Part III
Attachment III-D
Appendix III-D.7

LINER QUALITY CONTROL PLAN

Pescadito Environmental Resource Center
MSW No. 2374
Webb County, Texas

PESCADITO
ENVIRONMENTAL RESOURCE CENTER

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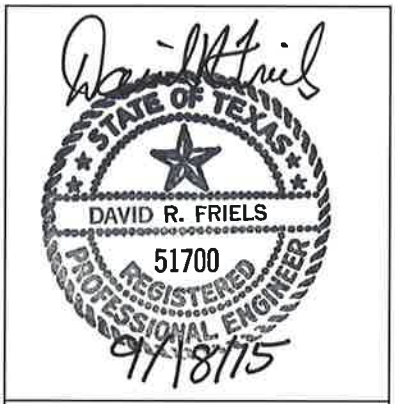

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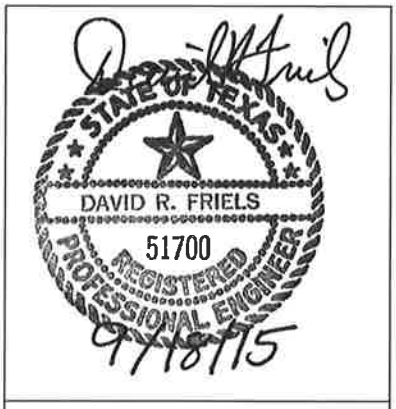

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1.0 INTRODUCTION

This Liner Quality Control Plan (LQCP) has been prepared on behalf of Rancho Viejo Waste Management for the Pescadito Environmental Resource Center (PERC). The purpose of this LQCP is to provide the Owner, Construction Quality Assurance Professional of Record, Earthwork Contractor, and Geosynthetics Contractor (as applicable) the means to govern the liner construction quality and to satisfy the environmental protection requirements. This LQCP has been prepared by a geotechnical/materials engineer licensed in the State of Texas and is part of the Site Development Plan for the landfill. This document has been prepared consistent with 30 TAC §330.339 of the Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Rules (MSWR), 30 Texas Administrative Code Chapter 330 and the Liner Construction and Testing Handbook published by the TCEQ and will provide guidance for:

- Materials, equipment, and construction methods for liner construction, and
- Liner testing, evaluation and reporting procedures.

1.1 Liner

PERC may accept industrial and municipal solid wastes for disposal (as well as liquid wastes for processing). The liner design is provided in Appendix III-D.3 to the Site Development Plan and will include (from the top down):

- Protective Cover
- Geosynthetic Drain
- 60-mil HDPE Geomembrane Liner
  - Option 1 – Utilizing geomembrane with bentonite bonded to one side (e.g., GundSeal or equivalent material) which does not require welded seams, hereinafter referred to as bentonite enhanced geomembrane (BEGM).
  - Option 2 – Utilizing geomembrane which will have welded seams.
- Compacted Clay Liner (CSL)

- 3-foot minimum thickness for Class 1 Industrial Waste
- 2-foot minimum thickness for MSW

1.2 Definitions

ASTM

American Society for Testing and Materials – an organization that publishes standards that are accepted internationally for numerous test methods and materials.

Compacted Soil Liner (CSL)

The compacted soil liner component of the composite liner system.

Conformance Tests

Conformance tests are tests of materials conducted by a third party to verify materials comply with project requirements and are part of the construction quality assurance (CQA) program.

Construction Quality Assurance (CQA)

Construction Quality Assurance (CQA) consists of a planned system of activities that provides the Owner and permitting agency assurance that the facility was constructed in accordance with the requirements of the plans, specifications, and permit for a project. CQA includes observations and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility and is performed by the POR and CQA monitor or a third party independent testing laboratory.

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR and are responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during liner construction and construction activities directly on the liner and reports directly to the POR. The CQA monitor shall be NICET-certified in geotechnical engineering technology at level 2 or higher for soils and geosynthetics, an

engineering technician with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) on behalf of the POR, and the CQA monitor may be assisted by monitors which do not meet the above experience levels.

Professional of Record (POR)

The Construction Quality Assurance Professional of Record (POR) is an authorized representative of the Owner and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer in Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitor working under the POR's direction. The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Construction Tests

Construction tests include tests of materials or constructed products that occur during construction. Testing may be conducted by the contractor if observed by the CQA monitor or may be performed directly by the CQA monitor.

Geomembrane Liner

The common industry term used to refer to high density or linear low density polyethylene sheets used as liner or cover material. Geomembrane and flexible membrane (FML) are often used interchangeable.

Geomembrane Liner Evaluation Report (GLER)

Certification report for the geomembrane liner prepared and sealed by the POR that is submitted to the TCEQ for approval. The report is also referred to as flexible membrane liner evaluation report (FMLER).

Geosynthetics Research Institute (GRI)

An organization supported by geosynthetics manufacturers, installers, consultants, and other interested parties that publishes certain standards for the geosynthetics industry.

Geotechnical Professional

The geotechnical professional (GP) is a Texas-licensed engineer who is experienced in geotechnical engineering. The GP will be responsible for the CQA activities and for preparing the liner reports. Also see POR.

Major Fraction Thereof

A term used to clarify that the calculated number of tests (or samples) determined for an area (or volume) may be rounded to the nearest whole number. It is the intent of this LQCP that where a frequency is specified it is understood that "major fraction thereof" will apply. For example with a test frequency of 1/500 lineal feet (lf) of seam; 7,200 lf will require 14 tests and 7,300 lf will require 15 tests.

Nonconformance

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

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor or manufacturer.

Soil Liner Evaluation Report (SLER)

Construction report prepared and sealed by the POR and submitted to the TCEQ to document the soil liner construction.

Subgrade

A surface that is exposed after stripping topsoil, filling low areas, or excavating to establish the grade directly beneath the first layer of the composite liner system.

1.3 Full Time Quality Assurance

Construction and testing of the liner system will be in accordance with this LQCP. All quality assurance (QA) activities will be under the direction of a licensed professional engineer experienced in geotechnical and materials engineering (POR). Full-time monitoring of the liner system construction, leachate collection system installation, and protective cover placement directly on geosynthetics is required by either the POR) or his representatives (i.e., CQA monitor). The POR will make periodic visits to the site during liner, leachate collection system, and installation cover placement to observe construction and CQA activities.

2.0 SUBGRADE AND GENERAL FILL

Prior to beginning liner construction, the subgrade will be excavated to the design base grade elevations and any low areas will be filled with compacted soil. The liner subgrade will be proof-rolled with rubber-tired construction equipment or a compactor to detect soft zones or areas subject to pumping. Areas of soft soils will be reworked and areas subject to pumping will be undercut to firm material and backfilled with suitable compacted earth fill. Visual examination of the subgrade preparation by the POR (or CQA monitor) and proof-rolling will generally be sufficient to evaluate suitability of the subgrade as a foundation for the liner system.

2.1 General Fill

General fill material will be used in the establishment of proper subgrade elevations and in the construction of perimeter embankments. General fill will be placed in uniform lifts that do not exceed 8 inches in loose thickness and are compacted to a dry density of at least 95 percent of standard Proctor (ASTM D 698) maximum dry density at a moisture content ranging from two percentage points below optimum to three percentage points above optimum (-2 to +3). It will not be necessary to include test results of general fill in the liner certification reports (SLER or GLER).

2.2 Surveying

Surveys will be conducted to verify the lines and grades of the liner system and establish the bottom elevation for cover thickness measurements. A survey grid will be established with a minimum of one point per 5,000 square feet of surface area (using a minimum of 2 points regardless of size) for thickness verification of the various liner components. The allowable vertical tolerance for the finished subgrade is – 0.2 feet to + 0 feet or as approved by the engineer.

The survey will be used to establish as-built information and verify that the:

- Subgrade (bottom of liner system) complies with design grades and does not extend below the approved permit grades (within accepted construction tolerances).

- Individual components meet the minimum thickness requirements at each of the grid points.
- Top of protective cover and leachate collection system (LCS) trenches comply with the design grades (within accepted construction tolerances).
- Coordinates of the constructed cell conform to cell design.

3.0 COMPACTED SOIL LINER

This section covers construction, inspection, and testing of the compacted soil liner (CSL) component of the composite liner system. The CQA monitor shall provide continuous observations during the CSL construction in accordance with §330.339(a)(2). The minimum CSL thickness, measured perpendicular to the surface being lined, will be as specified for the specific cell (i.e., 2 or 3 feet).

