane roll testing requirements, earthwork required for geomembrane placement, placement of the geomembrane, defects and repairs of geomembranes, and requirements applicable to other materials in contact with the geomembranes.

All parties involved in the installation of the geomembrane should be familiar with geomembranes and should emphasize protection of the geomembrane from damage during construction activities.

Test Methods

Geomembrane roll samples will be collected by the RPR at the rate of one sample per 100,000 square feet of geomembrane delivered to the site. At least one sample shall also be obtained for each geomembrane production batch in each shipment. The Installer shall not ship to, or receive at the site geomembrane from more than two production batches in any single shipment without the prior written approval of the CQA Officer.

Samples will be 3 feet long by the full width of the roll and will not include the first 3 feet of any roll. Since machine direction for geomembrane rolls is the direction that the material comes off the roll, machine direction for any sample will always be along the 3-foot-length dimension of the sample.

Tables 2.5-1, 2.5-2, 2.5-4 and 2.5-5 in Section 20 list the tests and the test methods to be performed on the HDPE and LLDPE geomembrane roll samples. Specifications and methods used in evaluating the results are discussed below under Procedures for Determining Geomembrane Roll Test Failures. Unless specified, preparation of sample specimens will be performed in accordance with the referenced test method. Results for tear resistance and each of the tensile property tests will be reported for both the machine and cross direction.

Role of Testing Laboratory

The Geosynthetic Testing Laboratory will be responsible for performing the tests on samples submitted to them as described above under Test Methods. Results of tests performed will be reported to the CQA Officer and the RPR.

Retesting of geomembrane rolls for quality assurance purposes, because of failure to meet any or all of the acceptance specifications listed in Tables 2..5-1, 2.5-2, 2.5-4 and 2.5-5 (see Section 20), can only be authorized by the CQA Officer.

The Geomembrane Manufacturer and/or Installer may perform their own tests according to the methods and procedures defined in Tables 2.5-1, 2.5-2, 2.5-4 and 2.5-5; however, the results will only be applicable to their own quality control needs. These results will not be substituted for the quality assurance testing described herein.

Procedures For Determining Geomembrane Roll Test Failures

Tables 2.5-1, 2.5-2, 2.5-4 and 2.5-5 (see Section 20) list the acceptance specifications for the HDPE and LLDPE geomembranes. These tables apply to both textured and nontextured geomembranes. For tests where results are reported for both machine and cross direction, each result will be compared to listed specification to determine acceptance.

The values listed in the acceptance specifications of Tables 2.5-1 and 2.5-2 are from GM-13 revision 8. The values listed in the acceptance specifications of Tables 2.5-4 and 2.5-5 are from GM-17 revision 5. If the specifications in GM-13 and GM-17 are further revised in the future by GRI, the revised specifications will be used.

The following procedure will be used for interpreting results:

- If the test values meet the stated specifications in Tables 2.5-1, 2.5-2, 2.5-4, and 2.5-5 (see Section 20), then the roll and the lot will be accepted for use at the job-site. If the sample represents all rolls from an entire shipment, then the entire shipment will also be considered accepted.

- If the result does not meet the specifications, then the roll and the batch may be retested using specimens either from the original roll sample or from another sample collected by the RPR. For retesting, two additional tests will be performed for the failed test procedure. Each additional test will consist of multiple specimen tests if multiple specimens are called for in the test procedure. If both of the retests are acceptable, then the roll and batch will be considered to have passed this particular acceptance test; if either of the two additional tests fail, then the roll and batch will be considered unsuitable without further recourse. The CQA Officer may obtain samples from other rolls in the batch. On the basis of testing these samples, the CQA Officer may choose to accept a portion of the batch while rejecting the remainder.
- If retesting does not result in passing test results as defined in the preceding paragraph, or if there is any other nonconformity with the material specifications, then the Installer shall withdraw the rolls from use in the project at the Installer's sole risk, cost, and expense. The Installer shall be responsible at its sole risk, cost, and expense for removing this geomembrane from the site and replacing it with acceptable geomembrane.

Earthwork

The construction contractor will be responsible for preparing the supporting soil according to the plans and specifications. The construction contractor will remove any stones greater than 2-inch diameter from the uppermost 6 inches of recompacted low-permeability soil liner below the geomembrane. Abrupt changes will be removed in grade, including ridges one inch or more left from smooth drum rolling and cracking greater than ½" in either width or depth. For installation of any of the geomembranes, the Installer will certify in writing that the surface on which the geomembrane will be installed is acceptable. This certification of acceptance will be reported daily by the Installer prior to the start of geomembrane installation in the area under consideration. Unacceptable areas noted by the Installer will be immediately reported to the RPR.

The soil surface will also be examined daily by the RPR to ensure the surface on which the geomembrane will be installed, does not contain undesirable objects and to evaluate any areas softened by precipitation or cracked due to desiccation. The daily observation will be documented in the daily report. Areas determined to be unacceptable will be reworked until acceptable.

Placement

Location and Layout Drawing

A layout drawing for the geomembrane installation covered by this plan will be prepared by the Installer prior to installation and submitted to the CQA Officer, showing the location of geomembrane panels to be installed.

Installation Techniques

Geomembrane panels will be installed using one of the techniques described below. The Installer will determine the method that best suits the conditions at the time of installation considering factors such as schedule and weather conditions.

- All geomembrane panels are placed prior to field seaming, in order to protect the underlying soil from rain, etc. Seams may be tack-welded or sand-bagged to prevent the geomembrane panels from shifting and to maintain proper overlap for eventual seaming.
- Geomembrane rolls are placed one at a time, and each panel is seamed immediately after placement.
- Any combination of the above two techniques.

If a decision is reached to place all panels prior to field seaming, care should be taken to facilitate drainage in the event of precipitation. Scheduling decisions must be made during placement in accordance with varying conditions. The RPR will evaluate every change in the schedule proposed by the Installer and will advise the CQA Officer on the acceptability of that change. The RPR will document that the condition of the supporting soil has not changed detrimentally during installation.

The RPR will record the roll number, location, and date of each geomembrane panel installed to document that the placement plan is followed. In addition, the RPR will document the following:

- Equipment used does not damage the geomembrane by handling, excessive heat, leakage of hydrocarbons, or by other means.
- Personnel working on the geomembrane do not smoke, wear damaging clothing, or engage in other activities that could damage the geomembrane.
- Method used to unroll the geomembrane does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
- Method used to place the rolls minimizes wrinkles.
- Adequate temporary loading or anchoring (continuously placed, if necessary), which will not damage the geomembrane, will be placed to prevent uplift by the wind.
- Direct contact with the geomembrane will be minimized. The geomembrane will be protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. No direct contact with the geomembrane by heavy equipment, automobiles, or all-terrain vehicles will be allowed.
- Method used to construct and backfill the anchor trench to prevent damage to the geomembrane.

The RPR will inform the CQA Officer and document if any of the above conditions are not fulfilled.

Weather Conditions

Geomembrane placement will not be performed in an area of ponded water, during precipitation events, in the presence of excessive winds, or if the ambient air temperature is less than 32°F. The RPR will document that this condition is fulfilled. The CQA Officer will cause to cease or postpone the geomembrane placement when conditions are unacceptable. With the approval of the CQA Officer, geomembrane placement may be performed in adverse weather conditions if all necessary steps are taken to provide an acceptable environment for geomembrane placement and welding.

Damages

The RPR will examine each panel for damage after placement and determine which panels, or panel portions, should be rejected, repaired, or accepted. Damaged panels or panel portions that have been rejected will be marked, and their removal from the site will be recorded by the RPR. Panel repairs will be made according to the procedures described below.

11.3 Defects and Repairs

This section applies to all defects and repairs resulting from examinations, tests, or visual observations performed on the geomembrane material itself and on the seams used in joining rolls in the field.

Identification

All seam and non-seam areas of the geomembranes will be examined and documented by the RPR for identification of defects, holes, blisters, undispersed raw materials, and any signs of contamination by any foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The geomembrane surface will be swept with a broom and/or washed by the Installer if the amount of dust or mud inhibits examination.

Evaluation

Each suspect area identified will be nondestructively tested using the vacuum box test method. Each location that fails the non-destructive tests will be marked (according to the marking procedures agreed upon during the preconstruction meeting) and repaired by the Installer.

Repair Procedures

Any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test will be repaired. Several procedures exist for the repair of these areas. The procedures available include the following:

- Patching—used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
- Grinding and rewelding—used to repair small sections of extruded seams.
- Spot welding or seaming–used to repair small tears, pinholes, or other minor, localized flaws.
- Capping—used to repair large lengths of failed seams.
- Removal and replacement—used to replace nonconforming or damaged panels or portions thereof.
- Others may be used at the recommendation of the Installer if agreed upon by the CQA Officer and the RPR.

The repair procedures, materials, and techniques will be approved in advance of the specific repair by the CQA Officer, RPR, and Installer. At a minimum, the following provisions will be satisfied:

- Patches or caps will extend at least 6 inches beyond the edge of the defect, and all corners of patches will be rounded with a radius of at least 3 inches.
- Geomembrane surfaces must be clean and dry at the time of repair.

Examination of Repairs

Each repair will be numbered and logged according to the repair procedures agreed upon during the preconstruction meeting. Each repair will be nondestructively tested using a vacuum box for extrusion welds and air-pressure testing for fusion welds. Repairs that pass the above testing will be considered to be adequately repaired, except that large caps may be of sufficient extent to require destructive seam sampling and testing, at the discretion of the RPR.

Failed tests indicate that the repair was inadequate and will be redone and retested until a passing result is obtained. The RPR will document that repairs have been subjected to nondestructive testing and will record the number of each repair, the date, and the test outcome.

Large Wrinkles

When seaming of the geomembrane is completed, the RPR will examine the geomembrane for wrinkles and determine which wrinkles should be cut and repaired by the Installer. Each repair will be numbered, logged and nondestructively tested to the procedures agreed upon during the preconstruction meeting.

11.4 Field Seaming

This section covers the quality assurance procedures on seams used to join the rolls of geomembrane into a continuous layer. The installation of each of the geomembranes at the landfill facility will include 100 percent nondestructive testing of all field seams to determine openings or gaps along the seams. In addition, destructive testing will be performed at a routine interval for determining the strength and mode of failure of field seams in both the shear and peel modes.

The allowable field seam methods, equipment, personnel qualifications, and destructive and nondestructive testing methods are described in this section.

