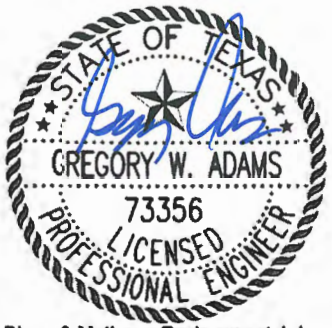
130 ENVIRONMENTAL PARK

APPENDIX D6-D
SECONDARY CONTAINMENT VOLUME CALCULATIONS



Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

11/6/2014

Includes pages D6-D-1 through D6-D-2

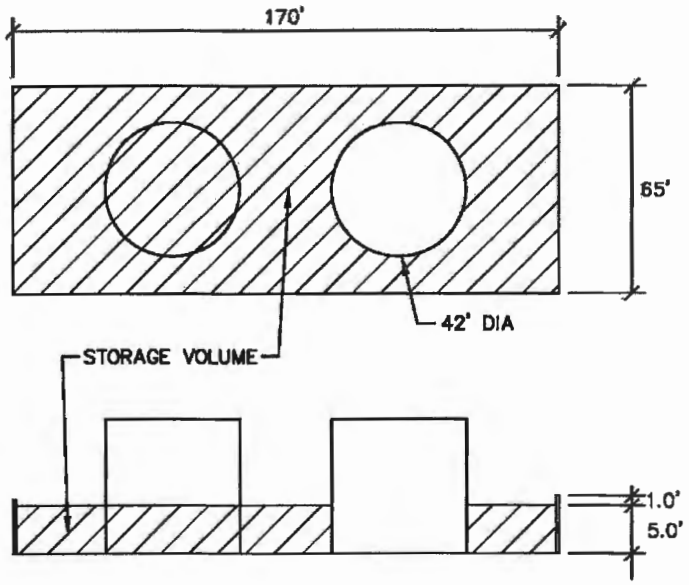
Technically Complete October 28, 2014

130 Environmental Park
Secondary Containment Volume

Required: Verify that the secondary containment area will contain 110% of one tank plus the precipitation from the 25-year, 24-hour rainfall event.

References: 1. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: ***Containment Volume***



Containment volume = (area of containment - area of one tank) x storage height

Containment length =	170.0	ft
Containment width =	65.0	ft
Containment area =	11,050.0	sf
Tank diameter =	42.0	ft
Tank area =	1,385.4	sf
Storage area =	9,664.6	sf
Containment wall height =	6.0	ft
Storage height with 1' of freeboard =	5.0	ft
Containment volume =	**48,322.8**	**cf**

130 Environmental Park
Secondary Containment Volume

Required Volume

Rainfall Volume

Calculate the rainfall volume that will collect in the containment area during the 25 year, 24-hour rainfall event.

Rainfall depth =	7.75	in.	Ref 1
Containment area =	11,050.0	sf	
Rainfall volume =	7,136.5	cf	
Storage Tank Volume			
Tank diameter =	42.0	ft	
Tank area =	1,385.4	sf	
Tank height =	24.0	ft	
Tank volume =	33,250.6	cf	
110% of tank volume =	36,575.7	cf	
Required Volume =	**43,712.1**	**cf**	

Therefore the containmnent volume exceeds the required volume.

130 ENVIRONMENTAL PARK
CALDWELL COUNTY, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 2383

TYPE I PERMIT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN

ATTACHMENT D7
LINER QUALITY CONTROL PLAN

Prepared for

130 ENVIRONMENTAL PARK, LLC

Technically Complete October 28, 2014

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256
11/6/2014

Prepared by

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11/6/2014

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

CONTENTS

30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

11/6/2014

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

CONTENTS (Continued)

30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

TABLES

1 INTRODUCTION

30 TAC §330.339

1.1 Purpose

This Liner Quality Control Plan (LQCP) has been prepared in accordance with 30 TAC §330.339 to establish procedures for the design, construction, testing, and documentation of the liner and leachate collection system.

1.2 Definitions

Specific terms and acronyms that are used in this LQCP are defined below.

ASTM – American Society for Testing and Material

Construction Quality Assurance (CQA) – CQA is a planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. CQA includes the observations, evaluations, and testing necessary to assess and document the quality of the constructed facility. CQA includes measures taken by the CQA organization to assess whether the work is in compliance with the plans, specifications, and permit requirements for a project.

GLER – Geomembrane Liner Evaluation Report

Geotechnical Professional (GP) – The GP is the authorized representative of the operator who is responsible for all CQA activities for the project. The GP must be registered as a Professional Engineer in Texas. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The GP must also have competency and experience in certifying similar projects.

The GP may also be known in applicable regulations and guidelines as the CQA engineer, resident project representative, geotechnical quality control/quality assurance professional (GQCP), or professional of record (POR).

CQA Monitors – CQA monitors are representatives of the GP who work under direct supervision of the GP. The CQA monitor is responsible for quality assurance monitoring and performing on-site tests and observations. The CQA monitor must be NICET-certified at Level 2 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.

Quality Assurance – Quality assurance is a planned program that is designed to assure that the work meets the requirements of the plans, specifications, and permit for a project. Quality assurance includes procedures, quality control activities, and documentation that are performed by the GP and CQA monitor.

Quality Control – Quality control includes the activities that implement the quality assurance program. The GP, CQA monitor, and contractor will perform quality control.

Seasonal High Water Table – The seasonal high water table is the highest measured water level within the construction area.

SLER – Soil Liner Evaluation Report

1.3 Sequence of Construction Activities

Generally construction of lined areas at 130 Environmental Park will proceed in the following sequence of activities:

- The area will be excavated to the proposed subgrade elevations.
- The subgrade elevations will be verified.
- The compacted soil liner will be constructed, tested, and verified in accordance with Section 4.
- The geomembrane liner will be constructed, tested, and verified in accordance with Section 5.
- The leachate collection system will be constructed and verified in accordance with Section 6. All soil testing and evaluation of constructed soil liners will be complete prior to installing the leachate collection system.
- The protective cover will be constructed and verified in accordance with Section 7.
- The Soils Liner Evaluation Report will be submitted to the TCEQ.
- The Geomembrane Evaluation Report will be submitted to the TCEQ.

2 LINER SYSTEM

30 TAC §330.331

2.1 Composite Liner and Leachate Collection Systems

The components of the composite liner systems are listed from top to bottom in Table D7-1. Details of the composite liner system are provided in Appendix D7-D – Liner System Details.

Table D7-1
130 Environmental Park
Components of the Composite Liner System

SUBTITLE D LINER (Top to Bottom)		
Liner System Component	**Description**	**Thickness**
Protective Cover	General earthfill	24 inches minimum
Leachate Collection Layer	Double-sided geocomposite	275 mil nominal
Geomembrane Liner	Textured HDPE geomembrane	60 mil nominal
Compacted Soil Liner	Compacted soil	24 inches minimum

The leachate collection layer will be graded to drain to collection trenches with chimney drains along the centerline of each cell. The leachate collection trenches will consist of perforated HDPE pipe encased in aggregate filled trenches. The leachate collection trenches will convey leachate to sumps located along the toe of the side slopes. A description of the leachate collection system is provided in Attachment D6 – Leachate and Contaminated Water Plan, and details of the leachate collection system are provided in Attachment D3.

The gas collection trench will be installed around the perimeter of the landfill, as shown on Drawing D7-C.2. The gas collection trench will consist of perforated HDPE pipe encased in an aggregate filled trench that is wrapped in a geotextile. Solid HDPE risers will be installed along the collection pipe at 100 feet intervals for future connection to the landfill gas collection system if necessary. The collection trench and risers will be installed above the geocomposite approximately 12 feet down slope from the crest of the sideslope.

2.2 Construction Monitoring

Continuous on-site monitoring is necessary to assure that the components of the liner system are constructed in accordance with this LQCP. In accordance with 30 TAC §330.339(a)(2), the CQA monitor shall provide continuous on-site observation and field sampling and testing as required during the following construction activities:

- Subgrade preparation

- Compacted soil liner placement, processing, compaction, and testing
- Geomembrane liner deployment, trial welds, seaming, testing, and repairing
- Leachate collection layer deployment and seaming
- Anchor trench backfill
- Protective cover layer placement
- Any work that could damage the installed components of the liner system

The GP will document and certify that the liner system was constructed in accordance with this LQCP. The GP shall make sufficient site visits to observe critical construction activities and to verify that the construction and quality assurance activities are performed in accordance with this LQCP.

3 EARTHWORK

30 TAC §§330.337, 330.339

3.1 General

The proposed grading plan (Attachment D1 – Site Layout Plans, Drawing D1.6 shows the landfill floor will slope at 1.5 to 2.5 percent (pre-settlement) and 1.4 to 2.4 percent (post-settlement) to the perimeter sidewalls, which will slope at 4H:1V. The fill area will be divided into cells, each of which has a two percent cross slope (pre-settlement and post-settlement) to a leachate collection trench along the centerline of the cell. Collection trenches will slope to sumps located along the perimeter of the landfill. Earthwork activities and testing will be documented in the SLER in accordance with Section 8.2.

3.2 Materials

The following material classifications will be encountered in excavations or will be required for landfill construction.

General Fill

General fill consists of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than four inches in diameter.

Compacted Soil Liner

Compacted soil liner materials consist of soil that is free from debris, rubbish, solid waste, organic matter, and meets the requirements of Section 4.2.

Protective Cover

Protective cover materials consist of soil that is free from debris, rubbish, solid waste, organic matter, and meets the requirements of Section 7.2.

Leachate Aggregate

Drainage aggregate consists of natural or manufactured granular material that meets the requirements of Section 6.2.4.

Anchor Trench Backfill

Anchor trench backfill consists of general fill that is free of particles larger than one inch in diameter.

Daily and Intermediate Cover

Daily and intermediate cover materials consist of soil that has not been previously mixed with solid waste.

Topsoil

Topsoil consists of soil that is capable of sustaining vegetation and is free of debris, rubbish, and solid waste.

Unsuitable Materials

Unsuitable materials consist of any material that is determined by the GP to not be suitable for use as classified above.

3.3 Construction Below Groundwater

The highest measured groundwater elevations will be used as the design groundwater elevations. The most recent groundwater elevations must be reviewed before the construction of each cell and, if necessary, the highest measured water elevations will be adjusted upward.

As shown in Appendix D7-A – Highest Measured Groundwater Elevations, Drawing D7-A.1, the excavation will not extend below the highest measured groundwater elevations within the landfill footprint. Consequently, the liners will be constructed above the highest measured groundwater elevations.

3.4 Excavation

A description of the materials that will be encountered in the excavations is provided in Attachment D5 – Geotechnical Design.

The slope stability analyses were performed for 4H:1V excavation and liner slopes, and 4H:1V interim waste and final waste slopes. Any changes to the excavation plan, liner system, final cover system, or landfill completion plan will necessitate that the slope stability analyses be revised to reflect the changed conditions. Waste must be placed and properly compacted in horizontal lifts generally less than 20 feet thick. Temporary construction slopes should not be steeper than the final or interim slopes and concentrated loadings such as heavy equipment and soil stockpiles should not be placed near the crest of slopes unless additional slope stability analyses are performed.

4 COMPACTED SOIL LINER

30 TAC §330.339

4.1 General

The compacted soil liner component of the composite liner system consists of a 24-inch-thick layer of compacted, relatively homogeneous, cohesive material. The CQA monitor shall provide continuous on-site observation during compacted soil liner placement, compaction, and testing in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during compacted soil liner construction to document the construction activities, testing, and thickness verification in the SLER, in accordance with Section 8.2.

4.2 Materials

Compacted soil liner material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material. The required compacted soil liner material properties are summarized in Table D7-2.

Table D7-2
130 Environmental Park
Compacted Soil Liner Material Properties

Test	Standard	Required Property
Plasticity Index	ASTM D 4318	15 or Greater
Liquid Limit	ASTM D 4318	30 or Greater
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	30% or Greater
Percent Passing 1-inch Sieve	ASTM D 422	100%
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1×10^{-7} cm/sec or less

Preconstruction testing procedures and frequencies for compacted soil liner materials are listed in Section 4.8.1.

4.3 Subgrade Preparation

Prior to placing soil liner material, the subgrade should be proof-rolled with heavy, rubber-tired construction equipment to detect soft areas. The GP or CQA monitor must observe the proof-rolling operation. Soft areas should be undercut to firm material, then backfilled with compacted general fill.

The subgrade elevations shall be verified in accordance with the requirements of Section 4.8.3 prior to the placement of compacted soil liner.

4.4 Placement and Processing

The compacted soil subgrade and surface of each lift should be roughened prior to placement of the next lift of compacted soil liner. The soil liner material should be placed in maximum eight-inch loose lifts to produce compacted lift thickness of approximately six inches. The material should be processed to a maximum particle size of one inch or less before water is added. Rocks and clods less than one inch in diameter should not total more than 10 percent by weight. The surface of the top lift shall contain no material larger than 3/8 inch.

If additional water is necessary to adjust the moisture content, it should be applied after initial processing, but prior to compaction. Water should be applied evenly across the lift and worked into the material. Water used for the soil liner compaction must not be contaminated by waste or any objectionable material.

4.5 Compaction

The soil liner shall be compacted with a pad/tamping-foot or prong-foot roller. A footed roller is necessary to bond the lifts, to distribute the water, and to blend the soil matrix through kneading action. Soil liner shall not be compacted with a bulldozer, rubber-tired roller, flat-wheel roller, scraper, truck, or any track equipment unless it is used to pull a footed roller. The compactor should weigh at least 40,000 pounds. The lift thickness shall be controlled to achieve penetration into the top of the previously compacted lift; therefore, the lift thickness should not be greater than the pad or prong length. Cleaning devices on the roller must be in place and maintained to prevent the prongs or pad feet from becoming clogged to the point that they cannot achieve full penetration.

The compactor should make approximately four passes across the area being compacted. A pass is defined as one pass of the compactor, front and rear drums. The material must be compacted to a minimum of 95 percent of the maximum dry density determined by standard Proctor (ASTM D 698) at a moisture content at or above optimum moisture. Areas with failing tests shall be reworked, recompacted, and retested, and passing tests must be achieved before another lift is added.

After a lift is compacted, it must be watered to prevent drying and desiccation until the next lift can be placed. If desiccation occurs, the GP must determine if the lift can be rehydrated by surface application of water or if the lift must be scarified, watered, and recompacted. Following compaction and fine grading of the final lift, the surface of the compacted soil liner shall be smooth drum rolled.

4.6 Protection

The completed compacted soil liner must be protected from drying, desiccation, rutting, erosion, and ponded water until the geomembrane is installed. Areas that undergo excessive desiccation or damage shall be reworked, recompacted, and retested as directed by the GP.

4.7 Tie in to Existing Liners

The edge of existing compacted soil liners shall be cut back on either a slope or steps to prevent the formation of a vertical joint. Details of the existing liner tie-in are shown in Attachment D3 – Construction Design Details.

4.8 Testing and Verification

4.8.1 Preconstruction Testing

Table D7-3 lists the minimum testing required for material proposed for use as compacted soil liner.

Table D7-3
130 Environmental Park
Compacted Soil Liner Material Preconstruction Tests

Test	Standard	Frequency
Plasticity Index	ASTM D 4318	1 per material type
Liquid Limit	ASTM D 4318	1 per material type
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	1 per material type
Percent Passing 1-inch Sieve	ASTM D 422	1 per material type
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1 per material type

After the moisture density relationship has been determined for a material type, a soil sample should be remolded to about 95 percent of the maximum dry density at the optimum moisture content. This sample will be tested to determine if the soil can be compacted to achieve the required coefficient of permeability. Either falling head or constant head laboratory permeability tests may be performed to determine the coefficient of permeability. The permeant fluid for testing must be tap water or 0.005N calcium sulfate solution. Distilled or deionized water shall not be used as the permeant fluid.