3.1 Liner Soil Requirements

The soil used for the compacted CSL shall be a cohesive, predominantly fine grained soil that meets or exceeds the following requirements:

- Clean and free of conspicuous organics, roots, or other debris
- Atterberg Liquid Limit (LL) not less than 30%, and Plasticity Index (PI) of not less than 15 (ASTM D 4318)
- Maximum particle size of 1 inch, at least 30% passing the No. 200 mesh sieve and no more than 10% by weight of rocks and stones (ASTM D 422 or 1140)
- Coefficient of permeability (hydraulic conductivity) of no greater than 1.0×10^{-7} cm/sec (Appendix VII of the U.S. Army Corps of Engineers Manual EM1110-2-1906 or ASTM D5084)

3.2 Preliminary Sampling and Testing Procedures

Preliminary soil sampling and testing will be performed on materials planned for use in soil liner construction to determine certain physical and engineering properties and verify the soil is suitable for construction of liners. Only clay soils that can be mechanically compacted to meet a coefficient of permeability (hydraulic conductivity) of no greater than 1.0×10^{-7} cm/sec and comply with the other requirements listed in 3.1 above may be used for liner construction.

Composite samples will be obtained by collecting equal volumes of clayey material from a number of locations within the liner material source. If material characteristics appear to change within the stockpile or borrow area, one composite sample will be obtained from each material

type planned for use in the liner construction. Samples will be sealed, labeled, and delivered to the laboratory for evaluation.

The laboratory will test each sample for Atterberg limits, percent passing the one-inch, No. 40, and No. 200 sieves, and the moisture-density relationship. The test procedures to be used are the most current versions of ASTM D4318, ASTM D422/1140, ASTM D2216, and ASTM D698 or ASTM D1557, respectively.

Hydraulic conductivity (laboratory permeability) testing will be conducted on test specimens formed by mechanically compacting the processed, and moisture conditioned, soil sample. The test specimens will be compacted using the standard Proctor (ASTM D 698) or modified Proctor (ASTM D 1557) compactive efforts or another approved modified effort. The compacted percent of the maximum dry density and moisture content at compaction will be adjusted as needed to establish the combination of soil compaction and moisture content that produces a laboratory sample that (a) meets the above stated maximum coefficient of permeability (i.e., no greater than 1.0×10^{-7} cm/sec) and (b) has an optimum moisture content sufficiently low to reduce shrinkage cracking in the constructed CSL. Once an acceptable coefficient of permeability is demonstrated by hydraulic conductivity testing, the percent compaction and moisture content of the demonstration test specimen becomes the minimum standards for use in field control. However, the minimum acceptable field compaction will meet or exceed the maximum dry density of 95% based on standard Proctor or 90% based on Modified Proctor.

Laboratory hydraulic conductivity (permeability) tests may be conducted in accordance with Appendix VII of the U.S. Army Corps of Engineers Manual EM1110-2-1906 or ASTM D5084. The permeant fluid must be tap water, water with a 0.005N solution of $CaSO_4$, or de-aired water.

3.3 Soil Liner Sampling and Testing

Each sidewall and floor area must be evaluated separately unless the two areas are constructed in a continuous monolithic fashion. Sampling and testing of the soil liner must be conducted during liner construction. All compacted clay liner samples will be visually inspected for compaction planes, permeable zones, poor compaction, or other problems, as well as to determine the appropriate reference moisture-density curve. Any compacted clay liner sections not meeting the

minimum standards on the first test will be reworked and re-tested, until the area meets the minimum standard. All test and sample locations will be identified by lift number and landfill grid coordinates on a drawing of the construction area.

3.3.1 Density and Moisture Content

For parallel lifts of bottom and slope liners, one test will be performed for each 8,000 square feet, or less, of surface area of lining for each six inches of depth (but no less than three density tests per six inch lift). For horizontal lifts of narrow wall liners, one test will be performed for each 100 lineal feet for each twelve inches of thickness. The test locations will be evenly distributed across each lift being tested. Any area appearing to be of questionable quality will be tested instead of, or in addition to, the area previously planned for testing. The dry density (compaction) obtained in the field must meet or exceed the maximum dry density and moisture content established by the laboratory demonstration sample. Additionally, the compaction must be at least ninety-five percent of the standard Proctor maximum dry density or 90% of the modified Proctor maximum dry density. Sections of compacted clay liner that do not pass the density and moisture requirements will be reworked and re-tested until the section in question does pass. All holes created for density machine probes will be backfilled with a liner material enriched with at least 20% bentonite or a suitable bentonite grout.

3.3.2 Sieve Analysis and Atterberg Limits

Bulk samples will be collected for analysis to determine the Atterberg limits and the percent passing the one-inch, No. 40, and No. 200 sieves. For parallel lifts of bottom or slope liners, there will be a minimum of one test sample for each 100,000 square feet of surface per 6-inch lift, or major fraction thereof, but no less than one test per six inch lift. For horizontal lifts of wall liners, a minimum of one test per 2,000 lineal feet for each 12 inches of horizontal liner will be performed. Test procedures and material requirements must comply with those given above in Section 3.2. If either the LL or PI varies by more than 10 points, the material is considered to have changed and will require a new laboratory test series (i.e., Proctor moisture-density relationship, Atterberg Limits, sieve analyses, and coefficient of permeability).

3.3.3 Coefficient of Permeability

Undisturbed samples of the constructed liner will be collected for permeability testing. These samples will be collected by pushing a Shelby tube sampler into the compacted lift (or by another suitable sampling method such as hand carving). The void left by the sampling device will be backfilled with a liner material enriched with at least 20% bentonite or a suitable bentonite grout. For parallel lifts of bottom or slope liners, a minimum of one test sample for each 100,000 square feet of surface area per 6-inch lift, or major fraction thereof, but no less than one test per six-inch lift of parallel liner will be taken. For horizontal lifts of wall liners, a minimum of one test per 2,000 lineal feet (for each twelve inches of horizontal liner) will be taken. Each sample shall be tested in the laboratory using a falling head procedure (Appendix VII of the U.S. Army Corps of Engineers Manual, EM1110-2-1906) or a constant head procedure (ASTM D5084). The permeant fluid must be tap water, water with a 0.005N solution of $CaSO_4$, or de-aired water. The liner coefficient of permeability (hydraulic conductivity) must not exceed 1×10^{-7} cm/sec.

3.3.4 Thickness Verification

Elevation of grid points taken with field surveying equipment before and after compacted clay liner placement will be used to determine constructed liner thickness. Elevations will be taken at a minimum of one per 5,000 square feet of surface area or major fraction thereof. Minimum allowable thickness is the thickness measured perpendicular to the liner surface. If the lined area under evaluation is less than 5,000 square feet, a minimum of two reference points is required for verification.

3.4 Construction of Compacted Soil Liners

3.4.1 Placing and Compacting

For excavation surfaces with a slope of 3 horizontal to 1 vertical (3H: 1V) or flatter, liner construction may utilize lifts parallel to the surface. For excavation surfaces that have steeper than 3H: 1V slopes, liners will be placed in successive horizontal soil lifts; however, such lifts must be sufficiently wide to safely accommodate both the construction equipment and the related placement and compaction operations.

The CSL must be constructed in compacted layers or lifts using a maximum loose lift thickness of eight inches (six-inch nominal compacted thickness). Layers may be formed by utilizing equipment that will spread the material as it is dumped. Alternately, layers may be formed by spreading or blading from piles or windrows previously dumped by excavating or hauling equipment in such amounts that the material is evenly distributed. Prior to compaction the soil shall be processed to the required moisture content and until the maximum clod size is not greater than 1 inch in diameter.

Water used for sprinkling must be clean and shall not have been in contact with solid waste or other objectionable matter. Water required to bring the material to the moisture content necessary for maximum compaction will be sprinkled evenly across each lift as needed to achieve a uniform moisture content within the required range throughout each lift. The liner material must not contain rocks, stones, or clods larger than one inch. In all cases, clayey material clods will be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory and to destroy any macrostructure after the compaction of the clods under density-controlled conditions.

The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the compacted lift thickness must not be greater than the pad or prong length. This is necessary to achieve adequate bonding between lifts and to reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clayey material to the point that they cannot achieve full penetration during initial compaction. A pad-footed or prong-footed roller shall be used to achieve bonding, to reduce the individual clod sizes, and to achieve a blending of the clay liner matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The compactor should be matched by type, weight, and compactive effort to the soils and specified laboratory moisture/density relationship (Proctor). Use of a dozer or other track-mobilized equipment for the primary compactor is prohibited unless the equipment is used to pull an approved pad/tamping-foot or sheep's-foot roller. Unless approved otherwise by the

engineer, the compactor shall have a minimum weight of 40,000 pounds and have tamping foot wheels with a minimum foot length of 7 inches.