Seam Layout

The CQA Officer shall be responsible for developing the roll/panel placement layout numbering system. In general, horizontal seams will not be allowed on slopes steeper than 10 percent. However, at the discretion of the CQA Officer this practice may be modified. In corners and at other odd-shaped geometric intersections, the number of seams should be minimized. A seam numbering system comparable and compatible with the geomembrane roll numbering system will be agreed upon at the Preconstruction Meeting.

Seaming Equipment

The approved process for production field seaming (roll to roll) are the dual track fusion-type welding seam method and the extrusion welding process. Specialty seams and repair seams (non-production) will be done by the extrusion welding process. No other processes can be used without prior written authorization from the CQA Officer and the RPR. Dual-track welding should be used on panel-to-panel seams whenever possible.

Dual Track Fusion Welding Process

The Installer will meet the following requirements regarding the use, availability, and cleaning of the equipment to be used at the job-site:

- An automated self-propelled type of apparatus will be used.
- The welding apparatus will be equipped to continuously monitor applicable temperatures.
- One spare operable seaming device will be maintained on site at all times.
- Equipment used for seaming should not damage the geomembrane.
- The geomembrane should be protected in areas of heavy traffic to prevent damage.
- For cross seams, the edge of the cross seams will be ground to a smooth incline (top and bottom) prior to welding.

- For seam intersections the intersecting dual track seams shall be patched.
- The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.
- A small movable piece of geomembrane may be used directly below each geomembrane overlap that is to be seamed to prevent buildup of water and/or moisture between the geomembrane sheets. The geomembrane piece is slid along the overlap as the seaming progresses. This piece is removed when the seam is completed.

The RPR will perform the following tasks relative to the use of dual hot wedge seaming devices:

- Log apparatus, ambient air, and geomembrane surface temperatures, and apparatus-operating temperatures and speed at appropriate intervals.
- Document that the Installer maintains on site the number of spare operable seaming devices agreed upon at the Pre-Construction meeting.
- Document that equipment used for seaming is not likely to damage the geomembrane.
- Document that for cross seams, the intersecting dual hot wedge seam is patched using the extrusion fillet process described below.
- Document that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
- Document that a smooth insulating plate or fabric is placed beneath the hot equipment after usage.
- Document if a small movable geomembrane layer is used directly below each geomembrane overlap that is to be seamed to prevent buildup of water and/or moisture between the geomembrane sheets.

Extrusion Welding Process

The Installer will meet the following requirements regarding the use, availability, and cleaning of extrusion welding equipment to be used at the job-site:

- The welding apparatus will be equipped to continuously monitor temperature at the nozzle.
- One spare operable seaming device will be maintained on site at all times.
- Equipment used for seaming should not damage the geomembrane.
- The geomembrane should be protected in areas of heavy traffic to prevent damage.
- The extruder will be cleaned and purged prior to beginning seaming, and at any time that seaming operations are stopped, until all heat-degraded extrudate has been removed from the barrel.
- The electric generator for the equipment will be placed on a smooth base in such a way that no damage occurs to the geomembrane. Similarly, a smooth insulating plate or fabric will be placed beneath the hot equipment after usage.
- Grinding geomembrane surfaces for welding preparation shall not be performed more than 1 hour prior to seaming.

The Installer and, if applicable, the Geomembrane Manufacturer will provide documentation to the CQA Officer regarding the quality of the extrudate used in the welding apparatus. At a minimum, the extrudate should be compatible with the geomembrane liner material and contain the same grade and quality of polyethylene resin as used in the base material.

The Installer and RPR will perform the following tasks relative to the use of extrusion welding devices:

- Log apparatus (machine number/ ID), extrudate, ambient air, and geomembrane surface temperatures at appropriate intervals.
- Document that the Installer maintains on site the number of spare operable seaming devices agreed upon at the Pre-Construction meeting.
- Document that equipment used for seaming is not likely to damage the geomembrane.
- Document that the extruder is purged prior to beginning a seam until all heat degraded extrudate has been removed from the barrel.
- Document that the electric generator is placed on a smooth base such that no damage occurs to the geomembrane.
- Document that grinding is completed no more than 1 hour prior to seaming.
- Document that a smooth insulating plate or fabric is placed beneath the hot equipment after usage.

Personnel Qualifications

All personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests for the type of seaming equipment to be used. At least one seamer will have experience seaming a minimum of 2,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used at the landfill facility. The most experienced seamer, the "master seamer," will have direct supervisory responsibility at the job-site over less experienced seamers. At least 90% of the seams shall be completed by seamers who have installed at least 100,000 ft^2 of geomembrane.

The Installer will provide a list of proposed seaming personnel and their experience records to the CQA Officer and the RPR for their review and approval.

Weather Conditions

The range of weather conditions under which geomembrane seaming can be performed are as follows:

- Unless otherwise authorized in writing by the CQA Officer, no seaming will be attempted or performed at an ambient temperature below 32°F or above 104°F.
- Geomembrane will be dry and protected from the wind.
- Seaming will not be performed during any precipitation event unless the Installer erects satisfactory shelter to protect the geomembrane areas for seaming from water and/or moisture.
- Seaming will not be performed in areas where ponded water has collected below the surface of the geomembrane.

If the Installer wishes to use methods that may allow seaming at ambient temperatures below 32°F or above 104°F, the Installer will demonstrate and certify that the methods and techniques used to perform the seaming produce seams that are entirely equivalent to seams produced at temperatures above 32°F and below 104°F, and that the overall quality of the geomembrane is not adversely affected.

The RPR will document the following items:

- Ambient temperature at which seaming is performed.
- Any precipitation events occurring at the site, including the time of such occurrences.

The RPR will inform the CQA Officer if any of the weather conditions are not being fulfilled. The CQA Officer will cause to cease or postpone the geomembrane seaming when weather conditions are unacceptable.

Overlapping and Temporary Bond

The Installer will be responsible for the following:

- Panels of geomembranes have a finished overlap of a minimum of 3 inches for extrusion welding and 4 inches for fusion welding; but, in any event, sufficient overlap will be provided to allow peel tests to be performed on the seam.
- No solvents or adhesives will be used on the geomembranes unless the product has been approved in writing by the CQA Officer. Approval can only be obtained by submitting samples and data sheets to the CQA Officer for testing and evaluation.
- Procedures used to temporarily bond adjacent geomembrane rolls does not damage the geomembrane; in particular, the temperature of the hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is protected at all times against potential damage.

The RPR will log all appropriate data and information for the above requirements.

Trial Seams

Trial seams will be made on fragment pieces of geomembrane representative of actual material to be used to document that seaming conditions are adequate. Trial seams will be made at the beginning of each day of seaming period, and at least once every five hours thereafter, for each seaming apparatus used that day. Also, each seamer will make at least one trial seam each day. Trial seams will be made under the same conditions as actual seams. The trial seam samples will be at least 3 feet long by 1 foot wide after seaming, with the seam centered lengthwise. Seam overlap will be as indicated above under Overlapping and Temporary Bond.

The trial seams will be examined for squeeze-out, foot pressure applied by seaming equipment, and general appearance by the Installer. If the seam fails any of these examinations, it will be repeated until satisfactory seams are obtained.

Four specimens, each 1 inch wide, will be cut from opposite ends of the trial seam sample by the installer. The remainder of the sample shall be given to the RPR. Two specimens will be tested in shear and two specimens will be tested in peel (one peel test and one shear test from each end) using a field tensiometer provided by the Installer, and they shall not fail in the seam. If a specimen fails, a second trail seam shall be made, inspected, and tested. If the second test also fails, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.

The remainder of the trial seam sample will be identified and marked by the RPR as follows:

- The sample will be assigned a number and marked as to welding apparatus used and seamer name.
- The date, time, applicable welding equipment operating temperatures, and ambient temperature at the time of seaming.

- Whether the sample passes or fails.

The RPR will observe all trial seam procedures. The RPR may randomly select trial field samples for destructive testing by the Geosynthetic Testing Laboratory. Testing frequency will be at the discretion of the RPR.

If a trial seam sample fails a destructive test performed by the Geosynthetic Testing Laboratory, according to the acceptance criteria, then a destructive test seam sample(s) will be taken from each of the seams completed by the seamer during the shift related to the failed trial seam test. These samples will be forwarded by the RPR to the Geosynthetic Testing Laboratory and, if any of them fails the tests, the procedures described in Destructive Seam Testing will apply. The conditions of this paragraph will be considered met if a destructive seam test sample, collected and tested according to the provisions under Destructive Seam Testing has already been taken and passed.

Seam Preparation

The Installer will meet the following conditions for each of the geomembrane installations covered by this plan:

- Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
- If seam overlap grinding is required, the grinding process will be completed according to the Geomembrane Manufacturer's instructions within 1 hour of the seaming operation, and in a way that will not damage the geomembrane or cause excessive striation of the geomembrane surface.
- Seams will be aligned so as to minimize the number of wrinkles and "fishmouths."

General Seaming Procedures

Unless otherwise specified, the general seaming procedures to be used by the Installer for each of the geomembrane installations covered by this plan, and observed by the RPR, will be as follows:

- As much as practical, field seaming shall start from the top of the slope down. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted;
- The completed liner shall not exhibit any "bridging" or "trampolining" (i.e., lifting of geomembrane off the subgrade surface due to excessive tension on the geomembrane) at the time protective cover or other materials are being placed over the Geomembrane;
- Dual hot wedge fusion welding shall be used wherever possible;
- Fishmouths or wrinkles at the seam overlaps shall be "walked out" if possible or cut along the ridge of the wrinkle in order to achieve a flat overlap and the cut fishmouths or wrinkles seamed or patched;
- If seaming operations are to be conducted at night, adequate illumination shall be provided;
- Seaming shall be done under conditions which will eliminate overlap beads, beads on top of beads, and sharp creases on the bottom of seams;
- If an extrusion seam must be restarted, the end of the existing extrusion bead must be ground and the new seaming must start such that there is no less than a 2-inch overlap of the existing and new beads;
- Seaming shall extend to the outside edge of the geomembrane panels which shall be placed in the anchor trenches;

- Grinding shall be completed in accordance with manufacturer recommendations; over-ground or improperly ground areas shall be replaced at no expense to Owner.

Nondestructive Testing

Each field seam will be nondestructively tested over its full length using one of the methods described in this section. The purpose of nondestructive testing is to determine the continuity of the seams. Nondestructive testing, at this stage of development, does not provide any information on the strength of seams. Seam strengths will be determined by destructive testing methods. Failure of any of the nondestructive or destructive tests will require the repair of the failed section.

Nondestructive testing as described in this section will be performed on seams for every geomembrane installation covered by this plan. The recommended test methods for conducting the nondestructive seam testing are the air pressure test for fusion welds and the vacuum box test for extrusion welds. These two nondestructive testing methods are described below.