4.8.2 Construction Testing

All quality control testing will be performed during construction of the liner, except for testing that is required after individual lifts are constructed. All testing will be completed prior to the installation of the leachate and gas collection systems and the protective cover. Table D7-4 lists the minimum testing required for material used as compacted soil liner.

Table D7-4
130 Environmental Park
Compacted Soil Liner Material Construction Tests

Test	Standard	Frequency
Field Density	ASTM D 2922	1/8,000 sf per 6-inch lift
Plasticity Index	ASTM D 4318	1/100,000 sf per 6-inch lift
Liquid Limit	ASTM D 4318	1/100,000 sf per 6-inch lift
Percent Passing 1-inch and No. 200 Sieve	ASTM D 1140 ASTM D 422	1/100,000 sf per 6-inch lift
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1/100,000 sf per 6-inch lift
Moisture Content	ASTM D 2216	1/100,000 sf per 6-inch lift

The Atterberg limits of the in-place compacted soil liner must be compared to the Atterberg limits of the Proctor curve sample to assure that the Proctor curve represents the in-place material. Any variance of more than 10 points between the liquid limit or plasticity index of the in-place soil and those of the Proctor curve sample will require that a new Proctor curve be developed. Permeability testing will be performed as described in Section 4.8.1 and all test data will be reported.

4.8.3 Thickness Verification

The as-built thickness of the compacted soil liner shall be determined by standard survey methods. Prior to the placement of liner material, the subgrade elevations will be determined at a minimum rate of one survey point per 5,000 sf of lined area. After the compacted soil liner is completed, the top of the liner elevations will be determined at the same locations as the subgrade elevations.

5 GEOMEMBRANE LINER

30 TAC §§330.331, 330.339

5.1 General

The geomembrane liner (GM) component of the composite liner system will consist of a 60-mil-thick textured HDPE geomembrane placed over the compacted soil liner. The CQA monitor shall provide continuous on-site observation during GM deployment, trial welds, seaming, testing, and repairing in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during the GM installation to document the installation and testing in the GLER, in accordance with Section 8.3.

5.2 Materials

5.2.1 Properties

GM shall consist of textured high-density polyethylene (HDPE) geomembrane produced from virgin raw materials. Recycled materials are not acceptable. The GM shall not be manufactured from resin from differing suppliers. The GM shall meet the requirements in the most current revision of the Geosynthetics Research Institute (GRI) Standard GM13. A copy of GRI-GM13 is included in Appendix D7-B.

Manufacturer quality control testing procedures and frequencies for GM are listed in Section 5.5.1. Third party conformance testing procedures and frequencies for GM are listed in Section 5.5.2.

5.2.2 Delivery and Storage

GM shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site.

Upon delivery of the geomembrane, the CQA monitor will observe that:

- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location and not stacked more than five rolls high.
- The geomembrane is protected from puncture, dirt, grease, water, moisture, and excessive heat, or other damage.

- All manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications.

- The geomembrane receipt log form has been completed for all materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane.

5.3 Preparation

The surface of the compacted soil liner shall be protected in accordance with Section 4.6 until the GM is installed. Prior to installation of the GM, the compacted soil liner shall be tested and verified in accordance with Section 4.8, and the GP or CQA monitor and geosynthetics installer shall inspect the surface of the soil liner to verify that:

- The soil liner surface has been smooth drum rolled.

- The soil liner surface is free of irregularities, soft areas, or loose soil.

- The soil liner surface is free of stones, protrusions, or objects that could damage the GM.

The geosynthetics installer must accept the condition of the compacted soil liner and sign a subgrade acceptance form prior to the installation of the GM.

5.4 Installation

5.4.1 Deployment and Placement

The following activities must take place prior to GM deployment:

- The manufacturer's quality control and third party conformance tests should be completed and approved by the GP in accordance with the requirements of Section 6.5.

- The GP or CQA monitor and geosynthetics installer shall approve the subgrade in accordance with the requirements of Section 5.3.

- The geosynthetics installer shall sign the subgrade acceptance form.

GM shall be deployed by equipment that will unroll the GM without damaging, crimping, or stretching it and deployment equipment must not damage the underlying compacted soil liner. GM must not be deployed during periods of rain or high winds and shall not be deployed on top of frozen subgrade. The installer must only deploy the amount of GM that can be seamed on the same day. The GM shall be installed in direct and uniform contact with the compacted soil liner, if applicable.

Upon deployment, each panel shall be assigned a unique identification number. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and wearing shoes that could damage the GM shall not be permitted on the GM, and only low-ground pressure rubber tired supporting equipment shall be allowed on the GM. GM placed on side slopes shall extend to a minimum of 5 feet beyond the toe of the slope prior to seaming.

During GM placement, the CQA monitor must:

- Provide full time observation.
- Record panel numbers, panel dimensions, and roll numbers.
- Record weather conditions.
- Observe the condition of the subgrade and note any deficiencies. All deficiencies shall be repaired and be approved by the CQA monitor.
- Observe the condition of the GM and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM or engage in activities that could damage the GM.
- Observe that the deployment method minimizes wrinkles and that the GM is anchored to prevent movement from wind.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that there are no horizontal seams on side slopes and that the textured material extends a minimum of five feet past the toe of the slope.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and be repaired in accordance with Section 5.4.4 or be removed and replaced by the installer.

5.4.2 Seaming

Only welding apparatus and operators that have completed approved trial welds in accordance with Section 5.5.3 shall be allowed to weld panel seams. Each seam shall be assigned a unique number that is preferably consistent with the panel numbering system. Sidewall seams shall be oriented downslope. Prior to welding, the proper panel overlap shall be provided; dirt, grease, and free moisture shall be cleaned from the panel contact area; and wrinkles shall be removed when practical. For extrusion welds, oxidation shall be ground from the seam area within one hour of the welding operation and the extrudiate shall be purged from the extrusion welding apparatus. Seaming operations shall not be allowed when the ambient temperature is below 40°F or above 104°F unless trial welds have demonstrated that adequate welds can be achieved outside these limits.

During GM seaming operations, the CQA monitor must:

- Provide full-time observation.
- Record seam numbers.
- Record weather conditions.
- Observe that only approved welding apparatus and operators are allowed to weld seams.
- Observe the condition of the seams and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the seams are free of grease, dirt, moisture, and wrinkles.
- Observe that welding operations take place within the approved ambient temperature range.
- Observe that seam grinding has been completed less than one hour before extrusion welding and the extrudiate has been purged from extrusion welders.
- Observe that there are no horizontal seams on side slopes and that the textured material extends a minimum of five feet past the toe of the slope.

5.4.3 Anchor Trenches

The GM anchor trench shall be left open until the seaming is completed. Expansion and contraction of the GM should be accounted for during deployment. The top corner of the anchor trenches shall be rounded to prevent crimping the GM. The bottom of the anchor trench shall be dry, stable and be free of loose particles and rocks. Anchor trenches shall be backfilled with compacted general fill that is free of particles larger than one inch in diameter. The anchor trenches shall be backfilled and compacted in a manner that does not damage or induce stress to the GM.

5.4.4 Repairs

Defects in the GM, defects in seams, failing destructive tests, failing nondestructive tests, holes from nondestructive tests, and destructive test sample locations shall be repaired by one of the following repair techniques:

- Patching – used to repair large holes, tears, large GM defects, and destructive test locations.
- Extrusion – used to repair small GM defects, cuts, holes from nondestructive tests, and seam defects less than 1/2-inch long.

- Capping – used to repair failed seams or seams where nondestructive tests cannot be performed.

- Removal – used to replace areas with large defects where other repair techniques are not appropriate.

Repair procedures include the following:

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

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

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

Destructive and non-destructive testing will be performed on all repairs in accordance with Section 5.5.4.

5.5 Testing and Verification

5.5.1 Manufacturer's Quality Control Testing

The GM manufacturer shall test the geomembrane and raw materials in accordance with GRI Standard GM13 to assure the quality of the GM.

5.5.2 Conformance Testing

Conformance samples of the GM shall be cut across the full width of selected rolls in accordance with the test frequency specified in Table D7-5. Conformance samples may be taken at the manufacturing plant or at the project site and will be forwarded to a third party laboratory for testing. Material property requirements are provided in Section 5.2.1. Minimum conformance testing requirements are provided in Table D7-5.

Table D7-5
130 Environmental Park
GM Conformance Tests

Test	Standard	Frequency
Sheet Thickness	ASTM D 5199, 1593, or 5994	1 per 100,000 sf and every resin lot
Specific Gravity	ASTM D 1505	1 per 100,000 sf and every resin lot
Carbon Black Content	ASTM D 1603	1 per 100,000 sf and every resin lot
Carbon Black Dispersion	ASTM D 3015 or 5596	1 per 100,000 sf and every resin lot
Tensile Properties	ASTM D 638	1 per 100,000 sf and every resin lot
Direct Shear	ASTM D 5321	1 per GM/adjoining material type

A direct shear test will be performed on the GM/soil and the GM/geocomposite interfaces for each manufacturer's material used at the site. The GP will perform a slope

stability analysis using the site-specific direct shear test data. The angle of friction and cohesion values will be acceptable if the results of the site-specific slope stability analysis demonstrate that the factor of safety against sliding is 1.5 or greater.

5.5.3 Trial Welds

Each operator and welding apparatus must be tested to verify that seam welds that meet the specifications can be achieved under the site conditions. Trial welds must be performed at the beginning and midpoint of each day for each operator and apparatus used that day. If welding continues past 6:00 p.m., additional trial welds may be required. Trial welds should also be made at each occurrence of significantly different environmental conditions (such as temperature, humidity, or dust), anytime a machine is turned off for more than 30 minutes, and when seaming different geomembranes (such as at tie-ins).

The trial weld samples shall be 3 feet long and 12 inches wide, with the seam centered lengthwise. At least four one-inch-wide coupons will be cut from each trial weld sample. Two coupons from each sample will be tested for shear and two samples will be tested for peel. Peel test coupons for dual-track welds shall be tested on both sides of the air channel. Each coupon must meet the minimum strength requirements listed in Table D7-6 and exhibit a Film Tear Bond (FTB). If the trial weld fails, two more trial seams must be welded and tested. This process will continue until passing trial welds are achieved.

The CQA monitor must observe the trial welding operations and document the operator's initials, apparatus number, time, date, air temperature, apparatus temperature, and peel and shear test results. If the CQA monitor believes that an operator or apparatus is not functioning properly, or if the weather conditions have substantially changed since the trial welds were performed, new trial welds must be performed.

5.5.4 Construction Testing

Nondestructive Tests

Nondestructive seam tests include vacuum testing and air pressure testing. Nondestructive testing shall be performed for the entire length of each seam by the GM installer.

Vacuum testing shall be used to test extrusion-welded seams and fusion-welded seams that cannot be tested by air pressure methods. The vacuum box shall be placed over a seam section that has been thoroughly saturated with a soapy water solution. The rubber gasket on the bottom of the vacuum box must seal against the GM to prevent leaks. Three to five inches of vacuum in Hgwill be applied. Soap bubbles will indicate the presence of holes or non-bonded seams. The vacuum box dwell time shall be at least 10 seconds.

Air pressure testing shall be used to test fusion-welded seams that have an air channel. Both ends of the air channel shall be sealed and air shall be pumped into the channel to at least 30 psi or 1/2 psi per mil of thickness, whichever is greater. The air channel must sustain the pressure for at least five minutes, without more than a 4 psi pressure drop. Following a passing pressure test, the pressure shall be released from the end of the

seam that is opposite of the pressure gauge. The pressure gauge must return to zero; if it does not, the seam is probably blocked. After the blockage has been located, the seam shall be pressure tested on both sides of the blockage. All penetration holes shall be sealed after the air pressure testing is completed.

During the nondestructive testing, the CQA monitor must:

- Observe that equipment and operators perform the tests properly.
- Observe that the entire length of each seam is tested and record the results of the test.
- Identify failed seams and inform the installer of any required repairs.
- Record all completed and tested repairs on the repair log.

Destructive Tests

Destructive testing shall be performed at a frequency of one stratified test location per 500 linear feet of seam. Repairs over 10 feet long shall be included in the total seam length. Destructive test samples should be 45 inches long by 12 inches wide with the seam centered along the length of the sample.

Two coupons should be cut from each end of the sample and the installer must test these coupons with a tensiometer capable of measuring the seam strength. The installer shall test two coupons in shear and two coupons in peel. For double wedge-welded seams, both sides of the air channel shall be tested in peel. The CQA monitor must observe the tests and record the results on the destructive testing log. The minimum requirements for destructive testing are provided in Table D7-6. If one of the coupons fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established.

If the field test results are satisfactory, the remaining sample shall be divided into three parts: one-third for the installer, one-third for third party laboratory testing, and one-third for the owner to archive. The laboratory shall test five coupons from each sample in shear and test five coupons from each sample in peel (10 when testing both inner and outer welds of dual-track fusion welds). The minimum requirements for destructive testing are provided in Table D7-6. If the laboratory test fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established. All seams shall be bracketed by passing laboratory tests; field tests results shall not be used for final acceptance.

Table D7-6
130 Environmental Park
GM Seam Properties

Test	Standard	Frequency	Minimum Criteria
Shear	ASTM D 4437	One sample per 500 feet of seam	Four of five specimens from each sample must have a shear strength greater than or equal to 95% of sheet strength but not less than 120 ppi. The average shear strength value of all five specimens must be greater than or equal to 95% of sheet strength but not less than 120 ppi.
Peel	ASTM D 4437	One sample per 500 feet of seam	Four of five specimens from each sample must have a peel strength greater than or equal to 62% of sheet strength but not less than 78 ppi. The average peel strength value of all five specimens must be greater than or equal to 62% of sheet strength but not less than 78 ppi. Both sides of dual track seams shall meet the minimum criteria. Each track is considered a separate sample. All specimens shall exhibit Film Tear Bond.

During destructive seam testing, the CQA monitor must:

- Select sample locations and observe sample cutting.
- Assign sample numbers and label samples.
- Observe installer-performed tests.
- Record sample locations, sample number, sample purpose, and field test results.

5.5.5 Thickness Verification

The CQA monitor shall perform thickness verification tests on each panel. A series of five measurements along the leading edge of each panel shall be taken with a micrometer or caliper. Individual measurements shall not be greater than five feet apart. For smooth HDPE geomembrane, the average thickness shall be no less than the nominal thickness of the geomembrane and the minimum thickness shall be no less than 90% of the nominal thickness. For textured HDPE geomembrane, the average thickness shall be no less than 95% of the nominal thickness of the geomembrane and the minimum thickness shall be no less than 85% of the nominal thickness. The CQA monitor shall record panel numbers, panel dimensions, roll numbers destructive test numbers, and repair numbers.

6 LEACHATE AND GAS COLLECTION SYSTEMS

30 TAC §330.333

6.1 General

The leachate collection system will consist of the collection layer, collection trenches, piping, and sumps. Details of the leachate collection system design are provided in Attachment D3 – Construction Design Details. The design capacity calculations are provided in Attachment D6 – Leachate and Contaminated Water Management Plan, Appendix D6-A – Leachate Collection System Design Calculations.

The gas collection system consists of a perimeter collection trench, piping and risers that may be connected to the landfill gas collection system in the future if necessary. The landfill gas collection system is described in Attachment G – Landfill Gas Management Plan. The gas collection trench and risers will be installed around the perimeter of the landfill as shown on Drawing D7-C.2.