3.4.2 Liner Tie-Ins

New liner sections will be properly tied back into previous liner sections to ensure continuous liner coverage by cutting back the previous liner section. Continuous floor liners will not be constructed by "butting" the entire thickness of a new liner segment to the previous section with a vertical or near vertical joint between the two sections. Proper tie-in of the two sections will use "stair-step" construction with each lift offset into the previous liner forming steps or benches, or the previous liner may be cut back on a slope of approximately 5:1 and new liner lapped over the previous liner. The length of the tie-in overlap of the new and old sections will be at least 5 feet per foot of liner thickness.

3.4.3 Surface Preparation and Maintenance

The completed surface of the CSL will provide the subgrade for the geomembrane liner component of this composite liner system. The finished surface shall be relatively smooth and free of foreign and organic material, sharp objects, exposed soil or aggregate particles greater than 3/4 inch, or other deleterious materials. The top surface of the completed compacted clay liner will be bladed and proof-rolled with a smooth-wheel compactor to provide a smooth surface for installation of the geomembrane component. Liner thickness verification will be conducted after proof-rolling. The surface of the CSL must be maintained moist and free of shrinkage cracks and will be sprayed with water as needed. The finished CSL component of the composite lining system must be approved by the POR before placement of the geomembrane component(s).

On sidewall liner sections with surfaces steeper than 3H: 1V where horizontal lifts have been used, the completed liner will be graded with smooth bucket equipment such as a Gradall® or track hoe to obtain a smooth surface for installation of the geomembrane component and to shave the liner back to the thickness tested, but in no case to less than three feet in thickness. Since the sidewall liner will be installed and tested to a minimum of equipment width, irregularities in the surface can simply be smoothed out; however, the sidewall liner

must meet minimum thickness requirements. Sidewall soil liner thickness will be determined using standard surveying techniques.

4.0 GEOMEMBRANE WITH BENTONITE (Option 1)

PERC has two approved geomembrane liner options for the waste containment units. The first option is to utilize a geomembrane liner that has sodium bentonite (montmorillonite) bonded to one side of the geomembrane. With this option the geomembrane will consist of 60-mil HDPE and comply with the same material specifications used for geomembrane without the bentonite surface provided in the following section. The presence of the bentonite allows the liner to be installed without welding the seams. The panels are overlapped a minimum of 12 inches and the bentonite between the two geomembrane surfaces provides a satisfactory seam. This section specifically addresses geomembrane liner with bentonite bonded to one side. The following section (Section 5) addresses geomembrane that does not utilize the bonded bentonite and does require welded seams. With the exception of bentonite seams and other differences specific to this material, the requirements given in the following section apply to the geomembrane with the bonded bentonite.

The geomembrane with bentonite shall consist of a 60-mil HDPE with approximately 0.75 lb/ft^2 of high quality sodium bentonite bonded to one side of the HDPE. The HDPE will be smooth or textured as shown on the construction plans (and permit drawings). The bentonite will provide bonding agent between the geomembrane and CSL components to achieve direct and uniform contact.

GundSeal (typically referred to as a geomembrane backed GCL and manufactured by GSE Lining Technology, Inc., Houston, Texas), or an approved equal product will be used to provide the geomembrane with bentonite bonded to one side. Herein the geomembrane with bentonite will be referred to as BEGM. To be an approved equal BEGM product, the material will have to meet or exceed the project specifications.

4.1 Manufacturing Quality Control (MQC) Testing

The MQC testing provided by the manufacturer shall be in accordance with the current editions of GM13 (HDPE geomembrane) and GCL3 (as applicable for the bentonite component), and shall meet or exceed the manufacturer's specified values for that product. Notwithstanding GRI and manufacturers specifications, the minimum acceptable average

thickness for a 60-mil HDPE geomembrane shall be 60 mils, and the lowest individual value may be 54 mils. Certifications and test results for each lot of BEGM shall be submitted to the POR for review and approval and the documentation will be included in the GLER. The bentonite certified values should include bentonite mass/unit area (on a dry weight basis).

4.2 Delivery

The BEGM shall be shipped in rolls which are wrapped individually in relatively impermeable and opaque protective covers. The rolls must be unloaded and handled with equipment that will not damage the material and may be stacked only as allowed by manufacturer's recommendations (typically a maximum of three rolls high). The rolls must be stored above ground and protected from surface water and covered by an additional waterproof cover (i.e., canvas tarp, plastic sheet) until installation. Refer to Section 5.2 for additional general requirements that apply to the GM as well as the BEGM.

4.3 Conformance Testing

A minimum of one BEGM sample will be obtained for each 100,000 square feet of geomembrane installed with at least one sample for every resin lot of material. The material will be sampled at the site by the CQA monitor or at the manufacturing plant by the third party laboratory. Samples will be taken across the entire roll width and will typically be approximately 15 inches wide. Each sample will be marked with machine direction and the manufacturer's roll identification number. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Thickness (ASTM D 5199 for smooth geomembrane and ASTM D 5994 for textured)
- Specific gravity/Density (ASTM D 1505 or D 792)
- Tensile Properties (ASTM D 6693, Type IV)
- Carbon Black Content (ASTM D 1603)

- Carbon Black Dispersion (ASTM D 5596)

Conformance testing for the bentonite shall include bentonite mass for at least one sample per material lot with a minimum of one sample for each 100,000 square feet of BEGM installed.

4.4 BEGM Deployment

The subgrade for BEGM will be the approved CSL surface and will be smooth and free of all rocks greater than 0.75-inch (18-mm) diameter, sharp/angular objects sticks, roots, or debris of any kind with no sudden, sharp, or abrupt changes or breaks in grade.

4.4.1 Panel Placement

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations. During panel placement the POR or CQA monitor must:

- Record roll numbers, panel numbers, and dimensions on the panel logs. Field thickness measurements will not be required.
- Observe that the BEGM is installed in direct contact with the underlying CSL (or underlying BEGM where secondary BEGM is used) without bridging or excessive wrinkling.
- Observe the sheet surface as it is deployed and record all panel defects and repair of the defects on the repaired sheet. All repairs must be made in accordance with the specifications and located on a repair drawing.
- Observe that vehicular traffic is not allowed on the BEGM. Only low pressure support equipment with a contact pressure less than 5 psi and a total weight less than approximately 750 pounds will be allowed on the geosynthetics.
- Observe that the surface beneath the BEGM has not deteriorated since previous acceptance.

- Observe that there are no stones, construction debris, or other items beneath the BEGM that could cause damage to the BEGM or underlying CSL.
- Observe that the BEGM is not dragged across a surface that could damage the material.
- Record weather conditions including temperature and wind. The BEGM should not be deployed during inclement weather such as rain or freezing temperatures and should not be placed on frozen ground or standing water. Deployment when there is excessive wind (i.e., winds that could lift and move the BEGM panels) should also be avoided.
- Observe that people working on the BEGM do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind. Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor.
- Observe that panels are deployed generally parallel to the slope direction and there are no horizontal seams on sidewalls that are steeper than 6H: 1V. A panel shall extend from the anchor trench to a minimum of approximately 5 feet past the toe of the slope. The landfill has been designed to allow construction of slope lining in stages where the slope liner will be terminated in an interim anchor trench at the upper end of each stage. If only part of a sidewall is lined, the panel will extend from the interim anchor trench to a minimum of 5 feet past the toe of the slope (for the first stage). For succeeding stages the BEGM liner can be cut along the interim anchor trench, the new panel welded to the existing lower panel, and the new panel extended upward to another anchor trench (either interim or final).

If excessive wind conditions exist, the installation contractor must have a large enough crew to adequately deploy the panels without injury to personnel or damage to the panels. Additionally there shall be sufficient sand bags distributed to maintain the panel in position until it is covered.

The BEGM will generally be installed with the bentonite side down to provide the contact with the CSL. However, on the sidewall, a secondary BEGM liner will be installed under the primary BEGM liner component to encapsulate the bentonite. In this case, the secondary BEGM will be installed bentonite side up resulting in the two bentonite surfaces in contact. The installation procedures for these two methods are different; given that additional care must be taken when installing BEGM bentonite side down to prevent bentonite from dislodging from the geomembrane backing. The BEGM installation is illustrated on the project plans (and also on permit drawings).