The RPR will perform the following:

- Observe all nondestructive seam testing, and examine all seams for squeeze-out, foot pressure, and general appearance. Failure of these criteria will be considered as failure of the seam, and repair or reconstruction will be required.
- Document location, date, test unit number, name of tester, and outcome of all testing.
- Inform the Installer and CQA Officer of any required repairs.
- Confirm that appropriate repairs are made and that the repairs are retested nondestructively with passing results.

Air Pressure Testing

The following test procedures are applicable only to dual hot wedge fusion seams. The equipment for performing the test should meet the following minimum requirements:

- An air compressor or hand pump equipped with a pressure gauge and regulator capable of producing and sustaining a pressure of 50 psi and mounted on a cushion to protect the geomembrane surface.
- Fittings, rubber hose, valves, etc., to operate the equipment, and a sharp hollow needle or other approved pressure feed device.
- Air pressure monitoring device capable of indicating 150% of the minimum allowable testing pressure.

Air pressure testing will be performed according to the following procedure:

- Seal both ends of the seam to be tested.
- Insert needle or other approved pressure feed device into the air space at one end of the fusion welded seam.
- Energize the air compressor or hand pump and pressurize the air channel to a pressure of 30 psi. Close the valve and observe the pressure response in the seam air space.
- Record the pressure in the seam at the end of 2 minutes and again at the end of 7 minutes.

- If pressure loss exceeds Maximum Permissible Pressure Differential or dose not stabilize, locate faulty area, repair and retest seam.

  Maximum Permissible Pressure Differential after Five Minutes

Material (mil)	Pressure Difference (psi)
40-mil LLDPE	3
60-mil HDPE	2

- If pressure loss does not exceed the Maximum Permissible Pressure Differential over the 5-minute period, then the seam is considered to have passed the nondestructive test.
- The installer must verify that the air channel tested was not obstructed by noting a release of pressure at the end of the tested seam interval opposite the pressure gauge.

For any seam interval which fails the air pressure nondestructive test, additional nondestructive testing or visual inspection shall be used to identify, if possible, the faulty area of the seam. The faulty area shall be repaired and retested. If the faulty area cannot be identified, then the entire seam shall be repaired and retested.

Vacuum Box Test

Vacuum box testing is to be used on those seams made by the extrusion fillet process, to locate precisely the defects identified from air pressure testing, or to evaluate suspect seam and non-seam areas. Vacuum box testing shall be completed in accordance with ASTM 4437(method 7.3).

Vacuum box testing equipment must meet the following minimum standards:

- A five-sided vacuum box with an open bottom, a clear viewing panel on top, and a pliable gasket attached to the bottom.
- A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections capable of achieving a vacuum of 10 psig.
- A vacuum gauge on the tank with an operating range of 0 to 10 psig and a vacuum gauge on the vacuum box with an operating range from 0 to 10 psig.

The following procedure will be used in performing the vacuum box test:

- Seams to be tested should be clean and relatively free from soil or foreign objects that might prohibit a good seal from being formed between the vacuum chamber and the geomembrane.
- Energize the vacuum pump and reduce the tank pressure to approximately 24 inches of water vacuum
- Wet a strip of geomembrane approximately twice the size of the vacuum box with the soapy solution.
- Place and center the vacuum box with the gasket in contact with the geomembrane surface over the wetted area of the seam.
- Applying a normal force to the top of the vacuum box, close the bleed valve and open the vacuum valve. Check to make certain that a tight seal is created between the geomembrane and the vacuum box. A minimum vacuum of 5 inches of water should be used for testing with the maximum allowable testing pressure never exceeding 10 inches of water vacuum.

- With the vacuum drawn, use the viewing panel to examine the geomembrane seam for bubbles resulting from the flow of air through the seam. Continue this examination for not less than 10 seconds.
- Remove the vacuum box by first closing the vacuum valve and opening the bleed valve. Proceed to step 8 if bubbles appear in Step 6. If no bubbles appear in step 6, then proceed directly to step 9.
- If bubbles appear through the geomembrane, the defective area should then be marked for repair. All repairs must be nondestructively tested with passing results.
- Move the vacuum box along the seam to be tested, overlapping the previously tested area by no less than three inches.

Destructive Seam Testing

Destructive seam testing will be performed on the geomembrane seams covered by this plan. Destructive seam testing is performed to determine the strength of the seam in both shear and peel failure modes. Destructive seam testing should be performed within 48 hours of sampling either in an on-site laboratory by personnel under the direction of the CQA Officer or at the Geosynthetic Testing Laboratory.

Location and Sampling Frequency

The RPR will select locations where seam samples will be cut out for the destructive testing. Test locations will be determined during seaming at the RPR's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential causes of an imperfect seam. The Installer will not be informed in advance of any location where seam samples will be taken.

The minimum frequency of sample collection will be one test location per every 500 lineal feet of seam length per welder-seamer, per day unless otherwise approved by IEPA.

Sampling Procedure

Samples will be cut under the direction of the RPR as the seaming progresses. For each sample location, the following information will be documented:

- Assign a sample number and mark accordingly.
- Record sample location on layout drawing.
- By sample number, record the reason for collecting the sample (e.g., as part of statistical testing program, suspicious seam, etc.).
- Note on the sample, for the peel test, which geomembrane is the top and which is the bottom with respect to seams performed using dual hot wedge or fusion weld techniques.
- Record pertinent information including date, time, seaming unit number, seam number, and the name of the seamer.

Specimens for qualitative field and quantitative testing will be taken prior to removal of the laboratory sample. Samples for field tensiometer testing will be 1 inch wide by 12 inches long with the seam centered parallel to the width. The distance between the two samples should be 42 inches measured from inside edge to inside edge. If both samples pass the field tensiometer test described below under Field Test Methods, then the sample for laboratory testing will be taken according to the procedure described below.

The sample for laboratory testing will be located between the two samples used for field testing. Therefore, the laboratory sample will be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample will be cut by the RPR into three parts and distributed as follows:

- A 12-inch-by-14-inch sample will be given to the Installer for testing if so desired.
- A 12-inch-by-14-inch sample will be given to the Owner for record storage.
- A 14-inch-by-18-inch sample will be transmitted to the Geosynthetic Testing Laboratory or on-site testing laboratory by the RPR.

The RPR will make periodic reports to the Installer detailing the locations of samples taken that must be repaired.

All holes cut into the geomembrane resulting from destructive seam sampling will be immediately repaired and nondestructively test by the Installer.

Field Test Methods

The two 1-inch-wide samples for field tensiometer testing described above under Sampling Procedure will be qualitatively tested for both peel and shear. Quantitative test results shall be recorded and evaluated against the acceptance specifications listed in Tables 2.5-3 and 2.5-6 in Section 20. The seam will be considered as passing if the failure in both peel and shear does not occur within the seam. If the samples fail the field tensiometer test, then the seam reconstruction procedures for the repair of the defective seam must be implemented.

Laboratory Test Methods

Laboratory testing of the destructive seam samples will be performed by the Geosynthetic Testing Laboratory or on-site testing laboratory under the direction of the CQA Officer. All laboratory destructive seam tests, whether performed on trial seam samples or on samples cut out from production seams, will be performed in general accordance with the methodology of ASTM D4437, which stipulates that at least five specimens should be tested in shear and five in peel. Samples will be cut in alternating order and should also be tested in the order of cutting, to determine if any trend in seam quality along the length of the sample exists. All specimens will be cut as 1-inch-wide strips.

The following tests will be performed on each seam sample submitted for laboratory testing:

- Shear and peel maximum tension is the maximum load per unit width of a 1 inch-wide specimen expressed in pounds per inch of width in both the shear and peel mode, according to ASTM D4437 as modified by GM-13 and GM-17.
- Shear elongation at break is the extension at break expressed as a percentage of the initial distance between the edge of the fused track and the nearer grip. This distance should be the same on both sides of the seam and is usually 2 inches. No referenced ASTM test exists for this procedure as defined; however, the specimen will be elongated to a maximum of 100 percent with any failures of individual specimens noted. For specimens that fail below 100 percent elongation, the value that failure occurred at will be noted on the results.
- Peel seam separation estimates the area of seam interface separation expressed as a percentage of the original area.

Also, for both the seam shear and peel tension tests, an indication will be given for each specimen tested that defines the locus of the failure. The loci will be defined in accordance with GM-13 and GM-17.

For shear tests, the following values will be reported for each specimen tested:

- Maximum tension in pounds per inch
- Elongation at break indicating at what percentage the specimen failed (up to a tested maximum of 100)
- The locus of failure using the above designations

For peel tests, the following values will be reported for each specimen tested:

- Maximum tension in pounds per inch
- Seam separation expressed as percent of original seam area
- Locus of failure

Role of Testing Laboratory

The Geosynthetic Testing Laboratory or on-site testing laboratory will be responsible for performing the tests on samples submitted to them as described above. Results of tests performed will be reported to the CQA Officer and the RPR. Retesting of seams, because of failure to meet any or all of the specifications listed below can only be authorized by the CQA Officer.

The Geomembrane Manufacturer and/or Installer may perform their own quality control testing in accordance with the methods and procedures defined above under Laboratory Test Methods; however, the results, if substantially different from those obtained by the Geosynthetic Testing Laboratory or on-site laboratory, may only be used to request a retesting by the Geosynthetic Testing Laboratory or on-site testing laboratory. All quality assurance test results from the Geosynthetic Testing Laboratory or on-site laboratory govern over any test results from the Geomembrane Manufacturer of Installer. Only the CQA Officer is authorized to approve a retesting request.

Procedures for Determining Destructive Seam Test Failures

The procedures described in this section apply to the destructive testing procedures defined above under Field Test Methods and Laboratory Test Methods

Results from the shear and peel tests for the HDPE and LLDPE geomembrane will be evaluated against the criteria in Tables 2.5-3 and 2.5-6.

All of the tabular criteria for each respective geomembrane type must be met for a given seam to be considered acceptable.

The Installer has the following two options in determining the repair boundary whenever a seam has failed either the field tensiometer testing or laboratory destructive testing:

- The seam can be reconstructed between any two previously tested and passed destructive seam test locations.
- The Installer can trace the welding path to an intermediate location (at a 10 foot minimum from the point of the failed test in each direction) and request that field tensiometer tests be performed at these intermediate locations. If the field tensiometer sample results are acceptable, then full laboratory samples are taken and tested. If the laboratory tests are acceptable, then the seam is reconstructed between these intermediate locations. If either sample fails, then the process is repeated until

acceptable destructive seam tests have been performed in both directions away from the original failed sample location. All retesting of seams, according to this procedure, will use the sampling methodology described above under Sampling Procedure.