Material properties are described in Section 6.2. The CQA monitor shall provide on-site observation during leachate and gas collection layer and piping installation in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during the leachate and gas collection system installation to document the installation in the GLER, in accordance with Section 8.3.

6.2 Materials

6.2.1 Geocomposite

The leachate collection layer will consist of geocomposite drainage net installed above the GM. Double-sided geocomposite (nonwoven geotextile bonded to the top and bottom of HDPE drainage net) will be used exclusively. The geocomposite shall have the minimum properties listed in Table D7-7.

Table D7-7
130 Environmental Park
Geocomposite Properties

Material	Test	Standard	Required Property
Geotextile	Material		Nonwoven polypropylene or polyester
	Apparent Opening Size	ASTM D 4751	70 sieve
	Unit Weight	ASTM D 5261	8 oz/yd^2
	Grab Strength	ASTM D 4632	150 lbs
	Puncture Strength	ASTM D 4833	80 lbs
HDPE Drainage Net	Specific Gravity	ASTM D 1505	0.93 g/cm^3
	Thickness	ASTM D 5199	0.275 inch
	Carbon Black	ASTM D 1603	minimum 2%, maximum 3%
Geocomposite	Transmissivity	ASTM D 4716	7.0×10^{-4} m^2/sec

Manufacturer quality control testing procedures and frequencies for geocomposite are listed in Section 6.5.1.

6.2.2 Geotextile

The aggregate that is placed in the collection trenches and sumps shall be wrapped in a geotextile filter fabric. The geotextile shall have the minimum properties listed in Table D7-8.

Table D7-8
130 Environmental Park
Geotextile Properties

Test	Standard	Required Property
Material		Nonwoven polypropylene or polyester
Apparent Opening Size	ASTM D 4751	70 sieve max
Unit Weight	ASTM D 5261	8 oz/yd^2
Grab Strength	ASTM D 4632	150 lbs
Tear Strength	ASTM D 4533	60 lbs
Puncture Strength	ASTM D 4833	80 lbs

Manufacturer quality control testing procedures and frequencies for geotextile are listed in Section 6.5.1.

6.2.3 Pipe

The piping will include perforated collection trench pipes and the solid sidewall riser pipes. The piping shall meet the cell classification PE345434C in accordance with ASTM D 3350. The pipe shall have the minimum SDR rating and perforation schedule shown on the plans.

6.2.4 Aggregate

Aggregate will be placed in the collection trenches and in the sumps. The aggregate shall consist of manufactured or natural materials having the properties listed in Table D7-9. Alternate gradations may be approved by the GP.

Table D7-9
130 Environmental Park
Leachate Aggregate Properties

Test	Standard	Required Property	
Gradation	ASTM D 422	Sieve	% Passing
		1 1/2"	90-100
		1/2"	20-50
		3/8"	0-15
Hydraulic Conductivity	ASTM D 2434	≥ 1 x 10^{-2} cm/sec	
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	Maximum 15% loss	

[a] Use an HCL solution having a pH of 5 or lower.

Conformance testing procedures and frequencies for leachate aggregate are listed in Section 6.5.1.

6.2.5 Delivery and Storage

Geocomposite and geotextile shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected. Pipe shall be shipped in bundles labeled with the manufacturer's name and cell classification number.

The geocomposite, geotextile, and pipe shall be unloaded and handled with equipment that does not cause damage. Rolls should not be pushed, slid, or dragged to the storage location. The geocomposite and geotextile must not be stored on wet, soft, or rocky subgrade but must be stored on a stable subgrade. Geocomposite and geotextile must not be stacked more than five rolls high to avoid crushing the roll cores. The stored geocomposite, geotextile, and pipe must be protected from puncture, grease, dirt, excessive heat, or other damage.

6.3 Preparation

Prior to installation of the leachate collection layer the soil liner and GM shall be tested and verified in accordance with Sections 4.8 and 5.5. The CQA monitor shall observe that the surface to receive the geocomposite is free of debris, stones, and dirt and verify that the geocomposite conformance documentation has been submitted and approved.

6.4 Installation

6.4.1 Geocomposite

Geocomposite shall be deployed by equipment that will unroll the geocomposite without damaging, crimping, or stretching it and deployment equipment must not damage the underlying geosynthetics. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and wearing shoes that could damage the geocomposite or underlying geosynthetics shall not be permitted on the geocomposite and only low ground pressure supporting equipment shall be allowed on the geocomposite. Adjacent rolls of geocomposite shall be securely tied through the drainage net with plastic fasteners every five feet along the length of the panel and every six inches along the ends of the panels. The top geotextile of adjacent rolls shall be overlapped and sewn or heat bonded together. Additional geotextile will be used at end seams to cover holes made by installation of the plastic fasteners. This material shall be sewn or heat bonded to the geotextile on the geocomposite. The installer shall take precautions to prevent burning holes in the geotextile when using heat bonding techniques.

During geocomposite placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe the condition of the geocomposite and note any defects. All defects must be repaired or replaced.
- Observe that people working on the geocomposite do not smoke, wear shoes that could damage the geocomposite or underlying geosynthetics, or engage in activities that could damage the geocomposite or underlying geosynthetics.
- Observe that the deployment method minimizes wrinkles in the geocomposite and underlying geosynthetics.
- Observe that the geocomposite panels have been properly tied and seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or removed and replaced by the installer.

6.4.2 Geotextile

Geotextile shall be placed around the aggregate in the collection trenches and the sumps in accordance with the plans. Geotextile shall be deployed by equipment that will unroll the geotextile without damaging or stretching it, and deployment equipment must not damage the underlying geosynthetics. Smoking and wearing shoes that could damage the geotextile or underlying geosynthetics shall not be permitted on the geotextile and only low ground pressure supporting equipment shall be allowed on the geotextile. Adjacent rolls shall be overlapped and sewn or heat bonded together. The installer shall take precautions to prevent burning holes in the geotextile when using heat bonding techniques.

During geotextile placement, the CQA monitor must:

- Provide full time observation.
- Observe the condition of the geotextile and note any defects. All defects must be repaired or replaced.
- Observe that people working on the geotextile do not smoke, wear shoes that could damage the geotextile or underlying geosynthetics, or engage in activities that could damage the geotextile or underlying geosynthetics.
- Observe that the deployment method minimizes wrinkles in the geotextile and underlying geosynthetics.
- Observe that the geotextile panels have been properly seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or removed and replaced by the installer.

6.4.3 Pipe

Pipe shall be placed to the lines and grades shown on the plans. The pipe shall be joined in accordance with the manufacturer's recommendations and the project specifications.

Construction equipment shall not be allowed to travel directly over the leachate pipes to prevent crushing or excessive deflection until aggregates and protective cover have been placed. Minimum equipment separation distances listed in Section 7.4, Table D7-14 shall be observed.

During pipe placement, the CQA monitor must:

- Provide full time observation.
- Observe the condition of the pipes and note any defects. All defective pipes must be replaced.
- Observe that people working on the geosynthetics do not smoke, wear shoes that could damage the geosynthetics, or engage in activities that could damage the geosynthetics.
- Observe that construction equipment does not damage pipes or underlying geosynthetics.
- Observe that the perforations and pipe orientation are in accordance with the plans and specifications.
- Observe that the pipes and fittings are joined in accordance with the project specifications and the manufacturer's recommendations.

Any pipes that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or removed and replaced by the installer.

6.4.4 Aggregate

Aggregate shall be placed in the collection trenches and sumps to the lines and grades shown on the plans. During aggregate placement, the CQA monitor must:

- Observe that aggregate is placed in accordance with the plans and specifications.
- Observe that the aggregate is consistent with the conformance test samples.
- Observe that aggregate placement activities do not dislodge or damage pipes or underlying geosynthetics.

6.5 Testing and Verification

6.5.1 Manufacturer's Testing

The geocomposite manufacturer shall test the geocomposite to assure the quality of the geocomposite. Material property requirements are provided in Section 6.2.1. Minimum manufacturer's testing requirements are provided in Table D7-10. The manufacturer's testing shall be conducted at a minimum frequency of 1 test per 100,000 sf of material.

Table D7-10
130 Environmental Park
Geocomposite Manufacturer's Tests

Material	Test	Standard
Geotextile	Weight	ASTM D 5261
	Apparent Opening Size	ASTM D 4751
	Grab Strength	ASTM D 4632
	Tear Strength	ASTM D 4533
	Puncture Strength	ASTM D 4833
	Burst Strength	ASTM D 3786
HDPE Drainage Net	Specific Gravity	ASTM D 1505
	Thickness	ASTM D 5199
	Carbon Black	ASTM D 1603
Geocomposite	Transmissivity	ASTM D 4716

The geotextile manufacturer shall test the geotextile to assure the quality of the geotextile. Material property requirements are provided in Section 6.2.2. Minimum manufacturer's testing requirements are provided in Table D7-11. The manufacturer's testing shall be conducted at a minimum frequency of 1 test per 100,000 sf of material.

Table D7-11
130 Environmental Park
Geotextile Manufacturer's Tests

Test	Standard
Weight	ASTM D 5261
Apparent Opening Size	ASTM D 4751
Grab Strength	ASTM D 4632
Tear Strength	ASTM D 4533
Puncture Strength	ASTM D 4833
Burst Strength	ASTM D 3786

The piping manufacturer shall provide a certification that the pipe meets the cell classification PE345434C in accordance with ASTM D 3350, and the minimum SDR rating and perforation schedule shown on the plans.

The aggregate shall be tested at the source to assure that the aggregate meets the specifications. Material property requirements are provided in Section 6.2.4. Minimum source testing requirements are provided in Table D7-12.

Table D7-12
130 Environmental Park
Leachate Aggregate Source Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per source
Hydraulic Conductivity	ASTM D 2434	1 per source
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per source

[a] Use an HCL solution having a pH of 5 or lower.

6.5.2 Construction Testing

The leachate aggregate shall be tested to assure that the aggregate meets the specifications. Material property requirements are provided in Section 6.2.4. Minimum construction testing requirements are provided in Table D7-13.

Table D7-13
130 Environmental Park
Leachate Aggregate Construction Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per 3,000 cy
Hydraulic Conductivity	ASTM D 2434	1 per 3,000 cy
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per 3,000 cy

[a] Use an HCL solution having a pH of 5 or lower.

6.5.3 Verification

The as-built location of the leachate and gas collection piping shall be determined and reported in the GLER. All components of the leachate collection system shall be verified and documented in the GLER in accordance with Section 8.3.

7 PROTECTIVE COVER

30 TAC §330.339

7.1 General

The protective cover component of the composite liner system will consist of a 24-inch-thick layer of soils placed over the leachate collection layer. The drainage aggregate around the leachate collection pipes will extend through the protective cover to form a chimney drain for the leachate collection system. The CQA monitor shall provide continuous on-site observation during protective cover placement to assure that protective cover placement does not damage underlying geosynthetics in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during protective cover placement to document the construction activities, testing, and thickness verification in the GLER in accordance with Section 8.3.

7.2 Materials

Protective cover material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material, or any material that could damage the underlying geosynthetics. Since drainage aggregate chimneys will be provided above the LCS trenches, there are no permeability requirements for protective cover materials.

7.3 Preparation

Prior to placing the protective cover material, the top of compacted soil liner elevations shall be verified in accordance with the requirements of Section 4.8.3 and all testing on the underlying geosynthetics shall be completed.

7.4 Placement

The protective cover shall be placed in a manner that minimizes the potential to damage the underlying geosynthetics. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geosynthetics. The protective cover shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geosynthetics. On sidewalls, protective cover shall be placed from the bottom to the top, not across or down. Protective cover shall not be placed over geosynthetics that are stretched across the toes of slopes. The minimum separation distances between construction equipment and the geosynthetics are listed in Table D7-14.

Table D7-14
130 Environmental Park
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
Less than 6	12
6 to 12	18
12 to 16	24
Greater than 16	36

Any geosynthetic material that, in the opinion of the CQA monitor, has been damaged by the protective cover placement must be repaired and retested in accordance with Sections 5.4 and 6.4.

7.5 Testing and Verification

The as-built thickness of the protective cover shall be determined by standard survey methods. Prior to the placement of protective cover, the top of compacted soil liner elevations will be determined at a minimum rate of 1 survey point per 5,000 sf of lined area. After the protective cover is completed, the top of the protective cover elevations will be determined at the same locations as the top of compacted soil liner elevations.

8 DOCUMENTATION

30 TAC §330.341

8.1 Reports

Each report shall be submitted in triplicate to the Municipal Solid Waste Division and shall be prepared in accordance with the methods and procedures contained in this LQCP. The evaluated area should not be used for the receipt of solid waste until acceptance is received from the executive director. The executive director may respond to the permittee either verbally or in writing within 14 days from the date on which the Soils and Liner Evaluation Report is date-stamped by the Municipal Solid Waste Division. Verbal acceptance may be obtained from the executive director, which will be followed by written concurrence. If no response, either written or verbal, is received within 14 days, the SLER or Geomembrane Liner Evaluation Report shall be considered accepted and the owner or operator may continue facility construction or operations. Each report must be signed and, where applicable, sealed by the individual performing the evaluation and countersigned by the site operator or his authorized representative.

Markers will be placed to identify all disposal areas for which a SLER has been submitted and accepted by the executive director. These markers shall be located so that they are not destroyed during operations.

The surface of a liner should be covered with a layer of solid waste within a period of six months to mitigate the effects of surface erosion and rutting due to traffic. Liner surfaces not covered with waste within six months shall be checked by the SLER evaluator, who shall then submit a letter report on his findings to the executive director. Any required repairs shall be performed properly. A new SLER shall be submitted on the new construction for all liners that need repair due to damage.

8.2 Soils and Liner Evaluation Report

After construction of the compacted soil liner, the GP will submit a Soils and Liner Evaluation Report (SLER) to the TCEQ on behalf of the owner. No area may be used for the receipt of solid waste until the TCEQ has accepted the SLER or 14 days from the date of receipt of the SLER by the TCEQ, if the executive director has not provided a verbal or written response.

Preparation and submission of the SLER shall be in accordance with TCEQ MSWR. The purpose of the SLER is to document that the construction methods and test procedures are consistent with this LQCP, the TCEQ MSWR, and the project specifications.

At a minimum, the SLER will contain the following:

- A summary of all construction activities
- A summary of all laboratory and field test results

- Sampling and testing location drawings
- A description of significant construction problems and the resolution of these problems
- Record drawings
- A statement of compliance with the LQCP
- An updated seasonal high water table map
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

8.3 Geomembrane Liner Evaluation Report

After construction of the geosynthetics portion of the liner, the GP will submit a Geomembrane Liner Evaluation Report (GLER) to the TCEQ on behalf of the owner. No area may be used for the receipt of solid waste until the TCEQ has accepted the GLER or 14 days from the date of receipt of the GLER by the TCEQ have lapsed, if the executive director has not provided a verbal or written response.

Preparation and submission of the GLER shall be in accordance with TCEQ MSWR. The purpose of the GLER is to document that the construction methods and test procedures are consistent with this LQCP, the TCEQ MSWR, and the project specifications.

At a minimum, the GLER will contain the following:

- A summary of all construction activities
- A summary of all laboratory and field test results
- Sampling and testing location
- A description of significant construction problems and the resolution of these problems
- Record drawings
- A statement of compliance with the LQCP
- An updated seasonal high water table map
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

130 ENVIRONMENTAL PARK

APPENDIX D7-A
HIGHEST MEASURED GROUNDWATER ELEVATIONS

Technically Complete October 28, 2014

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- LANDFILL FOOTPRINT
- 510 — 2' CONTOURS
- N 13,904,000 — STATE PLANE GRID
- PIEZOMETER
- (P26) PIEZOMETER NO.
- 489.72 BOTTOM OF PIEZOMETER ELEVATION

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.