Bentonite Side Down - The BEGM roll should be aligned next to the adjacent BEGM sheet prior to unrolling. The installation equipment will then begin unrolling the panel as the equipment moves in the direction of material deployment. Panels will be overlapped using printed lines on the panel for control. BEGM seam acceptability will be based on a smooth, flat seam, free of significant wrinkles with the overlap of 12 inch (or as specified by the manufacturer and approved by the engineer).

Bentonite Side Up - Methods of deployment range from manually pulling the BEGM material from a suspended roll to securing the roll end and unrolling each panel as the equipment slowly moves backwards. Under no circumstances will the bentonite lining be subject to materials, sandbags, equipment, or other items being dragged across its surface, nor will workmen and others slide down slopes on top of the lining material. All scuffed or scratched surfaces resulting from abuse of any kind will be repaired or discarded and replaced at the GP's direction.

For final material alignment, laborers should manually move the panels to the proper position with the required overlaps. Special clamps or vise grips can be utilized by laborers for handling, but are not required. Placement of the BEGM will be done such that good fit, without bridging, is provided on all covers and grade changes. Deployed panels should contain no folds or excessive slack that could cause rippling during the soil cover placement. Refer to Section 5.4.3 for additional general requirements that apply to the GM as well as the BEGM.

4.4.2 Equipment

Equipment used to deploy BEGM over soil shall not cause excessive rutting of the subgrade. Only lightweight equipment with low contact pressure rubber tires (i.e., less than approximately 5 psi) will be allowed on the BEGM. Generators or gasoline or solvent cans or other equipment that may damage the liner shall not be placed directly on the liner. Generators or other necessary equipment may be placed on a rub sheet. Installation personnel shall not smoke or wear damaging shoes when working on BEGM. Protective cover should be placed as soon as practicable after completion of geosynthetics for protection against damage from elements or equipment and premature hydration.

Sidewalls - On sidewalls rolls shall be unrolled parallel to the direction of the slope (not across slope). Panels should be anchored at the top of the slope and then unrolled down slope to prevent wrinkles and folds. Horizontal seams shall not be allowed on slopes steeper than 7H: 1V except where the roll length is less than the slope length (anchor trench to 5 feet past the toe or berm). See Section 4.5.3.

4.4.3 Anchor Trenches

Anchor Trenches will be excavated prior to BEGM placement to the depths and widths shown on design drawings. If the anchor trench is excavated in a clay liner susceptible to desiccation, no more than the amount of trench required for BEGM to be anchored in one day will be excavated (unless otherwise specified). Trench corners will be slightly rounded to avoid sharp bending of the BEGM. BEGM material will not be placed into the anchor trench on top of any rocks greater than 1-inch diameter or sharp/angular objects, sticks, roots, or debris of any kind.

4.4.4 Moisture Protection

BEGM placement will not take place during any precipitation, in the presence of excessive moisture, or in the presence of excessive winds (unless wind barriers are provided). When BEGM is deployed with the bentonite side up (geomembrane against the subgrade), to the extent practicable the exposed bentonite will be covered on the same day. Alternatively, a temporary geomembrane (rain flap) may be used.

4.5 Seams

4.5.1 Panels

Panels of BEGM will be of such lengths and widths and will be placed in such a manner as to reduce field seaming to a minimum. The panels will be anchored in accordance with details shown on approved plans and drawings. The liner will be anchored and sealed to structures, pipes, and other types of penetrations, if any, in accordance with details shown on approved plans and drawings.

4.5.2 Seaming

Seaming will be in accordance with the manufacturer's recommendations. Seams between adjacent BEGM panels are accomplished by simply overlapping edges. The POR will assure that there are no holidays in the bentonite backing of the BEGM. Overlaps will be "shingled" in the down-slope direction (for the bentonite down condition). If a secondary bentonite up layer is used, the overlap will be shingled up slope to reduce groundwater access to the seam. No added granular bentonite is required for typical BEGM seams. Overlap distance of all seams will be a minimum twelve inches, unless a different overlap is recommended by the manufacturer and approved by the engineer. Where subgrade settlement or soft subgrade conditions are anticipated, the overlap distance can be increased to twenty-four inches to allow for movement and to insure long term seam performance. Lap lines are printed on the lengthwise edges during the manufacturing process to facilitate added accuracy of the overlap distance and installation shall confirm to the lab lines unless directed otherwise by the engineer. All seams and seals of the BEGM will be smooth and flat upon completion of the work. Any lining surface showing injury

due to scuffing or penetration by foreign objects or showing distress will be replaced or repaired as directed by the POR.

On occasion where the manufactured roll length is less than the slope length (i.e., length from anchor trench to 5 feet past the toe) it will be necessary to have end laps. Horizontal seams may be used on sidewalls (steeper than 7H: 1V) only if the full roll length is too short to extend from the anchor trench to 5 feet past the toe of the slope. Horizontal seams, if used, are to be constructed as follows:

- Horizontal seams will be located on the lower half of the slope
- There will be a minimum overlap of 3 feet, shingled in the down slope direction
- Seams will be staggered; i.e., the horizontal seams will be at least 10 feet apart for any two adjacent panels

4.6 Repairs and Patching

Repairs shall be constructed in accordance with the manufacturer's recommendations. Damaged areas of BEGM will be repaired by placing a patch of the same BEGM material over the damaged area. Overlap distance of the patch around the damaged area will be a minimum twelve inches. For installations with the geomembrane side up, the patch can be secured to the installed BEGM geomembrane backing with duct tape or the equivalent. Bentonite enhancement will be provided if inadequate bentonite is present on the patch.

4.7 Construction Quality Assurance

During unwrapping of lining material for use and placement, all materials, particularly surfaces of lining sheets, will be visually examined by the POR or his representative for imperfections and faulty areas. All such defective places will be marked and repaired in accordance with approved methods. If the bentonite coating of BEGM becomes wet, allow air drying before installation. (Note: BEGM bentonite coating will be sufficiently dry for installation when desiccation marks show across the bentonite surface.) For roll edges that become hydrated, the overlap will be increased by the width of bentonite wetting to insure a minimum six inches of dry bentonite overlap.

Direct observation will be provided by the CQA team to assure that the panels have been installed properly, and that proper QA/QC procedures have been followed correctly. Installation of the BEGM panels will be in accordance with the manufacturer's recommendations and this LQCP. Overlap of the bentonite-backed panels obviates the need for further QA/QC testing since the seams are self-sealing. All seams will be smooth, flat, and without fish mouths to assure good contact between the panel edges or ends. The POR or his representative shall have authority to order an immediate stoppage of work because of improper installation procedures, or for any other reason, which may result in a defective liner.

5.0 GEOMEMBRANE LINER (Option 2)

This Section addresses geomembrane (GM) liner that requires the panels to be seamed by welding. The geomembrane liner material shall consist of high density polyethylene (HDPE) smooth or textured sheets complying with the current edition of GRI Test Method GM13 (GM13). Unless otherwise approved by TCEQ and the design engineer, the HDPE GM liner shall have a minimum nominal thickness of 60 mils.

5.1 Manufacturing Quality Control (MQC) Testing

The types and GM frequencies of the manufacturer's quality control testing of the resin and GM shall be in accordance with the current edition of GM13. With the exception of thickness the test results shall meet or exceed the requirements of GM13 (or the manufacturer's specification if no GM13 specification is applicable). The minimum acceptable average thickness for a 60-mil HDPE sample shall be 60 mils, and the lowest individual value may be 54 mils. Certifications and test results for each lot of GM shall be submitted to the POR for review and approval. The documentation will be included in the GLER.

5.2 Delivery

- The GM will be delivered in rolls and not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the GM will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets will not damage the GM.
- The GM will be stored in an acceptable location in accordance with the specifications and stacked not more than five rolls high. The GM shall be protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Rolls shall be protected with a sacrificial cover or under roof if stored on site more than 6 months.

- All manufacturing documentation required by the LQCP will be reviewed for compliance with the specifications. This documentation will be included in the GLER.
- The geosynthetics received log form will be completed for all materials received.

GM that does not have proper manufacturer's documentation or is damaged must be stored at a separate location until all documentation has been received, reviewed, and accepted.