For seams reconstructed due to a failing destructive seam sample, that are greater than 150 feet in length, an additional sample taken from the reconstructed zone must pass destructive seam testing.

The RPR will be responsible for documenting all actions, including test results submitted by the Geosynthetic Testing Laboratory, taken in conjunction with seam testing. The RPR will also be responsible for keeping the CQA Officer informed on seam testing results and seaming progress.

11.5 Post-Construction

Each geomembrane covered by this plan will be examined by the RPR. Any defects, whether due to failed seams, pinholes, or other penetrations, will be repaired. Deployment of the geotextile cushion and placement of the drainage layer material shall proceed as soon as practical following the RPRs testing and acceptance of completed geomembrane areas.

For pipe penetrations and appurtenances, the Installer and RPR shall verify that the following requirements are met:

- Seaming performed on and pipe penetrations, and other appurtenances will be non-destructively tested according to one of the following methods: (1) vacuum box method; (2) spark testing according to manufacturer's recommended procedures; (3) factory testing, along with certification, of prefabricated seams (i.e., pipe boots).
- The geomembrane has not been visibly damaged while making connection to sumps and appurtenances; and
- Installation of the geomembrane in the area of the pipe penetrations and connections of the geomembrane to these structures and appurtenances have been made according to the approved engineering plans and shop drawings.

For soils placed above the geomembrane (or geotextile), the RPR shall document that the following general criteria is met:

- Do not place soils on the geomembrane at an ambient temperature below 32°F, nor above 104°F, unless otherwise specified.
- Do not drive equipment used for placing the soil directly on the geomembrane.
- A minimum thickness of 1 foot of soil is specified between a low ground pressure dozer (maximum contact pressure of 5 psi) and the geomembrane.
- A minimum thickness of 2 feet of soil is specified between tracked equipment (contact pressures exceeding 5 psi) and the geomembrane.
- A minimum thickness of 3 feet of soil is specified between rubber-tired vehicles and the geomembrane, including areas of heavy traffic.
- The geomembrane (geotextile) shall be covered with Select Granular Fill within 30 days of completing geomembrane quality control and quality assurance testing.

11.6 Leak Location Survey

A leak location survey may be performed after completion of installation of geomembrane liner and/or drainage layer blanket, in accordance with ASTM D7007, Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials, or an equivalent method approved by the CQA Officer and Owner.

12.0 Geotextiles

This section of the CQA Plan applies to non-woven geotextiles used in the final cover and leachate extraction system. An 8-ounce geotextile cushion may be placed over the geomembrane liner prior to placement of the leachate drainage layer material. A 6-ounce geotextile filter will be placed on top of the leachate drainage layer. Some geotextiles installed will be part of a geocomposite consisting of a non-woven geotextile heat bonded to each side of a geonet. The geotextile used in the geocomposites will meet the applicable requirements of this section.

This section is divided into three major subheadings, which cover the quality assurance requirements for Pre-Installation (includes geotextile manufacturers), Installation, and Post-Installation (includes the final examination of the geotextiles prior to placing the appropriate material above the geotextile). The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geotextile installation and do not apply to the overall construction of the landfill facility.

12.1 Pre-Installation

Manufacturing

Material Specifications

The Geotextile Manufacturer shall provide the Project Manager and the CQA Officer with a list of guaranteed properties for the type of geotextile to be supplied. The Geotextile Manufacturer shall provide the Project Manager and the CQA Officer with a written certification signed by a responsible party that the geotextile actually delivered has properties that meet or exceed the guaranteed properties. Material property values are provided in Tables 2.5-7, 2.5-8, and 2.5-9.

Quality Control Requirements

Every roll of geotextile for delivery to the site must be manufactured and inspected by the Geotextile Manufacturer, according to the following requirements:

- The geotextile must contain no needles used for punching.
- The geotextile must be free of holes and any other sign of contamination by foreign matter.

Delivery, Handling, and Storage of Geotextile Rolls

Each geotextile roll, for use at the landfill facility, will be marked by the Geotextile Manufacturer with the following information and in the following manner:

- When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- Each roll label will contain the following information at a minimum:
  - Name of manufacturer (or supplier)
  - Style and type number
  - Unit weight (ounces per square yard)
  - Roll length and width

- Batch (or lot) number
- Nominal product thickness
- Date of manufacture
- Direction for unrolling
- Roll number

The Geotextile Manufacturer will use the following guidelines in packaging, wrapping, and preparing all geotextile rolls for shipment:

- ❑ When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
- ❑ Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geotextile rolls in the designated storage area at the job-site:

- ❑ While unloading or transferring the geotextile rolls from one location to another, prevent damage to the wrapping or to the geotextile itself. If practicable, use fork lift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two-thirds the length of the rolls to avoid breaking the cores and possibly damaging the geotextile. Do not drag rolls.
- ❑ Store the geotextile rolls to ensure that they are adequately protected from the following:
  - Precipitation
  - Ultraviolet radiation, including sunlight
  - Strong oxidizing chemicals, acids or bases
  - Flames, including welding sparks
  - Temperatures in excess of 160°F
  - Soiling

The RPR will be responsible throughout the pre-installation, installation, and post-installation periods for observing and documenting that the Installer provides adequate handling equipment used for moving geotextile rolls and the equipment and that the handling methods used do not pose any risk of damage.

The RPR will be responsible for making certain that the manufacturer, type, and thickness of each roll are correct. The RPR will also maintain a log of geotextile roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- ❑ Date of shipment from Geotextile Manufacturer
- ❑ Date of receipt of delivery at job-site
- ❑ For each geotextile roll the following information will be noted:
  - Roll number
  - Batch lot number

12.2 Installation

This section describes the quality assurance requirements applicable to the installation of non-woven geotextiles.

Placement

The Installer will install all geotextiles in such a manner to ensure that they are not damaged in any way and in a manner that complies with the following:

- On sideslopes, the geotextiles will be securely anchored and then rolled down the slope, or each roll will be mounted on a spreader bar suspended from a loader, lift, or similar heavy equipment and the geotextile will be unrolled by pulling down the slope. Geotextile panels will be deployed in such a manner as to continually keep the geotextile in tension.
- In the presence of winds, all geotextiles will be secured by other suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
- In-place geotextiles will be cut with special care to protect other materials from damage that could be caused by the cutting of the geotextiles.
- The Installer will take necessary precautions to prevent damage to any underlying layers during placement of the geotextile.
- During placement of geotextiles, care will be taken not to entrap in the geotextile any stones, excessive dust, or moisture that could damage the geotextile, or generate clogging of drains or filters.
- A visual examination of the geotextile will be carried out over the entire surface after installation by the Installer to ensure that no potentially harmful foreign objects, such as needles, are present.

The RPR will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the RPR to the CQA Officer.

Seams and Overlaps

The following requirements will be met with regard to seaming and overlapping of geotextile rolls:

- Geotextile seams will be joined by overlapping, continuously sewing, wedge welding, or other methods approved by CQA Officer
- The Installer will pay particular attention to seams to ensure that no deleterious earthen materials could be inadvertently trapped beneath the geotextile.
- Sewing will be performed with thread made from the same base material as the geotextile, or suitable equivalent

The RPR will be responsible for observing and documenting that the above provisions are performed by the Installer in an acceptable manner. Any noncompliance with the above requirements will be reported by the RPR to the CQA Officer.

Any holes or tears in the geotextile can be repaired as follows:

- A patch from the same geotextile will be sewn or heat bonded in place with a 12-inch minimum overlap in all directions.

- Care will be taken to remove any soil or other material that may have penetrated the torn geotextile.

The RPR will observe and document that the repair of any geotextiles is performed according to the above procedure.

12.3 Post-Installation

Final Examination

The RPR will perform a final geotextile examination after installation of each geotextile layer has been completed. The objectives of the final examination are as follows:

- Examine for presence of holes, tears, or other deterioration.
- Examine geotextile for excessive tension due to stretching of the fabric during installation.

If there will be an extended time delay between completion of the geotextile and the start of the installation of any overlying cover, then the Installer will make provisions, by temporarily covering or using other suitable methods, to protect the geotextile against exposure to sunlight and ultraviolet radiation.

Placement of Soil Materials

- The construction contractor will place all soil materials located on top of a geotextile in such a manner as to minimize the following:
- Damage of the geotextile.
- Slippage of the geotextile on underlying layers.
- Excessive tensile stresses imposed on the geotextile.

The RPR shall document that the following general criteria is met:

- Do not place soil on the geotextile at an ambient temperature below 32°F nor above 104°F, unless otherwise specified.
- Do not drive equipment used for placing the soil directly on the geotextile.

13.0 Geonets

This section of the CQA Plan applies to geosynthetic drainage nets (geonets) installed within the final cover of the landfill, leachate drainage layer slopes (3H to 1V), and on subgrade excavation slopes for gradient control.

Some geonets installed will be part of a geocomposite consisting of a non-woven geotextile heat bonded to the top side of the geonet. The geonets used in the geocomposites will meet the applicable requirements of this section.

This section is divided into three major subheadings which cover the quality assurance requirements for Pre-Installation (includes geonet manufacturers), Installation, and Post-Installation (includes the final examination of the geonets prior to placing the appropriate material above the geonet). The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geonet installation and do not apply to the overall construction of the landfill facility.

13.1 Pre-Installation

Manufacturing

The Geonet Manufacturer shall provide the Project Manager and the CQA Officer with a list of guaranteed properties for the type of geonet to be supplied. The Geonet Manufacturer shall provide the Project Manager and the CQA Officer with a written certification signed by a responsible party that the geonet actually delivered has properties that meet or exceed the guaranteed properties. Material property values are provided in Table 2.5-10.

Delivery, Handling, and Storage of Geonet Rolls

Each geonet roll for use at the landfill facility will be marked by the Geonet Manufacturer with the following information and in the following manner:

- When the net is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- Each roll label will contain the following information at a minimum:
  - Name of manufacturer (or supplier)
  - Style and type number
  - Roll length and width
  - Batch lot number
  - Nominal product thickness
  - Date of manufacture
  - Direction for unrolling
  - Roll number

The Geonet Manufacturer will use the following guidelines in packaging and preparing all geonet rolls for shipment:

- When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
- Geonets must be rolled on the cores so that they will unroll in the machine direction. The machine direction is defined as the direction parallel with the longest diagonal in the diamond pattern of the geonet.