STATE OF TEXAS
GREGORY W. ADAMS
73356
LICENSED
PROFESSIONAL ENGINEER
11-6-2014

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
–	10/28/14	TECHNICALLY COMPLETE	GLW	GWA	GWA	GWA

HIGHEST MEASURED GROUNDWATER ELEVATIONS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
TYPE I PERMIT APPLICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. GWA	DATE : 10/13	DRAWING D7-A.1
DWN. GLW	SCALE : GRAPHIC	
CHK. GWA	DWG : D7-A-7-HighGrWat.dwg	

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130 ENVIRONMENTAL PARK

APPENDIX D7-B
GRI-GM13

Technically Complete October 28, 2014

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Revision 11: December 14, 2012
Revision schedule on pg. 11

GRI Test Method GM13*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers high density polyethylene (HDPE) geomembranes with a formulated sheet density of 0.940 g/ml, or higher, in the thickness range of 0.75 mm (30 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

1.4 This standard specification is intended to ensure good quality and performance of HDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

values for test indicated, may be necessary under conditions of a particular application.

Note 2: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
D 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes

2.2 GRI Standards

GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet

2.3 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HDPE polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

4. Material Classification and Formulation

4.1 This specification covers high density polyethylene geomembranes with a formulated sheet density of 0.940 g/ml, or higher. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.932 g/ml or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth HDPE geomembranes and Table 2 is for single and double sided textured HDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is soft.

Note 3: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of 23°C ± 2°C. Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of 21°C ± 2°C. The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of 23°C ± 2°C should be utilized for testing purposes.

Note 4: There are several tests often included in other HDPE specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693)
- Wide Width Tensile
- Water Vapor Transmission
- Water Absorption
- Ozone Resistance
- Modulus of Elasticity
- Hydrostatic Resistance
- Tensile Impact
- Field Seam Strength
- Multi-Axial Burst
- Various Toxicity Tests

Note 5: There are several tests which are included in this standard (that are not customarily required in other HDPE specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet (see Note 6)
- Trouser Tear (see Note 7)

Note 6: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

Note 7: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Puncture Resistance
- Stress Crack Resistance
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The properties of the HDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 8: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively.

6. Workmanship and Appearance

6.1 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.

6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marketing

9.1 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

ENGLISH UNITS

Table 1(a) – High Density Polyethylene (HDPE) Geomembrane -Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.)	D5199	nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density mg/l (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties *(1)* (min. ave.)	D 6693								20,000 lb
• yield strength	Type IV	63 lb/in.	84 lb/in.	105 lb/in.	126 lb/in.	168 lb/in.	210 lb/in.	252 lb/in.	
• break strength		114 lb/in.	152 lb/in.	190 lb/in.	228 lb/in.	304 lb/in.	380 lb/in.	456 lb/in.	
• yield elongation		12%	12%	12%	12%	12%	12%	12%	
• break elongation		700%	700%	700%	700%	700%	700%	700%	
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	54 lb	72 lb	90 lb	108 lb	144 lb	180 lb	216 lb	45,000 lb
Stress Crack Resistance *(2)*	D5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI-GM10
Carbon Black Content (range)	D 4218 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)*									200,000 lb
(a) Standard OIT	D 3895	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	
— or —									
(b) High Pressure OIT	D 5885	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	
Oven Aging at 85°C *(5), (6)*	D 5721								
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	55%	55%	55%	55%	55%	55%	55%	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	80%	80%	80%	80%	80%	80%	80%	
UV Resistance *(7)*	D 7238								
(a) Standard OIT (min. ave.)	D 3895	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 5885	50%	50%	50%	50%	50%	50%	50%	

(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 in.

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

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

SI (METRIC) UNITS

Table 1(b) – High Density Polyethylene (HPDE) Geomembrane - Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness - mils (min. ave.) • lowest individual of 10 values	D5199	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	per roll
Density (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties *(1)* (min. ave.) • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 11 kN/m 20 kN/m 12% 700%	 15 kN/m 27 kN/m 12% 700%	 18 kN/m 33 kN/m 12% 700%	 22 kN/m 40 kN/m 12% 700%	 29 kN/m 53 kN/m 12% 700%	 37 kN/m 67 kN/m 12% 700%	 44 kN/m 80 kN/m 12% 700%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	240 N	320 N	400 N	480 N	640 N	800 N	960 N	20,000 kg
Stress Crack Resistance *(2)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM-10
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	9,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 3895 D 5885	 N. R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	per each formulation

(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 33 mm
Break elongation is calculated using a gage length of 50 mm

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

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

ENGLISH UNITS

Table 2(a) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	D 7466	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(3)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 63 lb/in. 45 lb/in. 12% 100%	 84 lb/in. 60 lb/in. 12% 100%	 105 lb/in. 75 lb/in. 12% 100%	 126 lb/in. 90 lb/in. 12% 100%	 168 lb/in. 120 lb/in. 12% 100%	 210 lb/in. 150 lb/in. 12% 100%	 252 lb/in. 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(4)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	D 7238 D 3895 D 5885	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils; also see Note 6.

(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.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

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

(5) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

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

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

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

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

(10) 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.

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

SI (METRIC UNITS)

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	D 7466	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) *(3)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 11 kN/m 8 kN/m 12% 100%	 15 kN/m 10 kN/m 12% 100%	 18 kN/m 13 kN/m 12% 100%	 22 kN/m 16 kN/m 12% 100%	 29 kN/m 21 kN/m 12% 100%	 37 kN/m 26 kN/m 12% 100%	 44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance *(4)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	9,000 kg
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	D 7238 D 3895 D 5885	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13 mm; also see Note 6.

(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.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(4) 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.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

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

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

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

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

(10) 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.

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

Adoption and Revision Schedule
for
HDPE Specification per GRI-GM13

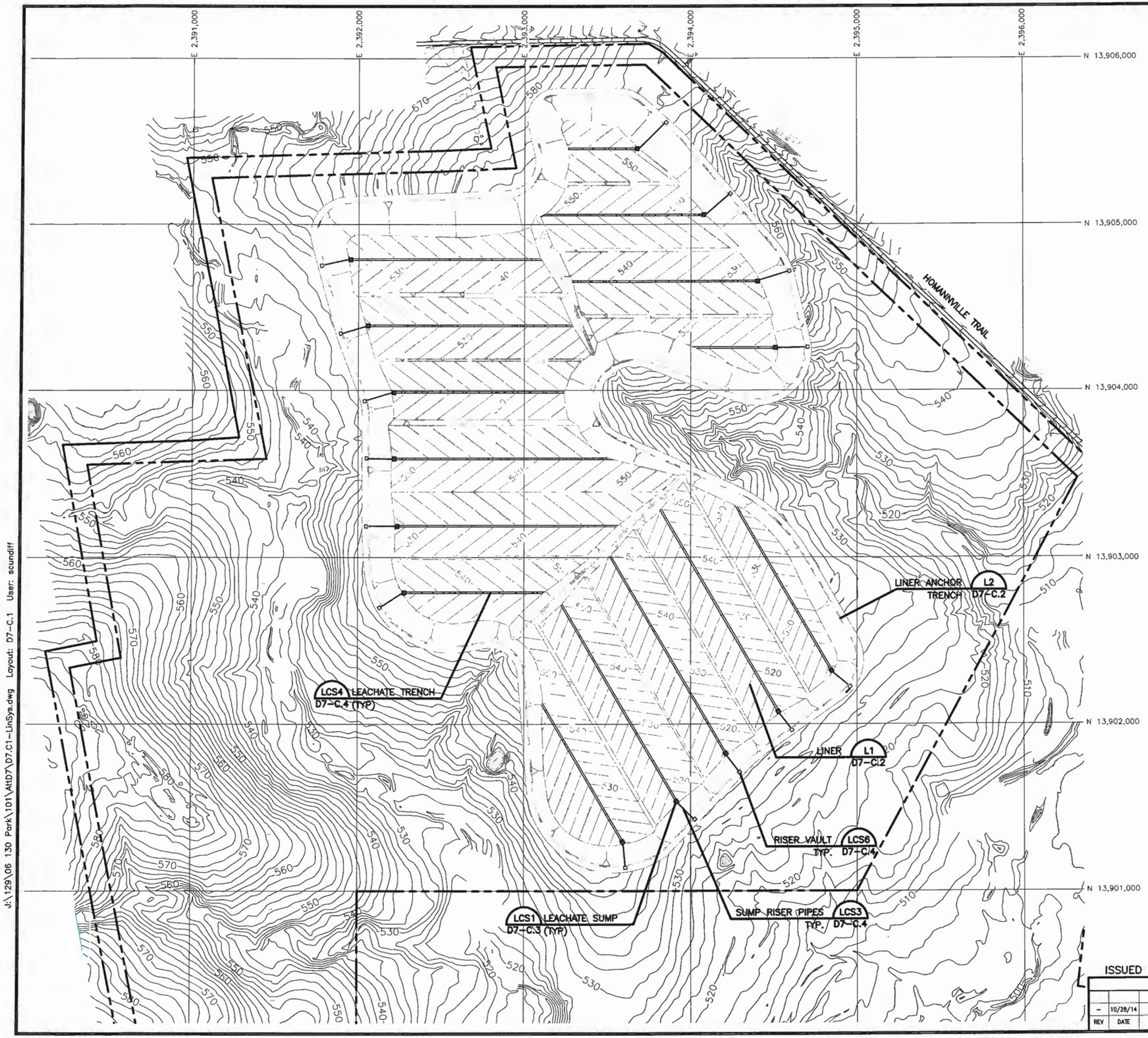
"Test Methods, Test Properties, Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

Adopted:	June 17, 1997
Revision 1:	November 20, 1998; changed CB dispersion from allowing 2 views to be in Category 3 to requiring all 10 views to be in Category 1 or 2. Also reduced UV percent retained from 60% to 50%.
Revision 2:	April 29, 1999: added to Note 5 after the listing of Carbon Black Dispersion the following: "(In the viewing and subsequent quantitative interpretation of ASTM D5596 only near spherical agglomerates shall be included in the assessment)" and to Note (4) in the property tables.
Revision 3:	June 28, 2000: added a new Section 5.2 that the numeric table values are neither MARV or MaxARV. They are to be interpreted per the the designated test method.
Revision 4:	December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".
Revision 5:	May 15, 2003: Increased minimum acceptable stress crack resistance time from 200 hrs to 300 hrs.
Revision 6:	June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 2.
Revision 7:	February 20, 2006: Added Note 6 on Asperity Height clarification with respect to shear strength.
Revision 8:	Removed recommended warranty from specification.
Revision 9:	June 1, 2009: Replaced GRI-GM12 test for asperity height of textured geomembranes with ASTM D 7466.
Revision 10	April 11, 2011: Added alternative carbon black content test methods
Revision 11	December 13, 2012 Replaced GRI-GM11 with the equivalent ASTM D 7238.

130 ENVIRONMENTAL PARK

APPENDIX D7-C
LINER SYSTEM DETAILS

Technically Complete October 28, 2014



0 300 600
SCALE IN FEET

LEGEND

- PROPERTY BOUNDARY
- FACILITY BOUNDARY
- LANDFILL FOOTPRINT
- 510 EXISTING 2' CONTOUR
- N 13,904,000 STATE PLANE GRID
- 530 TOP OF PROTECTIVE COVER
- LEACHATE SUMP

NOTES:

1. CONTOURS AND ELEVATIONS PROVIDED BY DALLAS AERIAL SERVICE FROM AERIAL PHOTOGRAPHY FLOWN MAY 13, 2013. HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83). ELEVATIONS ARE RELATIVE TO NAVD88 – GEOID 12A.
2. PROPERTY BOUNDARY, FACILITY BOUNDARY, EASEMENT LOCATIONS, AND PERMANENT BENCHMARK PROVIDED BY HODDE & HODDE LAND SURVEYING, INC.
3. PROPOSED CONTOURS DEPICT TOP OF PROTECTIVE COVER.

STATE OF TEXAS
GREGORY W. ADAMS
73356
LICENSED
PROFESSIONAL ENGINEER

11-6-2014

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–	10/28/14	TECHNICALLY COMPLETE	GLW	GWA	GWA	GWA

LINER SYSTEM PLAN

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
TYPE I PERMIT APPLICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. GWA	DATE : 10/13
DWN. GLW	SCALE : GRAPHIC
CHK. GWA	DWG : D7.C1-LinSys.dwg

DRAWING D7-C.1

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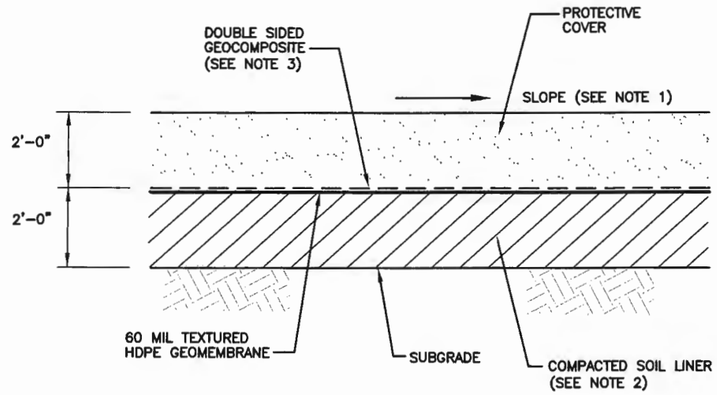


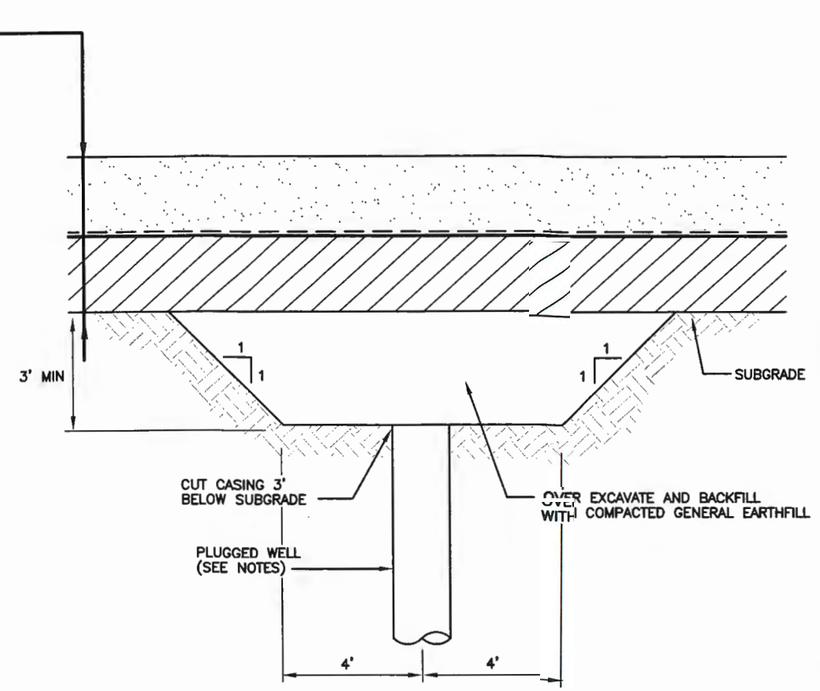
LINER L1 D7-C.2

0 2 4

SCALE IN FEET

NOTES:

1. THE LINER SYSTEM WILL HAVE A 4H:1V SLOPE ON THE PERIMETER SIDEWALLS AND A 1.5% TO 2.5% DOWN SLOPE AND 2% CROSS SLOPE ON THE FLOOR.
2. THE COMPACTED SOIL LINER MUST BE INSTALLED IN 6 INCH THICK LIFTS COMPACTED TO A MINIMUM OF 95% PROCTOR TEST (ASTM D 698) AT OR ABOVE THE OPTIMUM MOISTURE CONTENT. THE COMPACTED SOIL LINER MUST HAVE A COEFFICIENT OF PERMEABILITY OF 1 x 10^{-7} cm/sec OR LESS. THE WIDTH OF COMPACTED SOIL LIFTS GENERALLY WILL NOT EXCEED 400 FEET (TYPICAL CELL WIDTH).
3. THE DOUBLE SIDED GEOCOMPOSITE CONSISTS OF AN 8 OZ./SY NONWOVEN GEOTEXTILE BONDED TO EACH SIDE OF A 0.275 INCH THICK HDPE GEONET. THE GEOCOMPOSITE MUST HAVE A MINIMUM TRANSMISSIVITY OF 7 x 10^{-4} m^2/sec.