5.3 Conformance Testing

A minimum of one GM sample will be obtained for each 100,000 square feet of GM installed with at least one sample for every resin lot of material. The frequency for material thickness testing will be increased to one sample per 50,000 square feet in lieu of thickness testing during GM deployment. The material will be sampled at the site by the CQA monitor or at the manufacturing plant by the third party laboratory. Samples will be taken across the entire roll width and forwarded to the third-party laboratory for the following conformance tests:

- Thickness (ASTM D 5199 for smooth GM and ASTM D 5994 for textured) – *one thickness test per 50,000 sf of material installed*
- Specific gravity/Density (ASTM D 1505 or D 792)
- Tensile Properties (ASTM D 6693, Type IV)
- Carbon Black Content (ASTM D 1603)
- Carbon Black Dispersion (ASTM D 5596)

5.4 GM Installation

5.4.1 Continuous Inspection

The POR or the CQA monitor will provide continuous, full time inspections of the GM liner installation and related GM field testing (conducted by the contractor) consistent with §330.339(a)(2). The POR will make sufficient site visits to during GM installation to document the installation and testing in the GLER.

5.4.2 Subgrade

The GM will be installed over the CSL after all required verification and testing in accordance with Section 3. Prior to GM deployment, the CSL surface shall be rolled with a smooth drum roller and the surface shall be free of irregularities, soft areas, and loose soil. Additionally the surface shall be free of stones, protrusions, or other objects that could damage the GM.

5.4.3 Panel Placement

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations. During panel placement the POR or CQA monitor must:

- Record roll numbers, panel numbers, and dimensions on the panel logs. Field thickness measurements will not be required if conformance thickness tests are conducted at a minimum frequency of 1 measurement per 50,000 sf of installed GM.
- Observe that the GM is installed in direct contact with the underlying CSL without bridging or excessive wrinkling.
- Observe the sheet surface as it is deployed and record all panel defects and repair of the defects (panel rejected, patch installed, extrudate placed over the defect, etc.) on the repaired sheet. All repairs must be made in accordance with the specifications and located on a repair drawing.
- Observe that vehicular traffic is not allowed on the GM. Only low pressure support equipment with a contact pressure less than 5 psi and a total weight less than approximately 750 pounds will be allowed on the geosynthetics.
- Observe that generators and other support equipment are placed on a rub sheet if used on the GM liner.
- Observe that the surface beneath the GM has not deteriorated since previous acceptance.

- Observe that there are no stones, construction debris, or other items beneath the GM that could cause damage to the GM or underlying CSL.
- Observe that the GM is not dragged across a surface that could damage the material.
- Record weather conditions including temperature and wind. The GM should not be deployed during inclement weather such as rain or freezing temperatures and should not be placed on frozen ground or standing water. Deployment when there is excessive wind (i.e., winds that could lift and move the GM panels) should also be avoided.
- Observe that people working on the GM do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown GM). Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe the seaming (welding) of the panel edges and ends (if the end is not terminated in an anchor trench. Document panel seaming on logs for review by the POR and insertion in the GLER.
- Observe that panels are deployed generally parallel to the slope direction and there are no horizontal seams on sidewalls that are steeper than 6H: 1V. A panel shall extend from the anchor trench to a minimum of approximately 5 feet past the toe of the slope. The landfill has been designed to allow construction of slope lining in stages where the slope liner will be terminated in an interim anchor trench at the upper end of each stage. If only part of a sidewall is lined, the panel will extend from the interim anchor trench to a minimum of 5 feet past the toe of the slope (for the first stage). For succeeding stages the GM liner can be cut along the interim anchor trench, the new panel welded to the existing lower panel, and the new panel extended upward to another anchor trench (either interim or final).

If excessive wind conditions exist, the installation contractor must have a large enough crew to adequately deploy the panels without injury to personnel or damage or loss to the panels. Additionally there shall be sufficient sand bags distributed to maintain the panel until it is seamed.

5.4.4 Trial Welds

Prior to GM welding, each welder and welding apparatus (both wedge and extrusion welders), must be tested at daily start-up and after midday break to determine if the equipment is functioning properly. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, or if weather conditions have changed substantially since the trial welds were performed, or a machine is turned off for longer than 30 minutes; additional trial weld tests should be performed. The test weld must be allowed to cool to ambient temperature before testing. The GLER should include the names (or initials) for each welding personnel and the time and the temperatures for each welding machine used each day, and the machine identification. Welding of liner seams must not commence until the trial seam for that welding machine is tested and approved. The combination of welder and machine must be tested for extrusion welds; however, additional tests are not required if the operator of a fusion welder is changed. The trial weld sample should be approximately 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required for two peel tests of each side of the weld). Welding operations and trial seam testing will be conducted by the contractor and monitored by the CQA monitor. The tensiometer used for field testing must have a current calibration certificate. Test results shall be recorded on the trial weld form. It is very important that the trial weld be completed under conditions similar to those under which the panels will be welded. The trial weld break must be ductile and exhibit film tear bond (FTB). Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch). The peel strength shall be at least 62 percent of the manufacturer's parent sheet strength but not less than 78 ppi, and the minimum shear strength shall be at least 95 percent of the manufacturer's parent sheet strength, but not less than 120 ppi. For dual-track fusion welds, both

sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. The manufacturer's parent sheet strength will be the tensile yield strength certified by the manufacturer.

5.4.5 Field Seaming

A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. Unless otherwise approved by the POR the seam number will incorporate the adjacent panel numbers (e.g., the seam located between Panels 36 and 41 would be Seam No. 36/41 and may be abbreviated by 36/41.

During GM welding operations, the CQA monitor must observe the following:

- Equipment used for welding functions properly and will not damage the GM.
- The extrusion welder is purged prior to beginning a weld until all the heat-degraded extrudate is removed.
- Seam grinding has been completed less than one hour before extrusion welding a seam and the upper sheet is beveled.
- The ambient temperature, measured 6 inches above the GM surface, is between 32 and 104 degrees Fahrenheit. Special approval by the manufacturer and design engineer is required if seams are to be welded when the ambient temperature is outside this range.
- Deployment and seam welding or liner repairs will not be permitted at night unless adequate lighting is provided and the liner surface is free of condensation or other moisture accumulation.
- Deployment and seam welding will not be conducted during falling precipitation or in standing water.
- The ends of old extrusion welds, more than five minutes old, are ground to expose new material before restarting a weld.

- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding and the weld is free of dust, rocks, and other debris.
- The seams are overlapped in the downgrade direction a minimum of 4 inches or in accordance with manufacturer's recommendations for welding.
- Seams are oriented parallel to the line of maximum slope with no horizontal seams on side slopes that are steeper than 6H:1V (except for the designed partial slope liner where the panel extends from the upper anchor trench to 5 feet past the lower anchor trench or toe of the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- At the end of each day or installation segment, all unseamed edges are anchored with sandbags or other approved methods. Penetration anchors or other methods that will damage the GM or underlying CSL shall not be used.

5.5 Field Seam Evaluations

5.5.1 Nondestructive Seam Testing

The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests are required for all GM seams and repairs and include vacuum testing and air pressure testing. Nondestructive testing must be performed over the entire length of all seams where possible.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing performance is in compliance with the specifications and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section which has been thoroughly wetted with a soapy water solution consisting of approximately 1 oz. soap to 1 gallon water. The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is adjusted to approximately 3 to 5 psi gauge. Any pinholes, porosity or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Minimum dwell time prior to moving the box must not be less than ten seconds.

Air pressure testing is used to test dual-track welds with an enclosed air space. Both ends of the air channel should be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi or ½ psi per mil of GM thickness, whichever is greater. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air to verify there was no blockage. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. If a blockage is detected, isolate the blockage and test the seam on both sides of the blockage. After air testing, the penetration holes must be sealed by extrusion welding or patched and tested as a repair.

During nondestructive testing, the CQA monitor shall:

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

- Observe that testing is completed in accordance with the LQCP, and record results on the appropriate log.
- Identify the failed areas by marking the area with a water based marker compatible with the GM and inform the contractor of any required repairs.
- Observe that all repairs are completed and tested in accordance with this LQCP and the project specifications.
- Record all completed and tested repairs on the repair log and the repair drawing.