The following practices should be used as a minimum in receiving and storing geonet rolls in the covered storage area at the job-site:

- While unloading or transferring the geonet rolls from one location to another, prevent damage to the geonet. If practicable, use fork lift trucks fitted with poles that can be inserted into the cores of rolls. Be sure that the poles are at least two-thirds the length of the rolls to avoid breaking the cores and possibly damaging the geonet. Do not drag the rolls.
- Store the geonet rolls to ensure that they are adequately covered to protect the geonet from the following:
  - Precipitation
  - Ultraviolet radiation, including sunlight
  - Strong oxidizing chemicals, acids or bases
  - Flames, including welding sparks
  - Temperatures in excess of 160°F
  - Soiling

The RPR will be responsible throughout the pre-installation, installation, and post-installation periods, for observing and documenting that the Installer provides adequate handling equipment used for moving geonet rolls and that the equipment and handling methods used do not pose any risk of damage.

The RPR will be responsible for making certain that the manufacturer, type, and thickness of each roll (as noted on the roll marking label described above) are correct. The RPR will also maintain a log of geonet roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- Date of shipment from Geonet Manufacturer
- Date of receipt of delivery at job-site
- For each geonet roll the following information will be noted:
  - Roll number
  - Batch lot number

13.2 Installation

This section describes the quality assurance requirements applicable to the installation of geonets.

Placement

The Installer will install all geonets in such a manner as to ensure that they are not damaged in any way and in a manner that complies with the following:

- On sideslopes, the geonet will be securely anchored and then rolled down the slope, or each roll will be mounted on a spreader bar suspended from a loader, lift, or similar heavy equipment and the geonet will be unrolled by pulling down the slope. Geonet panels will be deployed in such a manner as to continually keep the geonet in tension.
- In the presence of winds, all geonets will be secured by suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
- Cutting shall be done according to manufacturer's recommendations.
- The Installer will take necessary precautions to prevent damage to any underlying layers during placement of the geonet.
- During placement of geonets, care will be taken not to entrap in the geonet any stones, excessive dust, or moisture that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane. If dirt or excessive dust is entrapped in the geonet, the geonet will be cleaned prior to placement of the next material on top of the geonet.
- Unless otherwise approved by the CQA Officer, geonets will not be welded or tack welded to the underlying geomembranes.

The RPR will observe and document that each of the above steps are performed by the Installer. Any non-compliance with the above requirements will be reported by the RPR to the CQA Officer.

Stacking and Joining

A stacked geonet should never be laid in a perpendicular direction to the underlying layer.

The following guidelines should be used in stacking and joining geonets:

- Adjacent rolls will be overlapped by a minimum of 4 inches at panel edges and 12 inches at panel ends.
- These overlaps will be secured by spot-welding to each other or tying at 5 feet on center at edges and 12 inches on center at ends.
- Tying can be achieved by self-locking nylon ties. Ties will be white or brightly colored for easy identification. Metallic devices will not be used in any circumstances.

The RPR will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the RPR to the CQA Officer.

Repairs

Any tears or other defects in the geonet will be repaired by placing a patch extending a minimum of 2 feet beyond the edges of the hole or tear. The patch will be secured to the original geonet by tying every 6 inches with at leat one tie on each edge of the patch. If the tear or other defect width is more than 50 percent of the roll width, the damaged area will be cut out and replaced with new geonet. Tying devices will be self-locking nylon ties. The RPR will examine and document that the repair of any geonets is performed according to the above procedure.

13.3 Post-Installation

Final Examination

The RPR will perform a final geonet examination after installation of each geonet layer has been completed. The objectives of this step are as follows:

- Examine for presence of tears or defects.
- Examine overlaps and tying or spot-welding.

If any portion of the geonet requires repairs due to the above examination, they will be performed. The RPR will document the result of the final examination, including any subsequent repairs.

14.0 Geocomposites

This section of the CQA Plan applies to geocomposites installed within the 4H:1V and 3H:1V final cover drainage layer slopes and on subgrade excavation slopes for gradient control.

This section is divided into three major subheadings, which cover the quality assurance requirements for Pre-Installation, Installation, and Post-Installation. The terms Pre-Installation, Installation, and Post-Installation are applicable only to the geocomposite installation and do not apply to the overall construction.

14.1 Pre-Installation

The geocomposite manufacturer will provide the project manager and the CQA Officer with a list of guaranteed properties for the type of geocomposite to be supplied. The geocomposite manufacturer will provide the project manager and the CQA Officer with a written certification signed by a responsible party that the geocomposites actually delivered have properties that meet or exceed the guaranteed properties. Material property values are provided in Table 2.5-11.

Delivery, Handling, and Storage of Geocomposite Rolls

Each geocomposite roll, for use at the landfill facility, will be marked by the Geocomposite Manufacturer with the following information and in the following manner:

- When fabric is rolled on a core, identify each roll with a durable gummed label, or an equivalent, on the inside of the core and on the outside of the protective wrapping for the roll.
- Each roll label will contain the following information at a minimum:
  - Name of manufacturer (or fabricator)
  - Style and type number
  - Roll length and width
  - Batch lot number, if applicable
  - Date of manufacture
  - Direction for unrolling
  - Roll number

The Geocomposite Manufacturer will use the following guidelines in packaging, wrapping, and preparing all geocomposite rolls for shipment:

- When cores are required, use those that have a crushing strength sufficient to avoid collapse or other damage while in use.
- Cover each roll with a wrapping material that will protect the geotextile from damage due to shipment, water, sunlight, or contaminants.

The following practices should be used as a minimum in receiving and storing geocomposite rolls in the covered storage area at the job-site:

- While unloading or transferring the geocomposite rolls from one location to another, prevent damage to the geocomposite. If practicable, use fork lift trucks fitted with poles that can be inserted into the

cores of rolls. Be sure that the poles are at least two-thirds the length of the rolls to avoid breaking the cores and possibly damaging the geocomposite. Do not drag the rolls.

- Store the geocomposite rolls to ensure that they are adequately covered to protect the geocomposite from the following:
  - Precipitation
  - Ultraviolet radiation, including sunlight
  - Strong oxidizing chemicals, acids or bases
  - Flames, including welding sparks
  - Temperatures in excess of 160°F
  - soiling

The RPR will be responsible throughout the pre-installation, installation, and post-installation periods for observing and documenting that the Installer provides adequate handling equipment used for moving geocomposite rolls and that the equipment and handling methods used do not pose any risk of damage.

The RPR will maintain a log of geocomposite roll deliveries. The following information, at a minimum, will be recorded on the log for each shipment received at the job-site:

- Date of shipment from Geocomposite Manufacturer
- Date of receipt of delivery at job-site
- For each geocomposite roll, the following information will be noted:
  - Roll number
  - Batch lot number, if applicable

14.2 Installation

This section describes the quality assurance requirements applicable to the installation of geocomposites.

Placement

The Installer will install all geocomposites in such a manner as to ensure that they are not damaged in any way and in a manner that complies with the following:

- On sideslopes, the geocomposites will be securely anchored and then rolled down the slope, or each roll will be mounted on a spreader bar suspended from a loader, lift, or similar heavy equipment and the geonet will be unrolled by pulling down the slope. Geonet panels will be deployed in such a manner as to continually keep the geonet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles.
- In the presence of winds, all geocomposites will be secured by suitable methods. The temporary weighted material will be left in place until replaced with cover material as shown on the design plans and specifications.
- Cutting should be done according to manufacturer's recommendations.
- The Installer will take necessary precautions to prevent damage to any underlying layers during placement of the geocomposite.

- ❑ During placement of geocomposites, care will be taken not to entrap any stones, excessive dust, or moisture that could cause clogging of the drainage system, and/or stones that could damage the adjacent geomembrane.

The RPR will observe and document that each of the above steps are performed by the Installer. Any non-compliance with the above requirements will be reported by the RPR to the CQA Officer.

Overlaps and Joining

The following requirements will be used with regard to the overlapping and joining of geocomposite rolls:

- ❑ The geonet portion of the geocomposite shall be overlapped a minimum of 4 inches. The geonet shall be joined by ties every 5 feet. At panel ends, the geonet shall be overlapped 12 inches and joined by ties every 12 inches.
- ❑ The geotextile portion of the geocomposite shall be overlapped a minimum of 6 inches. The geotextile above the geonet shall be continuously sewn or wedge welded along the length of the roll per the manufactures recommendation.
- ❑ The Installer will pay particular attention to the overlap areas to ensure that no earthen or foreign materials could be inadvertently trapped beneath the geocomposite.

The RPR will observe and document that each of the above steps are performed by the Installer. Any noncompliance with the above requirements will be reported by the RPR to the CQA Officer.

Repairs

Any tears or other defects in the geocomposite will be repaired by placing a patch extending a minimum of 2 feet beyond the edges of the hole or tear. The patch will be secured to the original geocomposite by tying the geonet component every 6 inches and heat bonding or sewing the geotextile component. If the tear or other defect width is more than 50 percent of the roll width, the damaged area will be cut out and replaced with new geocomposite material. Tying devices will be as indicated above. The RPR will examine and document that the repair of any geonets is performed according to the above procedure.

14.3 Post-Installation

Final Examination

The RPR will perform a final geocomposite examination after installation of each geocomposite layer has been completed. The objectives of this step are as follows:

- ❑ Examine for presence of tears or defects
- ❑ Examine overlaps to make certain that they are in conformance with the requirements.

If any portion of the geocomposite requires repairs due to the above examination, they will be performed according to the procedures established for that portion.

If there will be an extended time delay between completion of the geocomposite and the start of the installation of any overlying cover, the Installer will make provisions, by using a temporary covering or other suitable methods, to protect the upper geotextile component against exposure to sunlight and ultraviolet radiation.

Placement of Soil Materials

The construction contractor will place all soil materials located on top of a geocomposite in such a manner as to minimize the following:

- Damage of the geocomposite
- Slippage of the geocomposite on underlying layers
- Tensile stresses
- Time delays due to inclement weather or construction sequencing to the extent practical

15.0 Piping

This section of the CQA Plan applies to piping used throughout the facility. Piping will be used for conveying leachate from the leachate extraction and recirculation systems and landfill gas and condensate from gas extraction system. Piping will also be used to collect and discharge water from the final cover drainage layer. Quality assurance efforts relating to the manufacturing, fabricating, delivery, initial on-site handling, installation and Post-Construction observations will be the responsibility of the RPR.

This section is divided into three major subheadings, which cover the QA requirements for the Pre-Construction (includes piping manufacturers and fabricators), Installation, and Post Installation (includes the final observation and documentation of piping installations prior to installation of other materials over and around the pipe). These terms Pre-Installation, Installation, and Post-Installation are applicable only to the piping installation and do not apply to the overall construction.