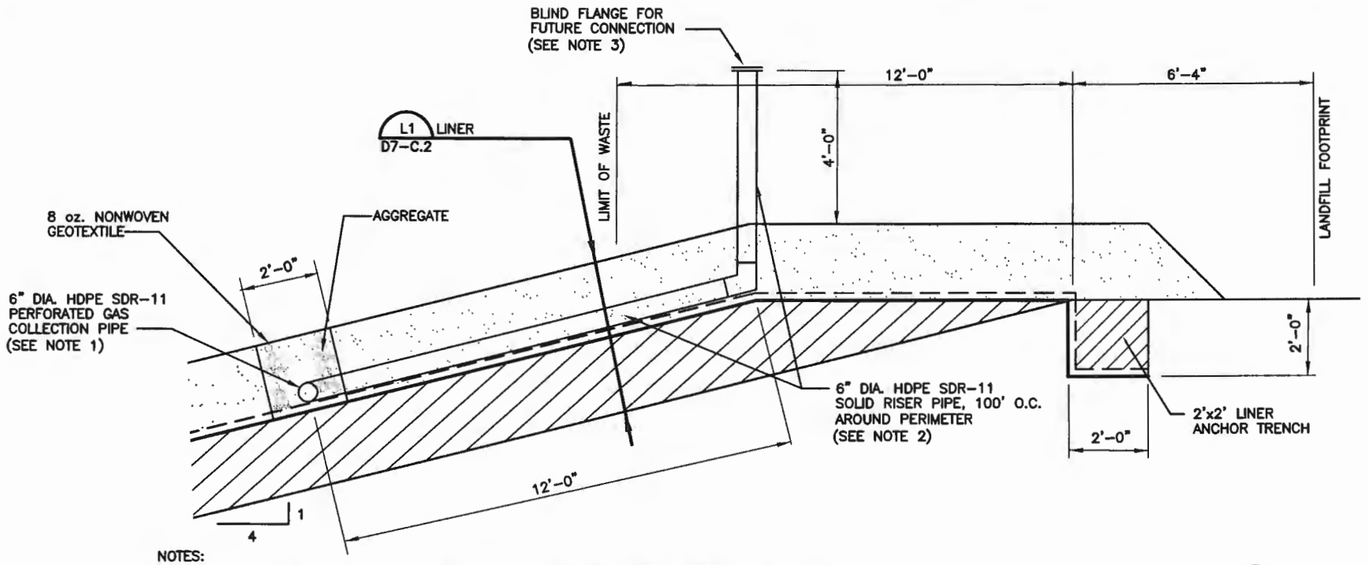
PLUGGED WELL COMPLETION L3 D7-C.2

0 2 4

SCALE IN FEET

NOTES:

1. ANY WATER WELL OR PIEZOMETER ENCOUNTERED WITHIN THE LANDFILL FOOTPRINT SHALL BE PLUGGED IN ACCORDANCE WITH THE RULES OF THE TCEQ AND OTHER APPLICABLE STATE AGENCIES.
2. ANY OIL OR GAS WELL ENCOUNTERED WITHIN THE LANDFILL FOOTPRINT SHALL BE PLUGGED IN ACCORDANCE WITH THE APPLICABLE TEXAS RAILROAD COMMISSION REGULATIONS.



NOTES:

1. THE PERFORATED GAS COLLECTION PIPE WILL BE INSTALLED ABOVE THE GEOCOMPOSITE AROUND THE ENTIRE PERIMETER OF THE LANDFILL FOR FUTURE GAS COLLECTION IF NECESSARY.
2. RISER PIPES WILL BE INSTALLED AT 100 FOOT INTERVALS AROUND THE PERIMETER OF THE LANDFILL FOR FUTURE CONNECTION TO THE GAS COLLECTION SYSTEM IF NECESSARY.
3. BLIND FLANGES WILL BE PROVIDED ON ENDS OF RISER PIPES FOR THE FUTURE CONNECTION TO THE GAS SYSTEM IF NECESSARY.
4. REFER TO ATTACHMENT G, SECTION 6A FOR A DESCRIPTION OF THE FUTURE GAS COLLECTION SYSTEM CONNECTIONS.

LINER ANCHOR TRENCH L2 D7-C.2

0 2 4

SCALE IN FEET

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GREGORY W. ADAMS
73356
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11-6-2014

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LINER DETAILS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
TYPE I PERMIT APPLICATION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. GWA | DATE : 10/13 | DRAWING
DWN. GLW | SCALE : GRAPHIC | D7-C.2
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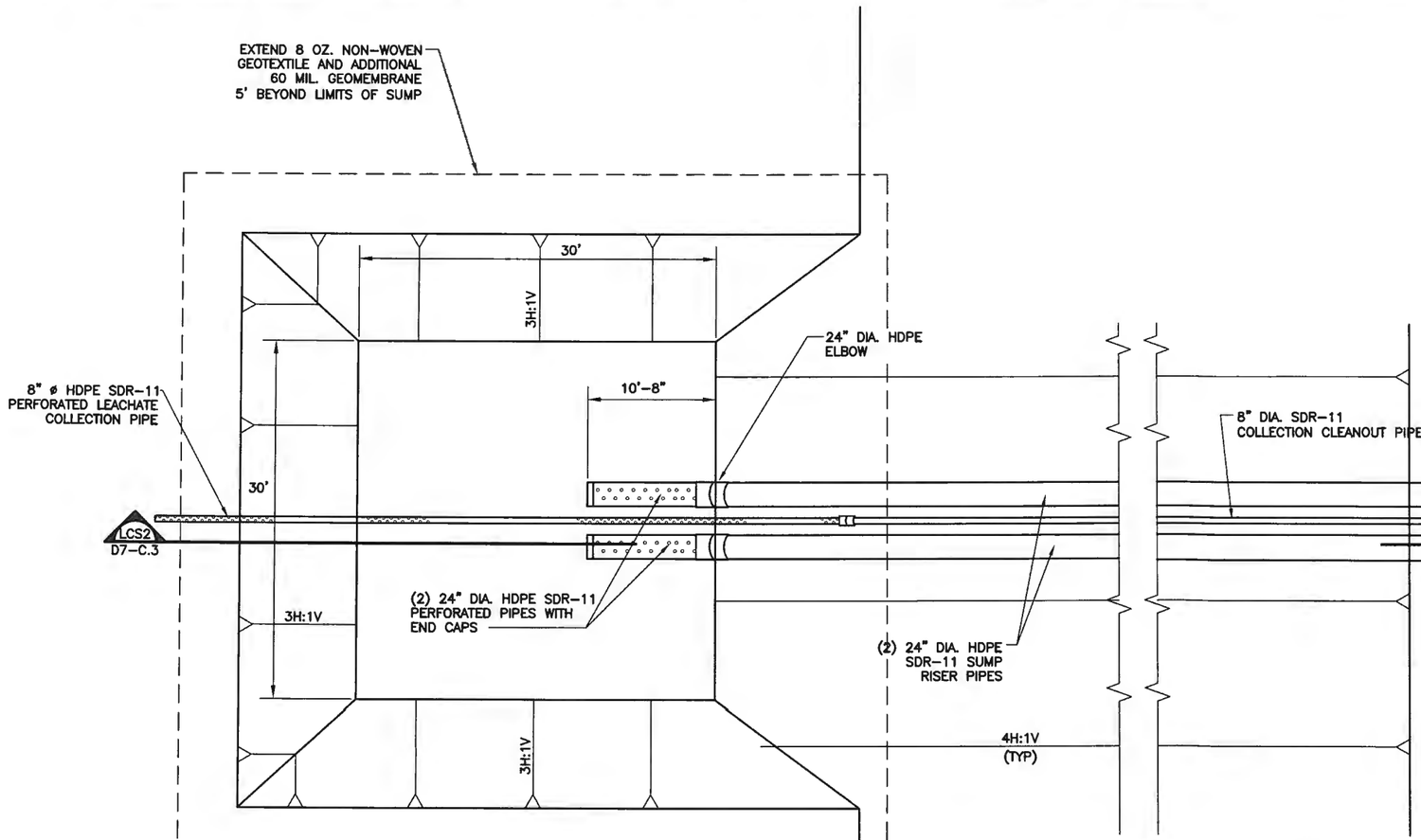
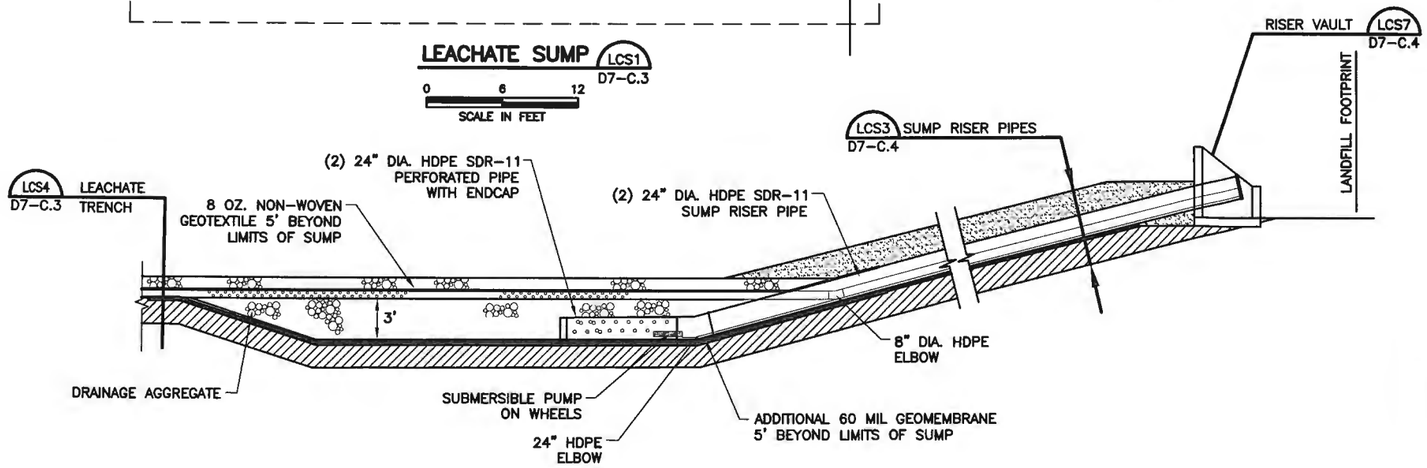


LEACHATE SUMP LCS1 D7-C.3

0 6 12

SCALE IN FEET



LEACHATE SUMP AND RISER LCS2 D7-C.3

0 6 12

SCALE IN FEET

NOTES:

1. DRAINAGE AGGREGATE NOT SHOWN FOR CLARITY.
2. REFER TO ATTACHMENTS D6 AND D7 FOR INSTALLATION AND MATERIAL REQUIREMENTS.
3. REFER TO ATTACHMENT D6, APPENDIX D6-A FOR LEACHATE SUMP DESIGN CALCULATIONS.

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11-6-2014

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LEACHATE COLLECTION SYSTEM DETAILS

130 ENVIRONMENTAL PARK, LLC
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MANSFIELD • WICHITA FALLS
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TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. GWA	DATE : 10/13	DRAWING	
DWN. GLW	SCALE : GRAPHIC	D7-C.3	
CHK. GWA	DWG : D3.4_5-LeaDet.dwg		

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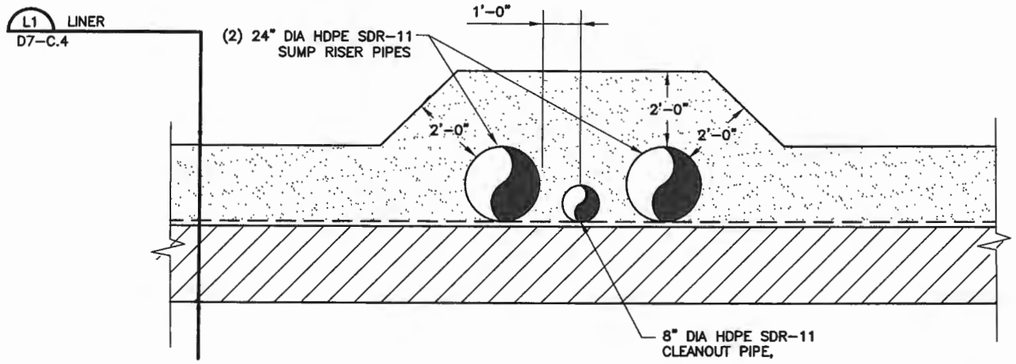
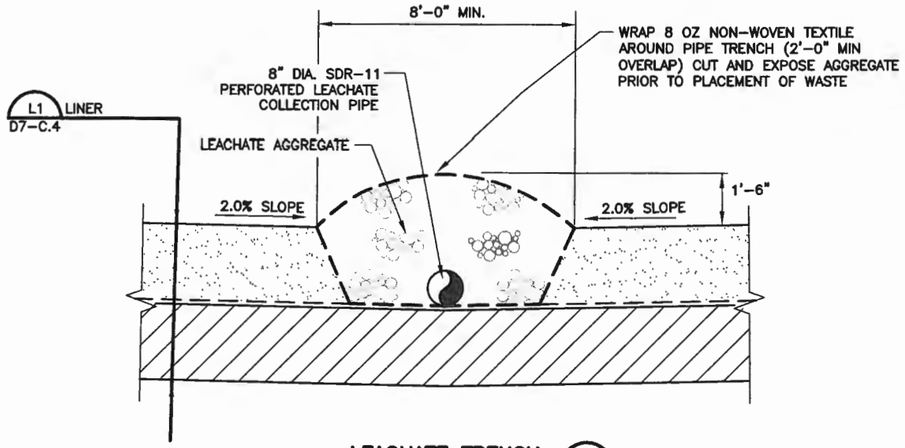


SUMP RISER PIPES LCS3 D7–C.4

0 2 4
SCALE IN FEET



LEACHATE TRENCH LCS4 D7–C.4

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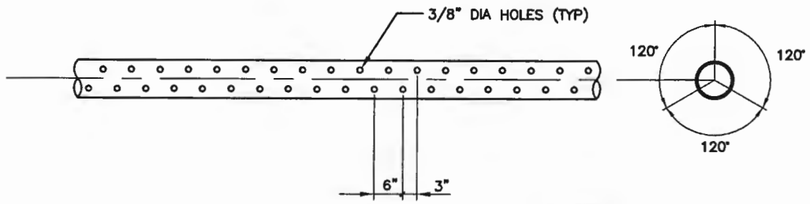
SCALE IN FEET

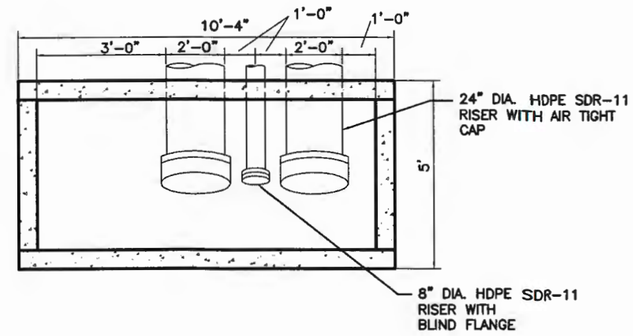


PERFORATED PIPE LCS5 D7–C.4

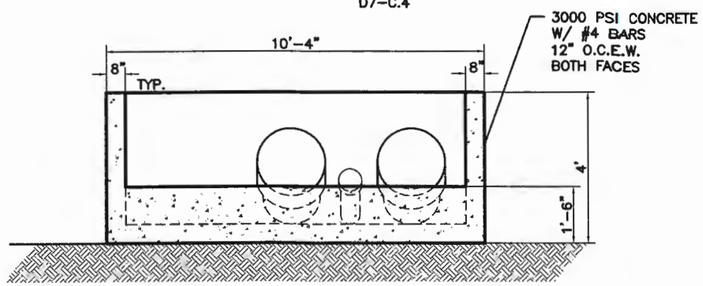
NTS

NOTES:

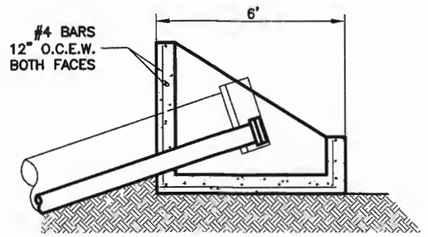
1. REFER TO ATTACHMENTS D6 AND D7 FOR INSTALLATION AND MATERIAL REQUIREMENTS.