5.5.2 Field Destructive Seam Sampling

Destructive seam tests for GM seams will be performed at a frequency of at least one test per 500 lineal feet of seam. Individual liner repair welds and field seam cap welds of 10 feet or more in length (i.e., the weld length along one side of the cap or patch that exceeds 10 feet) are to be included with the total length of seams when determining the minimum number of tests. The CQA monitor may perform additional tests if he suspects a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Insufficient overlap
- Adverse weather conditions (i.e., excessive dust or high humidity – condensation, or precipitation)
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Excessive failing tests by the same welder or equipment

The CQA monitor selects locations where seam samples will be cut for laboratory testing as follows:

- A minimum of one random test within each 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.
- Sample locations should not be disclosed to the contractor prior to completion of the seam.
- A minimum of one sample for each welding machine used for seaming or repairs. Any welding machine (fusion or extrusion) not used for welds at least 10 feet long will not require destructive testing.
- Samples taken as the result of failed tests do not count toward the total number of required tests.

The contractor will remove samples at locations identified by the CQA monitor. For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number which contains the seam number and destructive test number.
- Record sample location on the panel layout drawing
- Record the sample location, weather conditions, and note the reason sample was taken if for a purpose other than random testing.

5.5.3 Field Destructive Seam Testing

The contractor shall cut two 1-inch-wide coupons from each end of the sample and test two of these coupons in peel (one peel from each end) and one coupon in shear using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of

the air channel shall be tested in peel. The CQA monitor should observe the tests and record the results on the destructive seam test log. The weld break must be ductile and exhibit film tear bond (FTB). Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch) during peel testing. The peel strength shall be at least 62 percent of the manufacturer's parent sheet strength but not less than 78 ppi, and the minimum shear strength shall be at least 95 percent of the manufacturer's parent sheet strength, but not less than 120 ppi. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test, and if one coupon fails on either side, the seam is considered unsatisfactory.

If the field test coupons are satisfactory, divide the remaining sample into two parts: one approximately 12-inch by 15-inch section for the third party laboratory for testing and one approximately 12-inch by 12-inch section for the owner to archive. The laboratory sample will be shipped to the third party laboratory for delivery and testing. The archive sample shall be retained until the GLER has been approved by the TCEQ.

5.6 Third Party Laboratory Seam Testing

5.6.1 Samples

Destructive samples (typically approximately 12 inches wide with the weld centered and approximately 15 inches long) must be shipped to the third party laboratory for seam testing. Testing for each sample shall include 5 peel tests and 5 shear tests. For dual-track welds each peel test specimen (coupon) shall be tested on both sides of the air channel (i.e., the inner and outer welds), and if either side of a dual-track weld fails, the coupon fails.

5.6.2 Peel Test Requirements

The minimum peel test strength value is 62 percent of the manufacturer's parent sheet strength (i.e., certified HDPE GM strength) and not less than 78 ppi. A passing extrusion or fusion weld will be achieved in peel when:

- Yield strength for 4 out of 5 coupons is not less than the above minimum peel strength value, and the average of all 5 coupons is not less than the minimum value.

- At least 4 out of 5 coupons fail in FTB.

5.6.3 Shear Test Requirement

The minimum shear test strength value will be 95 percent of the manufacturer's parent sheet strength and not less than 120 ppi. A passing extrusion or fusion weld will be achieved in shear when the yield strength for 4 out of 5 coupons is not less than the above minimum shear strength value, and the average for all 5 coupons is not less than the minimum value.

5.7 Failing Seam Tests

If a destructive seam test does not meet the criteria given above for either the field or laboratory, the sample will fail and the seam will be considered unsatisfactory. The contractor may cap the seam between two passing tests or take two additional samples approximately 10 feet (or more) in either direction from the failing test and conduct retests. If either of the retests fails, the procedure shall be continued until the unsatisfactory seam is bracketed by passing seam tests. The unsatisfactory section of seam must then be capped full length each direction to passing tests. It will also be an option to terminate the cap at the end (or beginning) of the seam welded that day by the combination of welder and machine. That is, it will not be necessary to cap (or test) forward or back from the beginning or ending of seaming for that operator and machine for that day.

For tracking purposes the retest samples will be given letter identifiers. "A" will be used to designate a sample after or forward in the direction of welding, and "B" will be used to designate the sample back (in the direction of welding). Therefore, if destructive sample 6 (DS-6) fails, the two retest samples are DS-6A (forward) and DS-6B (back). Numbers will be used if additional tests are required; e.g., DS-6A1, DS-6A2.

5.8 Repairs

5.8.1 Repair Procedures

Any portion of the GM with a detected flaw, which fails a nondestructive or destructive test, where destructive tests were cut, or where nondestructive test left cuts or holes, must be repaired

in accordance with the specifications. The CQA monitor shall locate and record all repairs on the repair log and panel layout drawing. Repair techniques include the following:

- Patching - used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion weld bead - used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 1-inch in the largest dimension.
- Capping - used to repair failed welds or to cover unsatisfactory seams.
- Removal - used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fish-mouths, intersections, etc.) from the installed GM. Areas of removal shall be patched or capped as appropriate.

Repair procedures include the following:

- Abrade GM surfaces to be repaired by extrusion welding no more than one hour prior to the repair.
- Clean and dry all surfaces at the time of repair.
- Extend patches or caps approximately 6 inches or more beyond the edge of the defect, and round all corners of the HDPE patch to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.

5.8.2 Wrinkles

During placement of cover materials over the GM, temperature changes or creep can cause wrinkles to develop in the GM. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if practicable, by allowing the liner to contract by temperature reduction. In no case can material be placed over the GM which could result in the GM folding. The CQA monitor must monitor GM for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

5.8.3 Folded Material

All folded GM must be removed. Remnant folds evident after deployment of the roll which are due to manufacturing process are acceptable.

5.8.4 Bridging

Bridging must be corrected by cutting and patching or by allowing the GM to expand and adequately securing with sand bags until cover is applied.

5.9 GM Anchor Trench

The GM anchor trench will be left open until seaming is completed. Expansion and contraction of the GM should be accounted for in the liner placement. Prior to backfilling, the CQA monitor shall verify that the depth of penetration of the GM into the anchor trench is consistent with that shown on the plans or required in the specifications. Backfill shall be free of foreign material and large rocks and shall be tamped or wheel rolled to a density of at least 90 percent of the Standard Proctor maximum dry density without damage to the liner. Results of density tests need not be reported in the GLER.

5.10 GM Acceptance

The contractor retains all ownership and responsibility for the GM until all required documentation has been reviewed by the POR and the Owner has accepted the liner. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Owner's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly and promptly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the GM will be accepted by the POR only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.

- All as-built record drawings have been completed and verified by the POR. The as-built drawings show the panels, the location of all seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the GLER by TCEQ.

6.0 DRAINAGE GEOCOMPOSITE

The drainage geocomposite shall consist of a non-woven, needle punched, continuous or staple filament, polyester or polypropylene geotextile, heat bonded to one or both sides of an integrally formed high-density polyethylene geonet. The geotextile shall have a minimum weight of 6 ounces per square yard (oz/sy), and the geonet shall have a minimum initial thickness of 0.2 inch unless otherwise supported by design calculations and approved by the GP. Additional geocomposite requirements, if required, will be provided in the project specifications. Bottom liner drainage layer may consist of single sided geocomposite or a geonet placed directly on the GM liner and covered with a 6-oz/sy geotextile (i.e., two separate components). Double sided geocomposite shall be used on sidewalls (i.e., the geonet has geotextile bonded to both sides).

6.1 Delivery

The drainage geocomposite shall be shipped in rolls that are wrapped with protective covering. Each roll shall be marked with the manufacturer's name, lot number, roll number, and roll dimensions. The rolls shall be protected from mud, soil, dirt, dust, debris, cutting, or impact forces. Damaged rolls shall be rejected and removed from the site or stored at a location separate from accepted rolls.

6.2 Quality Control Testing

The drainage geocomposite manufacturer (or supplier) shall conduct quality control testing consistent with industry standards and supply test results and material certifications to the POR for all materials delivered to the site. The material certifications shall be reviewed by the POR to verify that the geocomposite meets the project requirements. Third party conformance testing will not be required, but may be conducted at the engineer's discretion.

6.3 Installation

The CQA Monitor working under the direct supervision of the POR shall monitor installation of geocomposite continuously during construction.

6.3.1 Surface Preparation

Prior to geocomposite installation, the CQA Monitor shall verify the following:

- Lines and grades have been verified by survey.
- Debris, soil, and other materials have been removed from the GM surface.
- The soil liner testing, field documentation and surveying meet the requirements of §330.339 and this LQCP.
- The underlying GM installation, including all required testing and documentation, has been completed for the area being covered.