Individual pipe sizes and standard dimension ratios (SDRs) to be used for each individual pipe installation are not detailed in this section; the plans and specifications should be used for the determination of correct size and wall thickness.

15.1 Pre-Installation

This section describes the QA measures that are applicable to the polyethylene (PE) or polyvinyl chloride (PVC) resin manufacturers, piping manufactures, piping fabricator used to perforate the pipe, and finished piping delivery to the site prior to installation.

Manufacturing

Material Specifications

The HDPE pipe used must be made from extra high molecular weight polyethylene (PE) resin, and the manufactured piping must be classified as Type III, Class C, Category 5, Grade P34 material according to ASTM D1248 and also have a cell classification of 345434C as defined by ASTM D3350. The PVC pipe and fittings used shall be manufactured from a PVC compound which meets the requirements of Cell Classification 12454-B polyvinyl chloride as outlined in ASTM D-1784. Pipe shall be free of paint or other surface treatment.

Fabricator

The Piping Fabricator will be responsible for perforating the pipe delivered by the Piping Manufacturer according to the plans and specifications. The Piping Fabricator will be responsible for preparing and shipping the perforated pipe to the job-site.

Delivery, Handling, and Storage of Piping

The pipe will be protected, during shipment, from excessive heat or cold, puncture, or other damaging or deleterious conditions. The pipe will be stored on-site in a manner suitable to protect it from long-term ultraviolet exposure prior to actual installation.

The RPR will be responsible throughout the pre-construction, construction, and post construction periods for observing and documenting that the Installer provide adequate handling equipment for moving pipe and that the equipment and handling methods used do not pose any risk of damage. The contractor is responsible for

means and methods to implement the work. The RPR will document that the manufacturer and the type and size of each pipe is correct.

15.2 Installation

This section describes the requirements applicable to pipe installation. This section includes installation, testing, observations, and documentation of piping installation.

Pipe Seams

Unless approved otherwise by the CQA Officer, HDPE pipe seams will be made by the butt fusion procedure in accordance with manufacturer's specifications. Care will be taken to make certain adequate pressures are used for fusing pipes and that sufficient cooling periods are allowed prior to testing, bending, or backfilling a pipe section. Unless approved otherwise by the CQA Officer, PVC pipe seams will be in accordance with ASTM D-2855. A coating of CPS primer as recommended by pipe supplier shall be applied to the entire interior surface of the fitting socket, and to an equivalent area on the exterior of the pipe prior to applying solvent cement. The solvent cement shall comply with the requirements of ASTM D-2564 and shall be applied in strict accordance with manufacturer's specifications.

Placement Requirements

Pipe placement will be done in accordance with the following procedures and requirements:

- Piping placement will not be performed in the presence of excessive moisture. The RPR will document that this condition is fulfilled. Additionally, the RPR will document that the supporting backfill has not been damaged by weather conditions. The RPR will inform the CQA Officer if any of the above conditions are not fulfilled for evaluation of the necessity of corrective action.
- The prepared surface underlying the piping has not deteriorated since previous acceptance, and it is still acceptable immediately prior to piping placement.
- Each piping system will be flushed with water. The RPR will observe and document that each flushing operation is carried out and will document that the pipes are free flowing. Any system that does not flush properly will be immediately reported to the CQA officer, and corrective action will be taken to remedy the problem.
- Method used to place the piping does not cause damage to the piping and does not disturb the supporting backfill.
- The RPR will observe and document all pipe installation. Deviations from the plans and specifications will be brought to the attention of the CQA Officer for evaluation of the necessity of corrective action.
- Observations and measurements should be made to insure that the pipes are the specified size, manufactured of the specified material, and that pipe perforations are sized and spaced as specified.
- All piping should be located as noted in the plans and specifications. Locations, grades, and size requirements are specified on the details of the plan set. Observations and surveying measurements should be made to insure the pipes are placed at the specified locations and grades, and the specified configuration. Observations should be made throughout the construction to ensure that backfilling is completed as specified in the plans and specifications and that, in the process, the pipe network is not damaged.
- Non-perforated pipe will be pressure tested: Landfill gas and gravity flow leachate pipes shall be pressure tested at 5 psi for 60 minutes; condensate pipe and forcemain pipes shall be pressure tested at 50 psi for 60 minutes; air supply lines shall be pressure tested at 150 psi for 60 minutes.

Damages

The RPR will examine each pipe after placement for damage. Damaged pipes or portions of pipes which have been rejected will be marked and removed from the installation area and documented by the RPR.

15.3 Post-Installation

Pipe inverts (or top of pipe elevations) and coordinate locations shall be surveyed at 50-foot intervals and at all tee connection locations. The maximum allowable tolerance for grade is 0.10 feet at each location. The minimum average slope shall be in accordance with the design drawings.

16.0 Surface Water Control Facilities

The CQA Plan applies only to permanent surface water control facilities, including retention basins, overflow structures, culverts, ditches, riprap, erosion matting, diversion berms, flumes, and velocity dissipaters. Temporary facilities such as silt fencing and temporary diversion berms are not subject to the requirements of this plan.

16.1 Procedures and Observation

Construction observation by the RPR will be required for some, but not all, drainage facilities. Generally, construction observation will be required for drainage features that will be backfilled and cannot be subsequently documented. This will be the case for culverts greater than 50 feet in length and any required undercuts, i.e., undercut for riprap placement, etc. Other structures, including basins, ditches, and diversion berms, can be documented in-place following construction as soil testing will not be required for these structures.

The following procedures and observations will be used for the construction of surface water drainage facilities.

- ❑ Retention basins will be constructed by excavating soils to the designed basin grades. Low-permeability soil liner quality soils meeting 1 x 10^{-5} cm/s will be used for forming the upper 2' of basin sidewalls above surrounding grade. See Section 8.2 for material qualifications.
- ❑ Retention basin sidewalls will be compacted to 90%standard proctor based on field testing. Laboratory soil testing will not be required.
- ❑ Drainage ditches will be constructed by excavation of existing soils along the ditch alignment.
- ❑ Low-permeability soil cover quality soil will be used for construction of diversion berms. The construction contractor shall employ reasonable compaction procedures; however, soil testing will not be required.
- ❑ The construction contractor shall employ reasonable compaction procedures for backfilling culverts; however, soil testing will not be required.
- ❑ The RPR will observe the placement of filter fabric below riprap areas.
- ❑ The RPR will field verify the placement of erosion matting.
- ❑ The RPR will observe the installation of basin overflow structures and verify components and sizes. Backfill procedures will be observed to verify reasonable compaction; however, testing will not be required.
- ❑ Low-permeability soil cover quality soil will be used for construction of spillway berms. The construction contractor shall employ reasonable compaction procedures; however, soil testing will not be required.

16.2 Surveying and Acceptance Criteria

- ❑ Adequate survey information shall be obtained in the field following basin construction to plot the basin contours and prepare a record drawing. If a post-construction aerial topo is obtained, the topo will be supplemented with key spot elevations obtained from this survey. The survey information shall be sufficient enough for the CQA Officer to certify that basin construction has been completed within reasonable conformance with the design plan.

- The tolerance for ditch invert elevations will be ±0.2 feet, providing positive drainage is maintained.
- Tolerance for diversion berm flow line elevations will be ±0.2 feet, providing positive drainage is maintained.
- Culvert invert elevations will be surveyed every 50 lineal feet (minimum), and culvert sizes will be field-verified. The tolerance for culvert invert elevations will be ±0.1 feet, providing positive drainage is maintained.
- Key components of basin overflow structures will be surveyed, including culvert inverts and inlet elevations. The tolerance for these elevations will be ±0.1 feet, providing positive drainage is maintained.

16.3 Deviations

The surface water design may be modified based upon unexpected conditions encountered in the field. Deviations from the designs that occur during construction/installation of stormwater runoff control structures shall be noted on the record drawings and accompanied by calculations showing that the hydraulic carrying capacity remains sufficient and erosion control principles were followed. Such deviations may include, but not be limited to, alternate slopes, locations, cross-sections, points of discharge and methods of erosion control.

17.0 Gas Extraction Wells

This section of the CQA Plan applies to gas extraction wells. High-density polyethylene (HDPE) or Polyvinyl Chloride (PVC) piping will be used for construction of the gas extraction wells.

Individual pipe sizes and standard dimension ratios (SDRs) to be used for each individual pipe installation are not detailed in this plan, rather the drawing plans should be used for the determination of correct size and wall thickness.

17.1 Installation of Gas Extraction Wells

The CQA Officer will observe well installation activities for conformance with the following procedures:

Drill or Bore Extraction Wells

The gas extraction wells will be drilled with minimum 36 inch diameter augers at the locations shown on the Drawings and to the total depth of the waste as directed by the CQA Officer. The CQA Officer (or surveyor) will survey and record the coordinates and surface elevation at each borehole location and obtain the corresponding landfill base elevation using available information. The depth to the landfill base will be calculated and provided to the driller. The driller will carefully monitor the auger depth and end each boring 10' from the landfill base. The actual location of the well may be adjusted if difficulty in drilling is encountered (rock, cables, metal, etc.) with approval of the CQA Officer. All wells will be drilled without drilling fluids.

All boreholes, regardless of depth, will be covered by plywood, barricaded, surrounded by orange safety mesh, or otherwise secured. Immediately after drilling and until completion of the well seal, an earthen berm around the borehole will be constructed and maintained to divert stormwater. All wells will be completed immediately after drilling to prevent loss of holes due to sloughing.

Waste Disposal

Drill cuttings shall be loaded and transported by the end of each day to the working face of the landfill and/or covered with approved daily cover or alternative daily cover material.

Well String

The well string is to be fabricated after completion of the boring and determination of actual well depths. This will allow for proper determination of perforated pipe length and proper finished elevation for the wellhead.

The well string, consisting of perforated and solid sections of HDPE or PVC pipe, will be joined together using the butt fusion process or glued and lag bolted, respectively according to the pipe manufacturer specifications. A copy of the recommended fusion procedure supplied by the manufacturer of the pipe used will be maintained on site at all times. The CQA Officer will inspect fused joints on the well string. Unacceptable joints will be cut out and re done.

The well string will be placed into the borehole and suspended. The well string will be centered and held in tension by the use of blocks, chains, etc., until the entire gravel pack and well seal has been installed.

Gravel Pack

The casing and gravel pack will be installed in the wells as soon as drilling is completed to prevent the loss of the holes due to sloughing.