RISER VAULT PLAN LCS6 D7–C.4



RISER VAULT SECTION LCS7 D7–C.4



RISER VAULT SECTION LCS8 D7–C.4

STATE OF TEXAS
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LEACHATE COLLECTION SYSTEM DETAILS

130 ENVIRONMENTAL PARK, LLC
130 ENVIRONMENTAL PARK
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CONSULTING ENGINEERS
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817–563–1144

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DSN. GWA | DATE : 10/13
DWN. GLW | SCALE : GRAPHIC
CHK. GWA | DWG : D3.4_5–LeaDet.dwg

DRAWING D7–C.4

130 ENVIRONMENTAL PARK
CALDWELL COUNTY, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 2383

TYPE I PERMIT APPLICATION

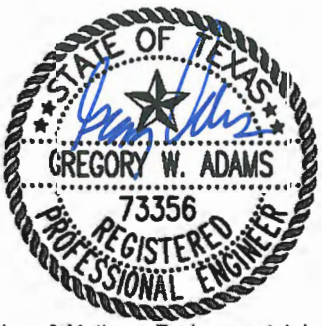
PART III – FACILITY INVESTIGATION AND DESIGN

ATTACHMENT D8
FINAL COVER QUALITY CONTROL PLAN

Prepared for

130 ENVIRONMENTAL PARK, LLC

Technically Complete October 28, 2014



Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256
11/6/2014

Prepared by

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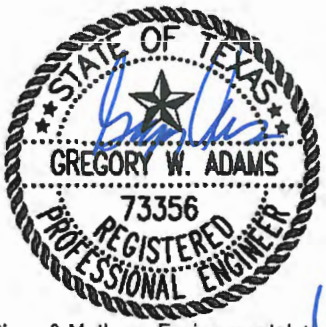
TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NO. F-256

TEXAS BOARD OF PROFESSIONAL GEOSCIENTISTS
FIRM REGISTRATION NO. 50222

And

BIGGS & MATHEWS, INC.
2500 Brook Avenue • Wichita Falls, Texas 76301 • 940-766-0156

TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NO. F-834



11/6/2014

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

CONTENTS

30 TAC §330.457

CONTENTS (CONTINUED)

30 TAC §330.457

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

11/6/2014

TABLES

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256
11/6/2014

1 INTRODUCTION

30 TAC §330.457

1.1 Purpose

This Final Cover Quality Control Plan (FCQCP) has been prepared in accordance with 30 TAC §330.457. This FCQCP establishes the procedures for the design, construction, testing, and documentation of the final cover system.

1.2 Definitions

Specific terms and acronyms that are used in this FCQCP are defined below.

ASTM – American Society for Testing and Material

Construction Quality Assurance (CQA) – CQA is a planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. CQA includes the observations, evaluations, and testing necessary to assess and document the quality of the constructed facility. CQA includes measures taken by the CQA organization to assess whether the work is in compliance with the plans, specifications, and permit requirements for a project.

Geotechnical Professional (GP) – The GP is the authorized representative of the owner who is responsible for all CQA activities for the project. The GP must be registered as a Professional Engineer in Texas. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The GP must also have competency and experience in certifying similar projects.

The GP may also be known in applicable regulations and guidelines as the CQA engineer, resident project representative, geotechnical quality control/quality assurance professional (GQCP), or professional of record (POR).

CQA Monitors – CQA monitors are representatives of the GP who work under direct supervision of the GP. The CQA monitor is responsible for quality assurance monitoring and performing on-site tests and observations. The CQA monitor must be NICET-certified at Level 2 for soils and geosynthetics, an engineering technician with a minimum of four years directly related experience, or a graduate engineer or geologist with one year of directly related experience.

Owner's Representative – The owner's representative is an official representative of the owner responsible for planning, organizing, and controlling the design and construction activities.

Quality Assurance – Quality assurance is a planned program that is designed to assure that the work meets the requirements of the plans, specifications, and permit for a project. Quality assurance includes procedures, quality control activities, and documentation that are performed by the GP and CQA monitor.

Quality Control – Quality control includes the activities that implement the quality assurance program. The GP, CQA monitor, and contractor will perform quality control.

2 FINAL COVER SYSTEM

30 TAC §330.457

2.1 Final Cover System

The final cover system will consist of an infiltration layer, a flexible membrane cover (FMC), a drainage layer on sideslopes, a cushion layer on topslopes, and an erosion control layer. The infiltration layer will consist of a minimum of 18 inches of compacted soil with a coefficient of permeability less than or equal to 1×10^{-5} cm/sec. The flexible membrane cover will consist of a 40-mil LLDPE geomembrane placed over the infiltration layer.

A geocomposite drainage layer will be installed above the geomembrane on the sideslopes. The geocomposite will protect the geomembrane during the placement of the erosion layer and will allow the erosion layer to drain, preventing the erosion layer on the sideslopes from becoming saturated. The stability calculations in Attachment D5, Appendix D5-B demonstrate that the erosion layer on the sideslope will be stable when drained.

A geotextile cushion layer will be installed above the geomembrane on the topslopes. The geotextile will protect the geomembrane during the placement of the erosion layer. Drainage is not required for the topslope erosion layer because it will be stable when saturated as demonstrated in the stability calculations in Attachment D5, Appendix D5-B.

The erosion control layer will consist of a minimum of 24 inches of soil, of which the top six inches is capable of sustaining native plant growth. The final cover will be vegetated following the application of the final cover in order to minimize erosion.

The final cover plan and details are included in Attachment D3 – Construction Design Details. The components of the final cover system are listed from top to bottom in Table D8-1.

Table D8-1
130 Environmental Park
Components of the Final Cover System

SUBTITLE D FINAL COVER		
Cover System Component	**Description**	**Thickness**
Erosion Layer	Soil that is capable of sustaining native plant growth	24 inches minimum
Drainage Layer (Sideslope only)	Double-sided geocomposite	200 mil nominal
Cushion Layer (Topslope only)	Nonwoven geotextile	6 oz/sy nominal
Flexible Membrane Cover	Textured LLDPE geomembrane	40 mil nominal
Infiltration Layer	Compacted soil	18 inches minimum

2.2 Construction Monitoring

Continuous on-site monitoring is necessary to assure that the components of the final cover system are constructed in accordance with this FCQCP. The CQA monitor shall provide continuous on-site observation during the following construction activities:

- Infiltration layer placement, processing, compaction, and testing
- Flexible membrane cover deployment, trial welds, seaming, testing, and repairing
- Drainage layer deployment and seaming
- Erosion layer placement
- Any work that could damage the installed components of the final cover system

The GP will document and certify that the final cover system was constructed in accordance with this FCQCP. The GP shall make sufficient site visits to observe critical construction activities and to verify that the construction and quality assurance activities are performed in accordance with this FCQCP.

3 INTERMEDIATE COVER AND GRADING

§330.165(c)

3.1 General

The proposed landfill completion plan (Attachment D1 – Site Layout Plans, Drawing D1.7) provides for the landfill cover to slope to the perimeter 4H:1V side slopes. The final lift of waste will be covered by intermediate cover that is placed in accordance with the Site Operating Plan.

3.2 Materials

Intermediate cover will consist of general fill that has not previously come into contact with waste.

3.3 Slopes

The slope stability analyses are provided in Attachment D5 – Geotechnical Design, Appendix D5-B. The slope stability analyses are only valid for the conditions that were analyzed. Any changes to the final cover system or landfill completion plan will necessitate that the slope stability analyses be revised to reflect the actual conditions. Further, the slope stability analyses represent end-of-construction conditions and may not represent temporary conditions during construction. Temporary construction slopes shall not be steeper than the final slopes and concentrated loadings, such as heavy equipment and soil stockpiles, shall not be placed near the crest of slopes unless additional slope stability analyses are performed.

3.4 Testing and Verification

Intermediate cover placement and grading will be observed and documented by the landfill staff in accordance with the Site Operating Plan.

4 INFILTRATION LAYER

30 TAC §330.457

4.1 General

The infiltration layer consists of an 18-inch-thick layer of compacted, relatively homogeneous, cohesive material. The CQA monitor shall provide continuous on-site observation during infiltration layer placement, processing, compaction, and testing. The GP shall make sufficient site visits during infiltration layer construction to document the construction activities, testing, and thickness verification in the Final Cover System Report, in accordance with Section 8.

4.2 Materials

Infiltration layer material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material. The required infiltration layer material properties are summarized in Table D8-2.

Table D8-2
130 Environmental Park
Infiltration Material Properties

Test	Standard	Required Property
Plasticity Index	ASTM D 4318	15 or greater
Liquid Limit	ASTM D 4318	30 or greater
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	30% or greater
Percent Passing 1-inch Sieve	ASTM D 422	100%
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1×10^{-5} cm/sec or less

Preconstruction testing procedures and frequencies for infiltration layer materials are listed in Section 4.8.1.

4.3 Subgrade Preparation

Prior to placing infiltration layer material, the subgrade should be proof rolled with heavy, rubber-tired construction equipment to detect soft areas. The GP or CQA monitor must observe the proof-rolling operation. Soft areas should be compacted and then be proof rolled again.

The subgrade elevations shall be verified in accordance with the requirements of Section 4.8.3 prior to the placement of infiltration layer.

4.4 Placement and Processing

The infiltration layer subgrade and surface of each lift should be scarified to a minimum depth of six inches prior to placement of the next lift of the infiltration layer. The infiltration layer material should be placed in maximum eight-inch loose lifts to produce a compacted lift thickness of approximately six inches. The material should be processed to a maximum particle size of one inch or less before water is added. Rocks and clods less than one inch in diameter should not total more than about 10 percent by weight. The surface of the top lift shall contain no material larger than 3/8 inch.

If additional water is necessary to adjust the moisture content, it should be applied after initial processing but prior to compaction. Water should be applied evenly across the lift and worked into the material. Waste or any objectionable material must not contaminate compaction water.

4.5 Compaction

The infiltration layer shall be compacted with a pad/tamping-foot or prong-foot roller. A footed roller is necessary to bond the lifts, distribute the water, and blend the soil matrix through kneading action. The infiltration layer shall not be compacted with a bulldozer, rubber-tired roller, flat-wheel roller, scrapers, or any track equipment unless it is used to pull a footed roller. The compactor should weigh at least 40,000 pounds. The lift thickness shall be controlled to achieve total penetration into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. Cleaning devices on the roller must be in place and maintained to prevent the prongs or pad feet from becoming clogged to the point that they cannot achieve full penetration.

The compactor shall make at least four passes across the area being compacted. A pass is defined as one pass of the compactor, front and rear drums. The material should be compacted to a minimum of 95 percent of the maximum dry density determined by standard Proctor (ASTM D 698) at a moisture content at or above optimum moisture. Areas with failing tests shall be reworked and recompacted, and then retested with passing tests before another lift is added.

After a lift is compacted, it must be watered to prevent drying and desiccation until the next lift can be placed. If desiccation occurs, the GP must determine if the lift can be rehydrated by surface application of water or if the lift must be scarified, watered, and then recompacted. Following compaction and fine grading of the final lift, the surface of the infiltration layer shall be smooth drum rolled.

4.6 Protection

The completed infiltration layer must be protected from drying, desiccation, rutting, erosion and ponded water until the FMC is installed. Areas that undergo excessive desiccation or damage shall be reworked, recompacted, and retested as directed by the GP.

4.7 Tie In to Existing Covers

The edge of existing infiltration layers shall be cut back on either a slope or step to prevent the formation of a vertical joint.

4.8 Testing and Verification

4.8.1 Preconstruction Testing

Table D8-3 lists the minimum testing required for material proposed for use as the infiltration layer.

Table D8-3
130 Environmental Park
Infiltration Layer Material Preconstruction Tests

Test	Standard	Frequency
Plasticity Index	ASTM D 4318	1 per material type
Liquid Limit	ASTM D 4318	1 per material type
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	1 per material type
Percent Passing 1-inch Sieve	ASTM D 422	1 per material type
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1 per material type

After the moisture density relationship has been determined for a material type, a soil sample should be remolded to about 95 percent of the maximum dry density at the optimum moisture content. This sample will be tested to determine if the soil can be compacted to achieve a suitable coefficient of permeability. Either falling head or constant head laboratory permeability tests may be performed to determine the coefficient of permeability. The permeant fluid for testing must be tap water or 0.005N calcium sulfate solution. Distilled or deionized water shall not be used as the permeant fluid.

4.8.2 Construction Testing

Table D8-4 lists the minimum testing required for material used as the infiltration layer.

Table D8-4
130 Environmental Park
Infiltration Layer Material Construction Tests

Test	Standard	Frequency[1,2]
Field Density	ASTM D 2922	1/8,000 sf per 6-inch lift
Plasticity Index	ASTM D 4318	1 per acre
Liquid Limit	ASTM D 4318	1 per acre
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	1 per acre
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1 per acre

[1] Tests should be evenly distributed through all lifts.
[2] A minimum of one test must be performed for each lift regardless of surface area.

The Atterberg limits of the in-place infiltration layer must be continually compared to the Atterberg limits of the Proctor curve sample to assure that the Proctor curve accurately represents the in-place material. Any variance of more than 10 points between the liquid limit or plasticity index of the in-place soil and those of the Proctor curve sample will require that a new Proctor curve be developed.

4.8.3 Thickness Verification

The as-built thickness of the infiltration layer shall be determined by standard survey methods. Prior to the placement of infiltration layer material, the subgrade elevations will be determined at a minimum rate of one survey point per 5,000 square feet of lined area. After the infiltration layer is completed, the top of infiltration layer elevations will be determined at the same locations as the subgrade elevations.