6.3.2 Deployment

The CQA Monitor shall observe the deployment and installation full time and shall verify the following:

- Panels with defects are either repaired or replaced. All repairs are to be made in accordance with the manufacturer's recommendations and the specifications.
- Equipment used to deploy the geocomposite does not damage the geocomposite or underlying GM.
- People working on the geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying GM or BEGM.
- The geocomposite is anchored to prevent movement by the wind.
- The geocomposite remains free of contaminants such as grease and fuel.
- The geocomposite is relatively free of tension, stress, folds, wrinkles, or creases.
- Adjacent panels are overlapped and shingled down in the direction of the slope.
- Geonet panels are tied, and the upper geotextile is seamed in accordance with the manufacture's recommendations.

- Unless otherwise specified, the geonet components will be overlapped on the edges at least 4 inches and tied with plastic fasteners at 5-foot intervals. The ends will be overlapped at least 12 inches, the geotextile peeled back, and the geonet tied at 1-foot intervals. The top geotextiles will be sewn or heat bonded. For end laps, it may be necessary to trim excess geonet so the top geotextile will adequately cover the attachment. If the top geotextiles cannot be adequately sewn or heat bonded, a geotextile cap strip shall be bonded over the seam to prevent soil from infiltrating into the geonet paths.

6.4 Repairs

Holes or tears in the drainage geocomposite (including the upper geotextile) shall be repaired by placing a patch of the same material extending 2 feet beyond the edges of the hole or tear and tying the geonet and heat bonding the geotextiles. A hole only in the upper geotextile may be patched with a piece of geotextile in a similar manner, except the patch should be heat bonded to the primary geotextile. Any edge or end laps where the upper geotextile does not cover the geonet or holes in the geotextile shall be covered with a geotextile cap strip or patch that is bonded to the primary geotextile to prevent soil infiltration into the geonet.

6.5 Documentation

The material certifications provided by the manufacturer and MQC test results shall be included in the GLER.

7.0 LEACHATE COLLECTION SYSTEM PIPING

The pipe shall consist of high density polyethylene (HDPE) SDR 7.3 or schedule 80 PVC unless otherwise specified by the engineer and shown on the construction plans or specifications. Unless specified otherwise, the pipe shall have a 6-inch minimum diameter. Unless otherwise shown on the plans, perforated pipe will be placed in the collection trenches and sumps and solid pipe will be used for the risers.

7.1 Delivery

Pipe will be unloaded and handled with equipment that does not cause damage. The contractor shall use pliable straps, slings, or rope to lift the pipe, and shall use at least two support points when lifting pipe sections greater than 20 feet in length. Stacking or insertion of the other construction materials onto or into the pipe and pipe fittings shall be prohibited.

7.2 Quality Control

The pipe supplier shall provide the following documentation for the various types and sizes of pipe and fittings delivered to the site:

- Name of manufacturer
- Product type, identification number, and classification
- Pipe diameter
- Pipe Standard Dimension Ratio (SDR) or strength classification

7.3 Perforation Schedule – As shown on the plans

7.4 Installation

CQA Monitor shall observe pipe installation on a full time basis and shall verify the following:

- Lines and grades have been verified by survey. The pipe trenches are free of any deleterious material that may damage the pipe or underlying GM or may clog the pipe.
- Pipes and fittings are not broken, cracked, or otherwise damaged or unsatisfactory.

- Pipe sections shall be joined by fusion welding unless otherwise shown on the plans and approved by the engineer.
- Personnel responsible for field welding pipe sections shall have a current certification.
- Prior to fusing HDPE sections of pipe, the pipe installer will provide a surface area which is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
- Pipe and fittings are being installed in accordance with specifications, manufacturer's recommendations, and accepted practices.
- Perforated pipe shall be installed with holes down as shown on the plans.
- People and equipment utilized to install the pipe do not damage the pipe or any other component of the liner system.

7.5 Documentation

The manufacturer's submittals shall be reviewed by the POR. The pipe grades, sizes, and perforation size will be addressed in the GLER, but the submittals will not be required

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8.0 DRAINAGE AGGREGATE

Drainage aggregate will be used in the leachate collection trenches and sumps to facilitate collection and transmission of leachate to the sumps.

8.1 Materials

Granular drainage material around the leachate collection pipes (in the trenches and sumps) will consist of durable particles of natural gravel, crushed stone, or expanded shale light weight aggregate. The material shall be free of conspicuous amounts of clay or other unsuitable materials. The aggregate shall have a loss of mass due to calcium carbonate of less than 15 percent in accordance with JLT-S-105-89 or ASTM D 3042 modified to use a solution of hydrochloric acid having a pH of 5. The drainage aggregate shall meet ASTM C 33 with at least 85% of the material (by dry weight) shall be greater in size than the drainage pipe perforations. Additionally the leachate collection aggregate shall be demonstrated to have a hydraulic conductivity of at least $1x10^{-2}$ cm/sec (either by permeability testing or by a correlation with the grain size analysis). Typically, the correlation will be based on the Hazen formula of hydraulic conductivity (K) (in cm/sec) = C x $(D_{10})^2$ where C is 90 and D_{10} is the effective grain size or size such that 10% by weight is finer.

8.2 Quality Assurance

8.2.1 Testing

The granular drainage material shall be tested for gradation and loss of mass due to calcium carbonate initially to qualify the material unless recent test results and certifications are provided for the source by the supplier. Test data for similar aggregate from the same source that was submitted in a previous GLER for this site may also be used to verify compliance with carbonate content requirements.

Gradation testing (ASTM D 422) will be performed at a minimum of 1 test per 3,000 cubic yards of installed material. Hydraulic conductivity testing will also be performed at a minimum frequency of 1 test per 3,000 cubic yards of installed material unless a correlation

with grain size as given in subsection 8.1 is used. In general, grain size correlation may be used for fine aggregate (sand) complying with ASTM C 33 and coarse grained aggregate (gravel).

8.2.2 Construction Observations

The CQA monitor will observe the aggregate during construction and verify the physical characteristics of the aggregate are consistent with those indicated on the plans and specifications, conformance test samples, and the laboratory test results. If the visual observations indicate inconsistencies, additional conformance testing may be conducted at the discretion of the CQA monitor or POR. The CQA monitor will also observe that the aggregate is placed in accordance with plans and specifications, and that placement activities do not dislodge pipe or damage geosynthetics or pipe.

8.2.3 Documentation

Certifications and test results for the coarse aggregate used in leachate collection system will be included in the GLER. If the hydraulic conductivity is demonstrated by correlation with the grain size analysis, the demonstration calculations will be included in the GLER.

9.0 GEOTEXTILES

Geotextile fabric will typically be used in the leachate collection sumps, trenches and chimney drains to separate the drainage aggregate from the protective cover soil. Geotextile fabric used with geonet to provide the geocomposite drainage layer is addressed in Section 6 – Drainage Geocomposite.

9.1 Materials

Geotextile fabric for use around the drainage aggregate shall consist of non-woven, needle punched, continuous or staple filament, polyester or polypropylene geotextile. Unless otherwise specified, the geotextile shall have a minimum weight of 8 ounces per square yard (oz/sy). Additional requirements, if required, will be provided in the project specifications. Geotextile used for a slip layer or other miscellaneous applications will be specified on the construction plans.

9.2 Delivery

Geotextile shall be shipped in rolls that are wrapped in opaque covers. Each roll shall be marked with the manufacturer's name, lot number, roll number, and roll dimensions. Materials shall be stored in a location that will protect the rolls from precipitation, mud, dirt, dust, puncture, cutting, or any other damaging conditions. Rolls should not be pushed, drug, or rolled to storage locations, and should not be stacked more than 5 rolls high. Damaged rolls shall be rejected and removed from the site or stored at a location separate from accepted rolls.

9.3 Quality Control Testing

The geotextile manufacturer shall conduct quality control testing consistent with industry standards and certify that the materials delivered to the site comply with their published standards. The material test results and certifications shall be reviewed by the GP and accepted for the project prior to placement of any of the material.

9.4 Installation

Installation of geotextile shall be monitored continuously during construction by the CQA Monitor.

9.4.1 Surface Preparation

Prior to geotextile installation, the CQA Monitor shall verify the following:

- Lines and grades have been verified by survey.
- Debris, soil, dust, and other materials are removed from the surface being prepared for geotextile deployment.
- Geocomposite drainage layer panels have been properly tied and seamed.