The 1"- 3" stone should be carefully poured into the annular space. Care should be taken to keep the gravel clean and to keep the well string centered as much as possible. The gravel pack should be installed to a minimum of 1 foot above the perforations.

Geonet Layer and Lower Bentonite Plug

A geonet with heat bonded geotextile on one side shall be installed above the gravel pack to isolate the bentonite plug or seal from the gravel.

Following placement of the isolation layer, the lower bentonite plug is to be installed as follows:

- The lower well seal will be formed by evenly distributed one 50 lb. bag of dry Baroid "Benseal" or an approved equal around the annulus of the well and then adding 5 gallons of fresh water in a manner that will allow for a thorough saturating of the bentonite material. This process will be continued until a minimum plug thickness of one foot has been achieved.
- For proper installation of this well plug, the bentonite material must be placed evenly around the annulus before hydrating or gelling.

Soil Backfill

Above the lower bentonite plug, the boring annulus shall be backfilled with soil backfill up to the level indicated on the Drawings. Care must be taken in order to distribute the backfill around the annulus in a manner to provide as much compaction as possible.

Upper Bentonite Plug

Formation of the upper bentonite plug will be achieved in the same manner as described for the lower bentonite plug. A minimum thickness of 2 feet shall be achieved. The intent of this top plug is to tie into the existing cover or material while providing a positive seal against the well pipe. Actual field conditions encountered may require various adjustments or modifications to the plug as designed.

Well Completion

The wellhead assembly, or approved equal, will be attached to the pipe casing with a flexible coupling and stainless steel clamps. The lateral shall be connected with flex hose, clamps and a flexible coupling. After installation of the header system, lateral connections will be made to the well heads and the remote wellheads for the leachate cleanout risers.

The CQA Officer, with assistance from the installer, will prepare an installation log for each extraction well including the following information:

- Number of Well Boring (from Site Plan Drawing)
- Date of Boring
- Total Depth of Boring

- ❑ Ground Surface Elevation
- ❑ Soil/Waste Profile
- ❑ Well Completion Details (including perforated length)
- ❑ Other

18.0 Seeding, Fertilizing, and Mulching

Specifications for vegetative work shall follow Sections 250 and 251, “Seeding” and “Mulching”, in the Illinois Department of Transportation (IDOT) Standard Specifications for Construction. Seeding mixture should comply with Table 1 or equivalent as approved by the Engineer, with the specific seed mixture to be determined based on the planting time and location (sloped or flat area).

19.0 Leachate Storage Tanks

By field observations and review of the manufacturer's literature, the CQA Officer will document tank capacity, leachate compatibility, secondary containment and tank integrity. Secondary containment volume should be equal to 110% of the capacity of the largest tank within each secondary containment structure.

20.0 MATERIAL ACCEPTANCE SPECIFICATION TABLES

Table 2.5-1
60 Mil Smooth HDPE Geomembrane Acceptance Specifications

Properties	Test Method	Required Values[11]	Manufacturer QC Test Frequency
Thickness (min. ave.) • Lowest individual of 10	ASTM D5199	60 mil 57 mil [12]	1 per Roll
Density (min. ave.)	ASTM D792 Method B or ASTM D1505	0.940 g/cc	1 per 200,000 lb (1 per 681,000 sf)
Tensile Properties [1] (min. ave.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	 126 lb/in. 228 lb/in. 12 % 700 %	1 per 20,000 lb (1 per 68,000 sf)
Tear Resistance (min. ave.)	ASTM D1004 Die C	42 lbs	1 per 45,000 lb (1 per 153,000 sf)
Puncture Resistance (min. ave.)	ASTM D4833	108 lbs	1 per 45,000 lb (1 per 153,000 sf)
Stress Crack Resistance [2]	ASTM D5397 (App.)	200 hours	[11]
Carbon Black Content (range)	ASTM D1603 [3]	2-3%	1 per 20,000 lb (1 per 68,000 sf)
Carbon Black Dispersion[4]	ASTM D5596	[4]	1 per 45,000 lb (1 per 153,000 sf)
Oxidative Induction Time (OIT)(min. ave.)[5] • Std. OIT, or • High Pressure OIT	 ASTM D3895 ASTM D5885	 100 min. 400 min.	1 per 200,000 lb (1 per 681,000 sf) [10]
Oven Aging at 85°C [5][6] • Std. OIT (min. ave.), % retained after 90 days, or • High Pressure OIT (min. ave.), % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	 55% 80%	1 per each formulation [10]
UV Resistance [7] • Std. OIT (min. ave.)[8] or • High Pressure OIT (min. ave.) % retained after 1600 hrs [9]	GM 11 ASTM D3895 ASTM D5885	 [8] 50%[10]	1 per each formulation [10]
Required Interface Friction Value	ASTM D-5321	(13)	1 per combination of materials in liner system cross-section

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens 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.

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value from MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   - 9 in Categories 1 or 2, and
   - 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(10) Manufacturer may provide certification letter.

(11) Based on GRI GM-13, Rev. 8, 7/10/06.

(12) IEPA regulations are more stringent than GM-13 specification of 54 mil.

(13) Required interface friction value: Equivalent shear strength at anticipated normal loads to achieve a FS ≥ 1.5 under static conditions

Table 2.5-2
60 Mil Textured HDPE Geomembrane Acceptance Specifications

Properties	Test Method	Required Values(13)	Manufacturer QC Test Frequency
Thickness (min. ave.)(1) • Lowest individual for 8 of 10 • Lowest individual, any of 10	ASTM D5994	60 mil (14) 57 mil (15) 57 mil (16)	1 per Roll
Asperity Height (min. ave.)(2)	GM 12	20 mil	1 per 2 Rolls (3)
Sheet Density (min ave.)	ASTM D792 Method B or ASTM D1505	0.940 g/cc	1 per 200,000 lb (1 per 681,000 sf)
Tensile Properties(4) (min. ave.) • Yield strength • Break strength • Yield elongation • Break elongation	ASTM D6693 Type IV	 126 lb/in 90 lb/in 12% 100%	1 per 20,000 lb (1 per 68,000 sf)
Tear Resistance (min. ave.)	ASTM D1004 Die C	42 lbs	1 per 45,000 lb (1 per 153,000 sf)
Puncture Resistance (min. ave)	ASTM D4833	90 lbs	1 per 45,000 lb (1 per 153,000 sf)
Stress Crack Resistance (5)	ASTM D5397 (App.)	200 hours	(13)
Carbon Black Content (range)	ASTM D1603 (6)	2-3%	1 per 20,000 lb (1 per 68,000 sf)
Carbon Black Dispersion(7)	ASTM D5596	(7)	1 per 45,000 lb (1 per 153,000 sf)
Oxidative Induction Time (OIT) (min. ave.)(8) • Std. OIT, or • High Pressure OIT	 ASTM D3895 ASTM D5885	 100 min. 400 min.	1 per 200,000 lb (1 per 681,000 sf) (13)
Oven Aging at 85°C (8)(9) • Std. OIT (min. ave.), % retained after 90 days, or • High Pressure OIT (min. ave.), % ret. after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	 55% 80%	1 per each formulation (13)
UV Resistance (10) • Std. OIT (min. ave.)(11) or • High Pressure OIT (min. ave.) % retained after 1600 hrs (12)	GM 11 ASTM D3895 ASTM D5885	 (11) 50%(12)	1 per each formulation (13)
Required Interface Friction Value	ASTM D5321	(17)	1 per combination of materials in liner system cross-section

(1) specification of 54 mil.
(2) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils.
(3) Alternate the measurement side for double sided textured sheet.
(4) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens 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.
(5) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
(6) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
(7) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
  - 9 in Categories 1 or 2, and
  - 1 in Category 3.
(8) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(9) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(10) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(11) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(12) UV resistance is based on percent retained value regardless of the original HP-OIT value.
(13) Manufacturer may provide certification letter.
(14) Based on GRI GM-13, Rev. 8, 7/10/06.
(15) IEPA regulations are more stringent than GM-13 specification of 57 mil.
(16) IEPA regulations are more stringent than GM-13 specification of 51 mil.
(17) Required interface friction value: equivalent shear strength at anticipated normal loads to achieve a FS ≥ 1.5 under static conditions.

Table 2.5-3
60 Mil HDPE Geomembrane Seam Testing Summary

Properties	Test Method[3]	Minimum Field and Lab Test Frequency	Acceptance Criteria
Shear Test [2]	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥120 lb/in. 5th test specimens have yield strength ≥96 lb/in. Elongation at break is ≥50%.
Peel Test [2] Hot Wedge Fusion	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥78 lb/in. 5th test specimens have yield strength ≥63 lb/in. Peel incursion is ≤25%. Locus-of-break other than AD and AD-Brk<25%.[1]
Peel Test Fillet Extrusion	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥78 lb/in. 5th test specimens have yield strength ≥63 lb/in. Peel incursion is ≤25%. Locus-of-break other than AD1, AD2, and AD-WLD (unless strength is achieved).[1]
Air-Pressure	GRI GM6	All dual track seams tested by Air Pressure	<3 psi drop in 5 minutes with initial pressure 30 psi, following an initial relaxation period.
Vacuum	N/A	All single track wedge and extrusion seams tested by Vacuum	Examine weld for approximately 10 seconds through window at vacuum of minimum 3 psig

(1) Locus of break codes are provided in ASTM D6392.
(2) For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
(3) Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 "Conditioning"). Destructive seams will be evaluated for elongation during cold weather seaming. Refer to Cold Weather Operations section of CQA plan.

Table 2.5-4
40 Mil Smooth LLDPE Geomembrane Acceptance Specifications

Properties	Test Method	Required Values[10]	Manufacturer QC Test Frequency
Thickness (min. ave.) Minimum individual	ASTM D5199	40 mil 38 mil [11]	1 per Roll
Sheet Density (max.)	ASTM D792 Method B or ASTM D1505	0.939 g/cc	1 per 200,000 lb (1 per 1,023,000 sf)
Tensile Properties (min ave)[1] Break strength Break elongation	ASTM D6693 Type IV	 152 lb/in. 800 %	1 per 20,000 lb (1 per 102,000 sf)
2% Modulus (max.)	ASTM D5323	2400 lb/in	1 per each formulation[9]
Tear Resistance (min. ave.)	ASTM D1004 Die C	22 lbs	1 per 45,000 lb (1 per 230,000 sf)
Puncture Resistance (min ave)	ASTM D4833	56 lbs	1 per 45,000 lb (1 per 230,000 sf)
Axi-Symmetric Break Resistance Strain (min.)	ASTM D5617	30%	1 per each formulation[9]
Carbon Black Content (range)	ASTM D1603 [2]	2-3%	1 per 45,000 lb (1 per 230,000 sf)
Carbon Black Dispersion[3]	ASTM D5596	[3]	1 per 45,000 lb (1 per 230,000 sf)
Oxidative Induction Time (OIT)(min. ave.)[4] Std. OIT, or High Pressure OIT	 ASTM D3895 ASTM D5885	 100 min. 400 min.	1 per 200,000 lb (1 per 1,023,000 sf) [9]
Oven Aging at 85°C [4][5] Std. OIT (min. ave.), % retained after 90 days, or High Pressure OIT (min. ave.), % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	 35% 60%	1 per each formulation [9]
UV Resistance [6] Std. OIT (min. ave.)[7] or High Pressure OIT (min. ave.) % retained after 1600 hrs [8]	 ASTM D3895 ASTM D5885	 [7] 35%	1 per each formulation [9]
Required interface friction value	ASTM D5321	(12)	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 2.0 inches at 2.0 in./min.