5 FLEXIBLE MEMBRANE COVER

30 TAC §330.457

5.1 General

The flexible membrane cover (FMC) component of the final cover system consists of a textured 40-mil-thick linear low-density polyethylene (LLDPE) placed over the infiltration layer. The CQA monitor shall provide continuous on-site observation during FMC deployment, trial welds, seaming, testing, and repairing. The GP shall make sufficient site visits during the FMC installation to document the installation and testing in the Final Cover Evaluation Report, in accordance with Section 8.

5.2 Materials

5.2.1 Properties

FMC shall consist of textured LLDPE geomembrane produced from virgin raw materials. Recycled materials are not acceptable. The FMC shall not be manufactured from resin from differing suppliers. The FMC shall meet the requirements in the most current revisions of Geosynthetics Research Institute (GRI) Standard GM17. A copy of GRI GM17 is included in Appendix D8-A.

Manufacturer quality control testing procedures and frequencies for FMC are listed in Section 5.5.1. Third party conformance testing procedures and frequencies for FMC are listed in Section 5.5.2.

5.2.2 Delivery and Storage

FMC shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected.

The FMC shall be unloaded and handled with equipment that does not damage the rolls. Rolls should not be pushed, slid, or dragged to the storage location. The FMC must not be stored on wet, soft, or rocky subgrade, but must be stored on a stable subgrade. FMC must not be stacked more than five rolls high to avoid crushing the roll cores. The stored FMC must be protected from puncture, grease, dirt, excessive heat, or other damage.

5.3 Preparation

The surface of the infiltration layer shall be protected until the FMC is installed in accordance with Section 4.6. Prior to installation of the FMC the infiltration layer shall be tested and verified in accordance with Section 4.8, and the GP or CQA monitor and geosynthetics installer shall inspect the surface of the infiltration layer to verify that:

- The infiltration layer surface has been smooth drum rolled.
- The infiltration layer surface is free of irregularities, soft areas, or loose soil.
- The infiltration layer surface is free of stones, protrusions, or objects that could damage the FMC.

The geosynthetics installer must accept the condition of the infiltration layer and sign a subgrade acceptance form prior to the installation of the FMC.

5.4 Installation

5.4.1 Deployment and Placement

The following activities must take place prior to FMC deployment:

- The manufacturer's quality control and third party conformance tests should be completed and approved by the GP in accordance with the requirements of Section 5.5.
- The GP or CQA monitor and geosynthetics installer shall approve the subgrade in accordance with the requirements of Section 5.3.
- The geosynthetics installer shall sign the subgrade acceptance form.
- The geosynthetics installer shall submit a drawing showing the proposed panel layout.

FMC shall be deployed by equipment that will unroll the FMC without damaging, crimping, or stretching it and deployment equipment must not damage the underlying compacted infiltration layer. FMC must not be deployed during periods of rain or high winds and shall not be deployed on frozen subgrade. The installer must only deploy the amount of FMC that can be seamed on the same day.

Upon deployment, each panel shall be assigned a unique identification number. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and wearing shoes that may damage the FMC shall not be permitted on the FMC and only low ground pressure supporting equipment shall be allowed on the FMC.

During FMC placement, the CQA monitor must:

- Provide full time observation.
- Perform thickness verification tests on each panel. Thickness verification shall be performed with a micrometer at a minimum of one measurement per five feet along the leading edge of the panel. A minimum of five tests is required for each panel. No measurement may be less than 90 percent of the nominal panel thickness.

- Record panel numbers, panel dimensions, and roll numbers on the panel layout drawing.

- Record weather conditions.

- Observe the condition of the subgrade and note any deficiencies. All deficiencies shall be repaired and approved by the CQA monitor.

- Observe the condition of the FMC and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.

- Observe that people working on the FMC do not smoke, wear shoes that could damage the FMC, or engage in activities that could damage the FMC.

- Observe that the deployment method minimizes wrinkles and that the FMC is anchored to prevent movement from wind.

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

- Observe that there are no horizontal seams on side slopes.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and repaired in accordance with Section 5.4.4 or be removed and replaced by the installer.

5.4.2 Seaming

Only welding apparatus and operators that have completed approved trial welds, in accordance with Section 5.5.3, shall be allowed to weld panel seams. Each seam shall be assigned a unique number, which is preferably consistent with the panel numbering system. Side slope seams shall be oriented downslope. Prior to welding, the proper panel overlap shall be provided; dirt, grease, and free moisture shall be cleaned from the panel contact area; and wrinkles shall be removed as much as practical. For extrusion welds, oxidation shall be ground from the seam area within one hour of the welding operation and the extrudiate shall be purged from the extrusion welding apparatus. Seaming operations shall not be allowed when the ambient temperature is below 40°F or above 104°F unless trial welds have demonstrated that adequate welds can be achieved outside these limits.

During FMC seaming operations, the CQA monitor must:

- Provide full time observation.

- Record seam numbers on the panel layout drawing.

- Record weather conditions.

- Observe that only approved welding apparatus and operators are allowed to weld seams.

- Observe the condition of the seams and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.

- Observe that people working on the FMC do not smoke, wear shoes that could damage the FMC, or engage in activities that could damage the FMC.

- Observe that the seams are free of grease, dirt, moisture, and wrinkles.

- Observe that welding operations take place within the approved ambient temperature range.

- Observe that seam grinding has been completed less than one hour before extrusion welding and the extrudiate has been purged from extrusion welders.

- Observe that there are no horizontal seams on side slopes.

5.4.3 Anchor Trenches

The FMC anchor trench shall be left open until the seaming is completed. Expansion and contraction of the FMC should be accounted for during deployment. The top corner of the anchor trenches shall be rounded to prevent crimping the FMC. The bottom of the anchor trench shall be dry, stable, and free of loose particles and rocks. Anchor trenches shall be backfilled with compacted general fill that is free of particles larger than 1 inch in diameter. The anchor trenches shall be backfilled and compacted in a manner that does not damage or induce stress to the FMC.

5.4.4 Repairs

Defects in the FMC, defects in seams, failing destructive tests, failing nondestructive tests, holes from nondestructive tests, and destructive test sample locations shall be repaired by one of the following repair techniques:

- Patching – used to repair large holes, tears, large FMC defects, and destructive test locations.

- Extrusion – used to repair small FMC defects, cuts, holes from nondestructive tests, and seam defects less than 1/2-inch long.

- Capping – used to repair failed seams or seams where nondestructive tests cannot be performed.

- Removal – used to replace areas with large defects where other repair techniques are not appropriate.

Patches and caps should extend six inches beyond the edge of the defect and the repair surfaces shall be clean and dry. The area to be repaired shall be abraded to remove oxidation and the top edges of patches should be beveled.

5.5 Testing and Verification

5.5.1 Manufacturer's Quality Control Testing

The FMC manufacturer shall test the geomembrane and raw materials in accordance with GRI Standard GM17 to assure the quality of the FMC. Material property requirements are provided in Section 5.2.1. Minimum manufacturer's testing requirements are provided in Table D8-5.

5.5.2 Conformance Testing

Conformance samples of the FMC shall be cut across the full width of selected rolls in accordance with the test frequency specified in Table D8-5. Conformance samples may be taken at the manufacturing plant or at the project site and will be forwarded to a third party laboratory for testing. Material property requirements are provided in Section 5.2.1. Minimum conformance testing requirements are provided in Table D8-5.

Table D8-5
130 Environmental Park
FMC Conformance Tests

Test	Standard	Frequency
Sheet Thickness	ASTM D 5199, 1593, or 5994	1 per 100,000 sf and every resin lot
Specific Gravity	ASTM D 1505	1 per 100,000 sf and every resin lot
Carbon Black Content	ASTM D 1603	1 per 100,000 sf and every resin lot
Carbon Black Dispersion	ASTM D 3015 or 5596	1 per 100,000 sf and every resin lot
Tensile Properties	ASTM D 638	1 per 100,000 sf and every resin lot
Direct Shear[1]	ASTM D 5321	1 per GM/adjoining material type

[1]Direct Shear Test (ASTM D 5321) will be performed at strain rates, confining pressures and other parameters that simulate the field conditions.

A direct shear test will be performed on the textured GM/soil interface and the textured GM/geocomposite interface for each manufacturer's material used at the site. The GP will perform a slope stability analysis using the site-specific direct shear test data. The angle of friction and cohesion values will be acceptable if the results of the site-specific slope stability analysis demonstrate that the factor of safety against sliding is 1.5 or greater.

5.5.3 Trial Welds

Each operator and welding apparatus must be tested to verify that seam welds that meet the specifications can be achieved under the site conditions. Trial welds must be performed at the beginning and midpoint of each day for each operator and apparatus used that day. If welding continues past 6:00 p.m., additional trial welds may be required. Trial welds should also be made at each occurrence of significantly different environmental conditions (such as temperature, humidity, or dust), anytime a machine is turned off for more than 30 minutes, and when seaming different geomembranes (such as at tie-ins).

The trial weld samples shall be three feet long and 12 inches wide, with the seam centered lengthwise. At least four one-inch-wide coupons will be cut from each trial weld sample. Two coupons from each sample will be tested for shear and two samples will be tested for peel. Peel test coupons for dual-track welds shall be tested on both sides of the air channel. Each coupon must meet the minimum strength requirements listed in Table D8-6 and exhibit a Film Tear Bond (FTB). If the trial weld fails, two more trial seams must be welded and tested. This process will continue until passing trial welds are achieved.

The CQA monitor must observe the trial welding operations and document the operator's initials, apparatus number, time, date, air temperature, apparatus temperature, and peel and shear test results. If the CQA monitor believes that an operator or apparatus is not functioning properly, or if the weather conditions have substantially changed since the trial welds were performed, new trial welds must be performed.

5.5.4 Construction Testing

Nondestructive Tests

Nondestructive seam tests include vacuum testing and air pressure testing. Nondestructive testing shall be performed for the entire length of each seam by the FMC installer.

Vacuum testing shall be used to test extrusion-welded seams and fusion-welded seams that cannot be tested by air pressure methods. The vacuum box shall be placed over a seam section, which has been thoroughly saturated with a soapy water solution. The rubber gasket on the bottom of the vacuum box must seal against the FMC to prevent leaks. The vacuum box pressure shall be reduced to about three to five inches of Hg. Soap bubbles will indicate the presence of holes or non-bonded seams. The vacuum box dwell time shall be at least 10 seconds.

Air pressure testing shall be used to test fusion-welded seams that have an air channel. Both ends of the air channel shall be sealed and air shall be pumped into the channel to at least 30 psi or 1/2 psi per mil of thickness, whichever is greater. The air channel must sustain the pressure for at least five minutes, without more than a 4-psi pressure drop. Following a passing pressure test, the pressure shall be released from the end of the seam that is opposite of the pressure gauge. The pressure gauge must return to zero; if it does not, the seam is probably blocked. After the blockage has been located, the

seam shall be pressure tested on both sides of the blockage. All penetration holes shall be sealed after the air pressure testing is completed.

During the nondestructive testing, the CQA monitor must:

- Observe that equipment and operators perform the tests properly.
- Observe that the entire length of each seam is tested and record the results of the test.
- Identify failed seams and inform the installer of any required repairs.
- Record all completed and tested repairs.

Destructive Tests

Destructive testing shall be performed at a frequency of one stratified test location per 500 linear feet of seam. Repairs over 10 feet long shall be included in the total seam length. Destructive test samples should be 45 inches long by 12 inches wide with the seam centered along the length of the sample.

Two coupons should be cut from each end of the sample and the installer must test these coupons with a tensiometer capable of measuring the seam strength. The installer shall test two coupons in shear and two coupons in peel. For double wedge-welded seams, both sides of the air channel shall be tested in peel. The CQA monitor must observe the tests and record the results on the destructive testing log. The minimum requirements for destructive testing are provided in Table D8-6. If one of the coupons fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established.

If the field test results are satisfactory, the remaining sample shall be divided into three parts: one-third for the installer, one-third for third party laboratory testing, and one-third for the owner to archive. The laboratory shall test five coupons from each sample in shear and test five coupons from each sample in peel (10 when testing both inner and outer welds of dual-track welds). The minimum requirements for destructive testing are provided in Table D8-6. If the laboratory test fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established. All seams shall be bracketed by passing laboratory tests; field test results shall not be used for final acceptance.

Table D8-6
130 Environmental Park
FMC Seam Properties

Test	Standard	Frequency	Minimum Criteria
Shear	ASTM D 4437	1 sample per 500 feet of seam	Four of five specimens from each sample must have a shear strength greater than or equal to 95% of sheet strength but not less than 40 ppi. The average shear strength value of all five specimens must be greater than or equal to 95% of sheet strength but not less than 40 ppi.
Peel	ASTM D 4437	1 sample per 500 feet of seam	Four of five specimens from each sample must have a peel strength greater than or equal to 62% of sheet strength but not less than 36 ppi. The average peel strength value of all five specimens must be greater than or equal to 62% of sheet strength but not less than 36 ppi. Both sides of dual track seams shall meet the minimum criteria. Each track is considered a separate sample. All specimens shall exhibit Film Tear Bond.

During destructive seam testing, the CQA monitor must:

- Select sample locations and observe sample cutting.
- Assign sample numbers and label samples.
- Observe installer-performed tests.
- Record sample locations, sample number, sample purpose, and field test results.

5.5.5 Thickness Verification

The CQA monitor shall perform thickness verification tests on each panel unless thickness conformance tests are performed at a frequency of 1 per 50,000 sf. If field thickness testing is required, thickness verification shall be performed with a micrometer at a minimum of one measurement per five feet along the leading edge of the panel. A minimum of five tests is required for each panel. Thickness criteria shall be in accordance with GRI-GM17 which is provided in Appendix D8-A. The CQA monitor shall record panel numbers, panel dimensions, roll numbers destructive test numbers, and repair numbers.

6 DRAINAGE/CUSHION LAYER

30 TAC §330.457

6.1 General

The drainage layer on sideslopes consists of a double-sided geocomposite. The cushion layer of topslopes consists of a nonwoven geotextile. The CQA monitor shall provide on-site observation during geocomposite and geotextile installation. The GP shall make sufficient site visits during the geocomposite and geotextile installation to document the installation in the Final Cover Evaluation Report.

6.2 Materials

6.2.1 Geocomposite

The double-sided geocomposite will have nonwoven geotextile bonded to the top and bottom of HDPE drainage net. The geocomposite shall have the minimum properties listed in Table D8-7.

Table D8-7
130 Environmental Park
Geocomposite Properties

Material	Test	Standard	Required Property
Geotextile	Material		Nonwoven polypropylene or polyester
	Apparent Opening Size	ASTM D 4751	70 sieve
HDPE Drainage Net	Specific Gravity	ASTM D 1505	0.93 g/cm^3
	Thickness	ASTM D 5199	0.2 inch
	Carbon Black	ASTM D 1603	Minimum 2%, maximum 3%
Geocomposite	Transmissivity	ASTM D 4716	1 x 10^{-5} m^2/sec

Manufacturer quality control testing procedures for geocomposite are listed in Section 6.5.

6.2.2 Geotextile

The geotextile shall have the minimum properties listed in Table D8-8.

Table D8-8
130 Environmental Park
Geotextile Properties

Test	Standard	Required Property
Material		Nonwoven polypropylene or polyester
Unit Weight	ASTM D 5261	6 oz/yd^2 ,
Grab Strength	ASTM D 4632	150 lbs
Tear Strength	ASTM D 4533	60 lbs
Puncture Strength	ASTM D 4833	80 lbs

Manufacturer quality control testing procedures and frequencies for geotextile are listed in Section 6.5.

6.2.3 Delivery and Storage

Geocomposite and geotextile shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected.