9.4.2 Deployment

During geotextile placement, the CQA Monitor shall verify the following:

- Defects are repaired in accordance with the specifications.
- That equipment used does not damage the geotextile or underlying geosynthetics.
- That people working on the geotextile do not smoke, wear shoes that could damage the geotextile or underlying GM liner, or engage in activities that could damage the geotextile or GM.
- That the seams are overlapped and continuously sewn or heat bonded in accordance with the specifications and consistent with the manufacturer's recommendations.

9.4.3 Repairs

Damaged geotechnical panels may be repaired by patching or replacing (where patching is not practicable). Patches must be a minimum of 6 inches larger than the defect and must be heat bonded to the base geotextile.

9.5 Documentation

Geotextile test results provided by the manufacturer along with the product data sheets shall be included in the GLER.

10.0 PROTECTIVE COVER

The protective cover component of the composite liner system will consist of 24 inches of soil placed over the geocomposite drainage layer. The liner system is designed with chimney drains which will be constructed by extending the aggregate over LCS trench and sump through the protective cover to allow a flow path through the cover. The aggregate thickness shall meet the minimum specified cover thickness and the top chimney drain shall have a minimum aggregate width of 1.5 feet. The chimney drain aggregate shall comply with the requirements given in Section 8 above with the exception that the hydraulic conductivity for aggregate in the upper part of the drain (above the aggregate surrounding the pipe or filling the sump) to at least $1x10^{-4}$ cm/sec.

10.1 Materials

The protective cover shall generally consist of materials excavated on site during cell development. Typically these materials will range from lean to fat clay mixed with varying amounts of silt or sand. Occasional zones or layers of sandy or gravelly soil may also be encountered. The cover material shall be free of organics, foreign objects, or other deleterious materials that could damage the underlying geosynthetics. Since the liner system is designed with chimney drains there is no permeability requirement for the cover soil. Where haul roads must cross a trench, the chimney will be covered with at least 3 feet of soil or 4 feet of waste for protection.

10.2 Quality Assurance Testing

Since chimney drains will be used, testing of protective cover will not be required. The thickness of the protective cover (and aggregate) shall be verified by survey procedures using a minimum of one point per 5,000 ft^2 of liner (horizontal projection) with a minimum of two survey points. The thickness of the protective cover shall be determined by calculating the difference between the elevation of the survey point on the completed CSL (prior to geosynthetic liner installation) and the corresponding point on the completed protective cover. At every point, the minimum difference in elevation shall be at least 2.0 feet (measured perpendicular to the liner surface).

10.3 Cover Placement

Protective cover shall be spread over the geosynthetics using low ground pressure equipment with less than approximately 5 psi ground contact pressure (e.g., a Caterpillar D6N LGP dozer). During spreading operations, the lift thickness (between tracks and geosynthetics shall not be less than 12 inches. The minimum cover over geosynthetics for heavy, rubber tired earth hauling equipment shall be approximately 3 feet unless it can be demonstrated that less cover will not result in excessive stress on the geosynthetics. The CQA Monitor shall continuously monitor the protective cover installation when cover is placed directly on the geosynthetics, and shall verify the following:

- The protective cover layer is spread using low ground pressure equipment and that underlying geosynthetics are not damaged during cover placement.
- The protective cover is spread with a minimum of 12 inches of soil (or aggregate) between the spreading equipment and the installed geosynthetics. Under no circumstances shall construction equipment come in direct contact with the installed geosynthetics.
- Protective cover material is free of rocks, sticks, roots, or debris of any kind that may damage the geosynthetics.
- Protective cover placed over geosynthetics on slopes shall be spread by pushing up the slope (except for BEGM – see following bullet).
- If the BEGM (HDPE/Bentonite option) is used, to the extent practicable cover soil should be pushed perpendicular to the BEGM seams in the direction of the overlap (i.e., upper sheet to lower sheet).
- Spreading of protective cover does not result in excessive wrinkles in the geocomposite or underlying GM liner. The wrinkling may be reduced by raising the blade when pushing soil onto the liner, placing soil over small wrinkles to prevent material accumulation, or spreading soil in "fingers" or different directions.

The thickness of the protective cover has been verified with surveying procedures using a minimum of 1 survey point per 5,000 square feet with a minimum of 2 survey points.

11.0 LINERS CONSTRUCTED BELOW THE SEASONAL HIGH WATER TABLE

The analyses, design, and construction of any liner constructed below groundwater will be accomplished in accordance with 30 TAC 330.337.

11.1 Seasonal High Water Elevations

Based on the groundwater elevations determined during the hydrogeologic studies for the site, it appears that some of the liners may be constructed below the seasonal high groundwater table. In order to demonstrate that the liner will not undergo detrimental uplift during from hydrostatic forces and comply with §330.337(b) owner or operator will meet one of the following:

1. Provide calculations that the weight of the liner system and any ballast is sufficient to offset by a factor of 1.2 any upward and inward unbalanced hydrostatic forces on the liner consistent with §330.337(b)(1).
2. Incorporate an active or passive dewatering system consistent with §330.337(b)(2).
3. Provide evidence that the soil surrounding the landfill is so poorly permeable that the groundwater cannot move sufficiently to exert force that damage the liner by submittal of a "poorly permeable" demonstration consistent with §330.337(b)(3) that has been approved by the TCEQ.
4. Provide evidence that the seasonal high groundwater is below the deepest excavation consistent with §330.337(b)(4).

11.2 Poorly Permeable

The results of geotechnical exploration and laboratory evaluation for the site indicate that the soil surrounding the landfill is so poorly permeable that that the groundwater cannot move sufficiently to exert force that would damage the liner. A demonstration in compliance with §330.337(b)(3) is provided Appendix III-D.7.1.

11.3 Liner Design

Liner design for each cell will include an evaluation of the potential for the liner system to undergo uplift from hydrostatic forces during construction and post construction. The evaluation will include review of the approved "Poorly Permeable" demonstration.

12.0 DOCUMENTATION

The POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied and submit the documentation in a Soil Liner Evaluation Report (SLER) and a GM Liner Evaluation Report (GLER) consistent with §330.341 of the MSWR. The POR shall prepare and submit to the TCEQ, on behalf of the owner, the SLER and GLER for approval of each lined cell to receive waste. Observations, testing, evaluation, and documentation for each liner system shall be in accordance with §330.339 and this LQCP.

The SLER will contain:

- The latest edition of the TCEQ Soil Liner Evaluation Report Form completed with appropriate attachments. *Form TCEQ-00674, Soil Liner Evaluation Report (Rev. 4/08) is currently in use.*
- A summary of all soil liner construction activities.
- Laboratory and field test results.
- Drawings illustrating sampling and testing locations.
- A description of significant construction problems and the resolution of these problems.
- Liner thickness survey documentation
- As-built record drawings.

The GLER will contain:

- The latest edition of the TCEQ Geomembrane/Geosynthetic Liner Evaluation Report Form completed with appropriate attachments. *Form TCEQ-10070, Geomembrane/Geosynthetic Liner Evaluation Report (Rev. 11/25/08) is currently in use.*
- A summary of all geosynthetics, leachate collection, and protective cover construction activities.
- Manufacturer's certifications and quality control test results for geosynthetics.

- Third Party conformance testing and seam testing (for welded seams).
- Field logs documenting the GM (or BEGM) liner installation.
- Liner panel and repair drawing(s) illustrating BEGM or GM panels, destructive sample locations (if required), and liner repair locations.
- A description of significant construction problems and the resolution of these problems.
- Protective cover thickness survey documentation.
- As-built record drawings.

The SLER and GLER will be signed and sealed by the POR, signed by the site operator, and submitted to the MSW Permits Section of the Permits Division of the TCEQ.

12.1 SLER Markers

SLER markers shall be installed consistent with §330.143(b)(6) to define the limits of the constructed liner. The markers will be 6-foot-tall steel, fiberglass, or wooden posts, painted red, and set in soil at the outer corners (outside the evaluated area).

12.2 Interim Status Report

An Interim Status Report (ISR) will be provided to TCEQ consistent with §330.341(d) for any portions of liner that remain uncovered with waste for more than six months from the date the protective cover was placed. The ISR will be prepared by the POR and submitted to the TCEQ.

12.3 Report Acceptance

In accordance with §330.34, no area may be used for the receipt of solid waste until the TCEQ has given confirmation of its acceptance of the required liner evaluation report(s) (i.e., SLER and GLER) or 14 days from the date of arrival of the report at the Municipal Solid Waste Permits Section of TCEQ have lapsed.

APPENDIX III-D.7-1

POORLY PERMEABLE DEMONSTRATION