(2) Other methods such as D 4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2, and
- 1 in Category 3.

(4) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(5) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(7) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(8) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(9) Manufacturer may provide certification letter.

(10) Based on GRI GM-17, Rev. 5, 7/10/06.

(11) IEPA regulations are more stringent than GM-17 specification of 36 mil.

(12) Required interface friction value: Equivalent shear strength at anticipated normal loads to achieve a FS ≥ 1.5 under static conditions.

Table 2.5-5
40 Mil Textured LLDPE Geomembrane Acceptance Specifications

Properties	Test Method	Required Values[12]	Manufacturer QC Test Frequency
Thickness (min. ave.) Lowest individual for 8 of 10 Lowest individual any of 10	ASTM D5994	40 mil [13] 38 mil [14] 38 mil [15]	1 per Roll
Asperity Height (min. ave.)[1][2]	GM 12	20 mil	1 per 2 Rolls
Sheet Density (max.)	ASTM D792 Method B or ASTM D1505	0.939 g/cc	1 per 200,000 lb (1 per 1,023,000 sf)
Tensile Properties[3] (min. ave.) Break strength Break elongation	ASTM D6693 Type IV	 60 lb/in. 250%	1 per 20,000 lb (1 per 102,000 sf)
2% Modulus (max.)	ASTM D5323	2400 lb/in	1 per each formulation[11]
Tear Resistance (min. ave.)	ASTM D1004 Die C	22 lbs	1 per 45,000 lb (1 per 230,000 sf)
Puncture Resistance (min. ave)	ASTM D4833	44 lbs	1 per 45,000 lb (1 per 230,000 sf)
Axi-Symmetric Break Resistance Strain (min.)	ASTM D5617	30%	1 per each formulation[11]
Carbon Black Content (range)	ASTM D1603[4]	2-3%	1 per 45,000 lb (1 per 230,000 sf)
Carbon Black Dispersion[5]	ASTM D5596	[5]	1 per 45,000 lb (1 per 230,000 sf)
Oxidative Induction Time (OIT) (min. ave)[6] Std. OIT, or High Pressure OIT	 ASTM D3895 ASTM D5885	 100 min. 400 min.	1 per 200,000 lb (1 per 1,023,000 sf) [11]
Oven Aging at 85°C [6][7] Std. OIT (min. ave.), % retained after 90 days, or High Pressure OIT (min. ave.), % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	 35% 60%	1 per each formulation [11]
UV Resistance [8] Std. OIT (min. ave.)[9] or High Pressure OIT (min. ave.) % retained after 1600 hrs [10]	 ASTM D3895 ASTM D5885	 [9] 35%	1 per each formulation [11]
Required Interface Friction Value	ASTM D5321	[16]	

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils.
(2) Alternate the measurement side for double sided textured sheet.
(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 2.0 inches at 2.0 in./min.

(4) Other methods such as D 4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2, and
- 1 in Category 3.

(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(10) UV resistance is based on percent retained value regardless of the original HP-OIT value.
(11) Manufacturer may provide certification letter.
(12) Based on GRI GM-17, Rev. 5, 7/10/06.
(13) IEPA regulations are more stringent than GM-17 specification of 38 mil.
(14) IEPA regulations are more stringent than GM-17 specification of 36 mil.
(15) IEPA regulations are more stringent than GM-17 specification of 34 mil.
(16) Required interface friction value: Equivalent shear strength at anticipated normal loads to achieve a FS ≥ 1.5 under static conditions.

Table 2.5-6
40 Mil LLDPE Geomembrane Seam Testing Summary

Properties	Test Method[3]	Minimum Field Test Frequency	Acceptance Criteria
Shear Test [2]	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥53 lb/in. 5th test specimens have yield strength ≥43 lb/in. Elongation at break is ≥50%.
Peel Test [2] Hot Wedge Fusion	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥44 lb/in. 5th test specimens have yield strength ≥36 lb/in. Peel incursion is ≤25%. Locus-of-break other than AD and AD-Brk<25%.[1]
Peel Test Fillet Extrusion	ASTM D6392 (excl. Section 6.3, "Conditioning")	1 test per 500 lf and at least 1 test per seaming crew per day	4 of 5 test specimens have yield strength ≥44 lb/in. 5th test specimens have yield strength ≥36 lb/in. Peel incursion is ≤25%. Locus-of-break other than AD1, AD2, and AD-WLD (unless strength is achieved).[1]
Air-Pressure	GRI GM6	All dual track seams tested by Air Pressure	<4 psi drop in 5 minutes with initial pressure 20-30 psi, following an initial relaxation period.
Vacuum	N/A	All single track wedge and extrusion seams tested by Vacuum	Examine weld for approximately 10 seconds through window at vacuum of minimum 3 psig

Notes:
(1) Locus of break codes are provided in ASTM D6392.
(2) For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
(3) Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 "Conditioning"). Destructive seams will be evaluated for elongation during cold weather seaming. Refer to Cold Weather Operations section of CQA plan.

Table 2.5-7
Geotextile Tests and Test Methods

Property	Test Methods
Apparent Opening Size[1]	ASTM D4751
Grab Tensile Properties Tensile Strength Break Elongation	ASTM D4632
Mass Per Unit Area[2]	ASTM D3776
Permittivity[1]	ASTM D4491
Puncture Resistance	ASTM D4833
Trapezoidal Tear	ASTM D4533
Mullen Burst	ASTM D3786

NOTES:
[1] Testing required only for geotextile filter.
[2] Testing required only for geotextile cushion.

Table 2.5-8
6 oz/yd^2 Geotextile Acceptance Specifications

Property	Units	Type of Criterion	Acceptable Value[1]
Apparent Opening Size	Mm	Minimum	.210
Grab Tensile Properties[2] Tensile Strength Break Elongation	 lb %	 Minimum Minimum	 150 50
Permittivity	gal/min/ft^2	Minimum	90
Mass Per Unit Area	oz/yd^3	Minimum	6
Puncture Resistance	Lb	Minimum	90
Trapezoidal Tear[2]	Lb	Minimum	65

NOTES:
[1] Values are based on discussions with acceptable manufacturers and represent production values at the time this document was prepared. Minimum values are based on -2 standard deviations from average production values.
[2] These tests will be performed and results reported in both the machine and cross directions.

Table 2.5-9
8 oz/yd^2 Geotextile Acceptance Specifications

Property	Units	Type of Criterion	Acceptable Value[1]
Apparent Opening Size	Mm	Range	0.074 - 0.177
Grab Tensile Properties[2] Tensile Strength Break Elongation	 lb %	 Minimum Minimum	 200 50
Mass Per Unit Area	oz/yd^3	Minimum	7.2
Puncture Resistance	Lb	Minimum	100
Trapezoidal Tear[2]	Lb	Minimum	80

NOTES:
[1] Values are based on discussions with acceptable manufacturers and represent production values at the time this document was prepared. Minimum values are based on -2 standard deviations from average production values.
[2] These tests will be performed and results reported in both the machine and cross directions.

TABLE 2.5-10
Geonet Properties

Property	Units	Value	Test	Criterion
Thickness	mils	200	ASTM D1777	Minimum
Density	g/ cu cm	0.94	ASTM D1505	Minimum
Metal Flow Index	g/10 min	0.1 - 1.1	ASTM D1238	Range
Carbon Black Content	Percent	2 - 3	ASTM D1603	Range
Wide Width Tensile	lbs/in	40 MD, 20 XD	ASTM D1682	Minimum
NOTES: The transmissivity (ASTM D4716) of the geocomposite shall exhibit a minimum value of 3×10^{-5} m^2/sec when tested between a geomembrane and geotextile under a load of 15,000 psf.				

TABLE 2.5-11
Geocomposite Properties[1]

Property	Units	Value	Test	Criterion
Thickness	mils	200	ASTM D1777	Minimum
Density	g/ cu cm	0.94	ASTM D1505	Minimum
Melt Flow Index	g/10 min	0.1 - 1.1	ASTM D1238	Range
Carbon Black Content	Percent	2 - 3	ASTM D1603	Range
Wide Width Tensile	lbs/in	40 MD, 20 XD	ASTM D1682	Minimum

NOTES:
The geocomposite shall be manufactured by heat bonding the geotextile to the geonet on both sides. No burn through geotextiles nor glue or adhesive shall be permitted.
The bond between the geotextile and the geonet shall exhibit an average peel strength of 1 pound per inch with a minimum peel strength 0.5 pounds per inch according to ASTM D7005.
The transmissivity (ASTM D4716) of the geocomposite shall exhibit a minimum value of 3 x 10-5 m2/sec when tested between a geomembrane and geotextile under a load of 15,000 psf.

21.0 Forms

OFFICER-IN-ABSENTIA
Veolia ES Zion Landfill

Date: _____

Operator and Owner: _____

Contractor: _____

Third-party CQA Firms: _____

_____

Description of Construction: _____

CQA Officer: _____

Period of Designated Authority: _____

Reason for CQA Officer's Absence: _____

_____

_____

The undersigned understand and agree to the following:

Until further notice, _____ has been designated as the CQA Officer-in-Absentia as described above, and as such, shall exercise professional judgment in fulfilling the CQA Officer's duties as described in the site's CQA Plan. The CQA Officer assumes full personal responsibility for the performance of all inspections and reports prepared by, or under the direction of, the designated CQA Officer-in-Absentia.

CQA Officer	_____ Signature	_____ Date
	_____ Print Name	
CQA Officer-in-Absentia	_____ Signature	_____ Date
	_____ Print Name	
Operator/Owner	_____ Signature	_____ Date
	_____ Print Name	

NOTE: This form must be fully completed and must accompany the Construction Documentation Report