The materials shall be unloaded and handled with equipment that does not cause damage. Rolls should not be pushed, slid, or dragged to the storage location. The geocomposite and geotextile must not be stored on wet, soft, or rocky subgrade, but must be stored on a stable subgrade. Geocomposite and geotextile must not be stacked more than five rolls high to avoid crushing the roll cores. The stored materials must be protected from puncture, grease, dirt, excessive heat, or other damage.

6.3 Preparation

Prior to installation of the drainage or cushion layers, the FMC shall be tested and verified in accordance with Section 5.5. The CQA monitor shall observe that the surface to receive the geocomposite or geotextile is free of debris, stones, and dirt and verify that the conformance documentation has been submitted and approved.

6.4 Installation

Geocomposite or geotextile shall be deployed by equipment that will unroll the material without damaging, crimping, or stretching it and deployment equipment must not damage the underlying FMC. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and wearing shoes that may damage the materials or underlying geosynthetics shall not be permitted and only low ground pressure supporting equipment shall be allowed on the materials. Adjacent rolls of geocomposite shall be securely tied through the drainage net with plastic fasteners every five feet along the

length of the panel and every six inches along the ends of the panels. Adjacent rolls of geotextile shall be sewn or heat bonded along the sides and ends.

During drainage and cushion layer placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe the condition of the geocomposite or geotextile and note any defects. All defects must be repaired or replaced.
- Observe that people working on the geocomposite or geotextile do not smoke, wear shoes that could damage the materials or underlying geosynthetics, or engage in activities that could damage the materials or underlying geosynthetics.
- Observe that the deployment method minimizes wrinkles in the materials or underlying geosynthetics.
- Observe that the geocomposite or geotextile panels have been properly tied and seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or removed and replaced by the installer.

6.5 Testing and Verification

The manufacturer shall test the geocomposite and geotextile to assure the quality of the drainage and cushion layer materials. Material property requirements are provided in Section 6.2. Minimum manufacturer's testing requirements are provided in Table D8-9. Manufacturer's testing shall be performed at a minimum frequency of one test per 100,000 sf.

Table D8-9
130 Environmental Park
Geocomposite and Geotextile Manufacturer's Tests

Material	Test	Standard
Geotextile	Weight	ASTM D 5261
	Apparent Opening Size	ASTM D 4751
	Grab Strength	ASTM D 4632
	Tear Strength	ASTM D 4533
	Puncture Strength	ASTM D 4833
	Burst Strength	ASTM D 3786
HDPE Drainage Net	Specific Gravity	ASTM D 1505
	Thickness	ASTM D 5199
	Carbon Black	ASTM D 1603
Geocomposite	Transmissivity	ASTM D 4716

7 EROSION LAYER

30 TAC §330.457

7.1 General

The erosion layer consists of an 24-inch-thick layer of soil with the top six inches capable of sustaining native plant growth. The CQA monitor shall provide continuous on-site observation during erosion layer placement to assure that erosion layer placement does not damage underlying geosynthetics. The GP shall make sufficient site visits during erosion layer placement to document the construction activities and thickness verification in the Final Cover Evaluation Report.

7.2 Materials

Erosion layer material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material, or any material that could damage the underlying geosynthetics.

7.3 Preparation

Prior to placing the erosion layer material, the top of infiltration layer elevations shall be verified in accordance with the requirements of Section 4.8.3 and all testing on the underlying geosynthetics shall be completed.

7.4 Placement

The erosion layer shall be placed in a manner that minimizes the potential to damage the underlying geosynthetics. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geosynthetics. The erosion layer shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geosynthetics. On side slopes, erosion layer shall be placed from the bottom to the top, not across or down. Erosion layer shall not be placed over geosynthetics that are stretched across the toes of slopes. The minimum separation distance between construction equipment and the geosynthetics are listed in Table D8-10.

The erosion layer will be seeded or sodded immediately following the application of final cover in order to minimize erosion.

Table D8-10
130 Environmental Park
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
Less than 6	12
6 to 12	18
12 to 16	24
Greater than 16	36

Any geosynthetic material that, in the opinion of the CQA monitor, has been damaged by the erosion layer placement must be repaired and retested in accordance with Sections 5 and 6.

7.5 Testing and Verification

The as-built thickness of the erosion layer shall be determined by standard survey methods. Prior to the placement of erosion layer, the top of infiltration layer elevations will be determined at a minimum rate of 1 survey point per 5,000 square feet of lined area. After the erosion layer is completed, the top of the erosion layer elevations will be determined at the same locations as the top of infiltration layer elevations.

8 DOCUMENTATION

After construction of the final cover system, the GP will submit a Final Cover Evaluation Report to the TCEQ on behalf of the owner. The purpose of the Final Cover Evaluation Report is to document that the construction methods and test procedures are consistent with this FCQCP.

At a minimum, the Final Cover Evaluation Report will contain the following:

- A summary of all construction activities
- A summary of all laboratory and field test results
- Sampling and testing location drawings
- A description of significant construction problems and the resolution of these problems
- Record drawings
- A statement of compliance with the FCQCP
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

130 ENVIRONMENTAL PARK

APPENDIX D8-A
GRI GM17

Technically Complete October 28, 2014

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Revision schedule on pg. 12

GRI Test Method GM17*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for
Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers linear low density polyethylene (LLDPE) geomembranes with a formulated sheet density of 0.939 g/ml, or lower, in the thickness range of 0.50 mm (20 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, maximum, or range of physical, mechanical and endurance properties that must be met, or exceeded by the geomembrane being manufactured.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

1.4 This standard specification is intended to ensure good uniform quality LLDPE geomembranes for use in general applications.

Note 2: Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application. In this situation, interactions with the manufacturers are required.

Note 3: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5323 Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5617 Test Method for Multi-Axial Tension Test for Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
D 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent Condensation Device

D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes

2.2 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

Linear Low Density Polyethylene (LLDPE), n – A ethylene/α-olefin copolymer having a linear molecular structure. The comonomers used to produce the resin can include 1-butene, 1-hexene, 1-octene or 4-methyl-1-pentene. LLDPE resins have a natural density in the range of 0.915 to 0.926 g/ml (ref. Pate, T. J. Chapter 29 in Handbook of Plastic Materials and Technology, I.I. Rubin Ed., Wiley, 1990).

Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For linear low density polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

4. Material Classification and Formulation

4.1 This specification covers linear low density polyethylene geomembranes with a formulated sheet density of 0.939 g/ml, or lower. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.926 g/ml or lower, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min. This refers to the natural, i.e., nonformulated, resin.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be of the same formulation (or other approved formulation) as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth LLDPE geomembranes and Table 2 is for single and double sided textured LLDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is "soft". It is to be understood that the tables refer to the latest revision of the referenced test methods and practices.

Note 4: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of 23°C ± 2°C. Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of 21°C ± 2°C. The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of 23°C ± 2°C should be utilized for testing purposes.

Note 5: There are several tests sometimes included in other LLDPE geomembrane specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693 and D 5397)
- Wide Width Tensile
- Water Vapor Transmission
- Solvent Vapor Transmission
- Water Absorption
- Ozone Resistance
- Hydrostatic Resistance
- Tensile Impact
- Small Scale Burst
- Various Toxicity Tests
- Field Seam Strength

Note 6: There are several tests which are included in this standard (that are not customarily required in other LLDPE geomembrane specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time

- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet

Note 7: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Tensile Properties, incl. 2% Secant Modulus
- Puncture Resistance
- Axi-Symmetric Break Resistance Strain
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

Note 8: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The various properties of the LLDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent, it must be followed in like manner.

Note 9: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively. Communication and interaction with the manufacturer is strongly suggested.

6. Workmanship and Appearance

6.1 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties and hydraulic integrity of the geomembrane.

6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from such defects that would affect the specified properties and hydraulic integrity of the geomembrane.

6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marketing

9.1 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

9.2 Marking of the geomembrane rolls shall be done in accordance with the manufacturers accepted procedure as set forth in their quality manual.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

English Units

Table 1(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane (SMOOTH)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness - mils (min. ave.)	D5199	nom.	nom.	nom.	nom.	nom.	nom.	nom.	nom.	per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,00 lb
Tensile Properties *(1)* (min. ave.)	D 6693									20,000 lb
• break strength - lb/in.	Type IV	76	114	152	190	228	304	380	456	
• break elongation - %		800	800	800	800	800	800	800	800	
2% Modulus – lb/in. (max.)	D 5323	1200	1800	2400	3000	3600	4800	6000	7200	per formulation
Tear Resistance - lb (min. ave.)	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance - lb (min. ave.)	D 4833	28	42	56	70	84	112	140	168	45,000 lb
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(2)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	45,000 lb
Oxidative Induction Time (OIT) *(4)*										
(a) Standard OIT (min. ave.)	D 3895	100	100	100	100	100	100	100	100	200,000 lb
— or —										
(b) High Pressure OIT (min. ave.)	D 5885	400	400	400	400	400	400	400	400	
Oven Aging at 85°C *(5)*	D 5721									
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	35	35	35	35	35	35	35	35	per formulation
— or —										
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	60	60	60	60	60	60	60	60	
UV Resistance *(6)*	D 7238									
(a) Standard OIT (min. ave.)	D 3895	N. R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	per formulation
— or —										
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 5885	35	35	35	35	35	35	35	35	

(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 in. at 2.0 in./min.

(2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

SI (Metric) Units

Table 1(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane (SMOOTH)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		0.50 mm	0.75 mm	1.0 mm	1.25 mm	1.50 mm	2.00 mm	2.5 mm	3.0 mm	
Thickness - mm (min. ave.)	D5199	nom.	nom.	nom.	nom.	nom.	nom.	nom.	nom.	per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties *(1)* (min. ave.)	D 6693 Type IV									9,000 kg
• break strength – N/mm		13	20	27	33	40	53	66	80	
• break elongation - %		800	800	800	800	800	800	800	800	
2% Modulus – N/mm (max.)	D 5323	210	370	420	520	630	840	1050	1260	per formulation
Tear Resistance - N (min. ave.)	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance - N (min. ave.)	D 4833	120	190	250	310	370	500	620	750	20,000 kg
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	20,000 kg
Oxidative Induction Time (OIT) *(4)*										90,000 kg
(c) Standard OIT (min. ave.)	D 3895	100	100	100	100	100	100	100	100	
— or —										
(d) High Pressure OIT (min. ave.)	D 5885	400	400	400	400	400	400	400	400	
Oven Aging at 85°C *(5)*	D 5721									
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	35	35	35	35	35	35	35	35	per formulation
— or —										
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	60	60	60	60	60	60	60	60	
UV Resistance *(6)*	D 7238									
(a) Standard OIT (min. ave.)	D 3895	N. R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	N.R. *(7)*	per formulation
— or —										
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 5885	35	35	35	35	35	35	35	35	

(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 50 mm at 50 mm/min.

(2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

English Units

Table 2(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	D 7466	10	10	10	10	10	10	10	10	Every 2nd roll *(2)*
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,000 lb
Tensile Properties *(3)* (min. ave.) • break strength – lb/in. • break elongation - %	D 6693 Type IV	 30 250	 45 250	 60 250	 75 250	 90 250	 120 250	 150 250	 180 250	20,000 lb
2% Modulus – lb/in. (max.)	D 5323	1200	1800	2400	3000	3600	4800	6000	7200	per formulation
Tear Resistance – lb (min. ave.)	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance – lb (min. ave.)	D 4833	22	33	44	55	66	88	110	132	45,000 lb
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(4)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	45,000 lb
Oxidative Induction Time (OIT) *(6)* (e) Standard OIT (min. ave.) — or — (f) High Pressure OIT (min. ave.)	 D 3895 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	200,000 lb
Oven Aging at 85°C *(7)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(8)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(10)*	D 7238 D 3895 D 5885	 N. R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	per formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils; also see Note 9.
(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 in. at 2.0 in./min.

(4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

SI (Metric) Units

Table 2(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		0.50 mm	0.75 mm	1.0 mm	1.25 mm	1.50 mm	2.00 mm	2.5 mm	3.0 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mm (min. ave.) *(1)*	D 7466	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	Every 2nd roll *(2)*
Density g/ml (max.)	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties *(3)* (min. ave.) • break strength – N/mm • break elongation - %	D 6693 Type IV	 5 250	 9 250	 11 250	 13 250	 16 250	 21 250	 26 250	 31 250	9,000 kg
2% Modulus – N/mm (max.)	D 5323	210	370	420	520	630	840	1050	1260	per formulation
Tear Resistance – N (min. ave.)	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance – N (min. ave.)	D 4833	100	150	200	250	300	400	500	600	20,000 kg
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(4)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	20,000 kg
Oxidative Induction Time (OIT) *(6)* (g) Standard OIT (min. ave.) — or — (h) High Pressure OIT (min. ave.)	 D 3895 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	90,000 kg
Oven Aging at 85°C *(7)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(8)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(10)*	D 7238 D 3895 D 5885	 N. R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	 N.R. *(9)* 35	per formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13 mm; also see Note 9.

(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 50 mm at 50 mm/min.

(4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

Adoption and Revision Schedule
for
GRI Test Method GM17

"Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes"

Adopted: April 3, 2000

Revision 1: June 28, 2000: added a new Section 5.2 that the numeric tables values are neither MARV nor MaxARV. They are to be interpreted per the designated test method. Also, corrected typographical error of textured sheet thickness test method designation from D5199 to D5994.

Revision 2: December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".

Revision 3: June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 4.

Revision 4: February 20, 2006: Added Note 9 on Asperity Height clarification with respect to shear strength.

Revision 5: Removed recommended warranty from specification.

Revision 6: June 1, 2009: Replaced GRI-GM12 test method for asperity height of textured geomembranes with ASTM D 7466.

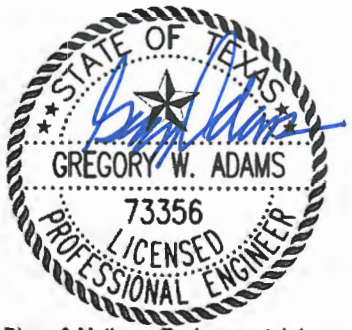
Revision 7: April 11, 2011: Added alternative carbon black test methods.

Revision 8: October 3, 2011: Expanded types of comonomers in the definition of LLDPE.

Revision 9: December 14, 2012: Replaced GRI-GM12 with the equivalent ASTM D7238.

130 ENVIRONMENTAL PARK

APPENDIX D8-B
GEOCOMPOSITE TRANSMISSIVITY CALCULATION



Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

11-6-14

Includes page D8-B-1

Technically Complete October 28, 2014

130 Environmental Park
Geocomposite Design

Required: Determine the minimum transmissivity for the final cover geocomposite.

References:

1) Giroud, J.P., Zornberg, J.G., and Zhao, A., 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layer", *Geosynthetics International,* Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp. 285-380.

Assumptions:

1) The liquid supply to the geocomposite will be limited to the hydraulic conductivity of the overlying erosion layer since the rate of infiltrating stormwater cannot exceed the soil's hydraulic conductivity.

Solution:

1) Calculate the ultimate transmissivity value for the final cover geocomposite from Reference 1.

$$T_{ult} = q_h L/\sin\beta \quad \text{[Ref 1., Eq. 35]}$$

where:

q_h = rate of liquid supply
L = horizontal drainage layer distance
β = slope angle of drainage layer, measured from horizontal

q_h = hydraulic conductivity of overlying erosion layer
= 0.00001 cm/sec
= 0.01417 in/hour

q_h in/hour	L ft	Sideslope %	β deg	T_{ult} m^2/sec
0.01417	83	25	14.0	1.0E-05