PERMIT AMENDMENT APPLICATION

Part III, Attachment 7

CLOSURE PLAN

Edinburg Regional Disposal Facility

Edinburg, Hidalgo County, Texas

TCEQ Permit MSW-956C

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

Submitted To: City of Edinburg
Department of Solid Waste Management
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Edinburg, Texas 78542 USA

Submitted By: Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA

July 2017 **Project No. 1401491**

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STATE OF TEXAS
7/21/17
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Professional Engineering Firm
Registration Number F-2578

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EXECUTIVE SUMMARY

30 TAC §330.457(e)(1)

This Closure Plan has been developed to addresses the requirements of Title 30 of the Texas Administrative Code (TAC) §§330.63(h) and 330.457 (Subchapter K), Closure Requirements for Municipal Solid Waste Landfill Units that Receive Waste on or after October 9, 1993. This plan includes a description of the final cover systems, a description of the steps that will be undertaken to close each filled disposal area, and the methods used to install the final cover.

1.0 FINAL COVER DESIGN

1.1 Final Contour Map

30 TAC §§330.63(h) & 330.457(e)(5)

A contour map showing the final constructed contour of the entire landfill is provided Figure III7-1, Final Contour Map. The final contours consist of 4 horizontal to 1 vertical (4H:1V) sideslopes and the upper portions of the final cover are sloped at a minimum 5-percent grade to a maximum elevation of approximately 398 ft-msl. Drainage features including on the final cover are add-on berms designed to intercept run-off from the top surface and along the sideslopes and direct it to downchutes. The downchutes convey stormwater run-off to the perimeter channels and stormwater ponds. These drainage structures as well as the drainage entering and departing the facility are shown on Figure III7-1, Final Contour Map. A perimeter berm protects the facility from flooding due to a 100-year frequency storm as depicted in Part IIC, Floodplains. Details of the surface water management features are included in Part III2, Surface Water Drainage Report. Cross-sections of the final filled condition are included as Figures III7-2A – III7-2E.

1.2 Final Cover System

The City shall install a final cover system for the unit that is constructed to minimize infiltration and erosion. The final cover system at the facility will consist of a conventional composite system meeting the requirements of 30 TAC §330.457(a)(1) or alternative final cover systems meeting the requirements of 30 TAC §330.457(d). The final cover systems will provide a low maintenance cover, protect against erosion, reduce rainfall percolation through the cover system and minimize leachate generation within the landfill.

1.2.1 Conventional Composite System

30 TAC §330.457(a)

The conventional composite final cover will consist of the following from top to bottom:

- Erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation.
- Double-sided geocomposite (geotextile/geonet/geotextile) drainage layer.
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane that has a permeability less than or equal to the permeability of the bottom liner system.
- 18-inch thick compacted clay rich earthen material with a hydraulic conductivity of 1×10^{-5} cm/sec or less.

Figure III7-3A, Conventional Composite Final Cover Details includes final cover and drainage feature installation details.

The erosion layer shall be composed of no less than two feet of soil where the first 18 inches shall be of clayey soil and the uppermost 6 inches shall be of suitable topsoil that is capable of sustaining native plant growth and shall be seeded or sodded immediately following the application of the final cover in order to minimize erosion.

Double-sided geocomposite (geotextile/geonet/geotextile) drainage layer shall be installed top of the geomembrane to prevent the buildup of excess pore water pressure at the on the geomembrane interface. Calculations are provided in Part III, Waste Management Unit Design Report.

A 40-mil linear low-density polyethylene (LLDPE) textured geomembrane that has a permeability less than or equal to the permeability of any bottom liner system shall be installed on top of an 18-inch thick compacted clay rich earthen material with a hydraulic conductivity of 1×10^{-5} cm/sec or less. The thickness of the 40-mil LLDPE textured geomembrane is of adequate thickness to ensure proper seaming.

1.2.2 Alternative Composite System

30 TAC §330.457(d) The alternative composite final cover varies from the conventional composite system by substituting a geocomposite clay liner for the 18-inch thick compacted clay rich earthen material and will consist of the following from top to bottom:

- Erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation.
- Double-sided geocomposite (geotextile/geonet/geotextile) drainage layer.
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane that has a permeability less than or equal to the permeability of the bottom liner system.
- Geosynthetic Clay Liner.

Figure III7-3B, Alternative Composite Final Cover Details includes final cover and drainage feature installation details.

Appendix III7A, Alternative Composite Final Cover Demonstration shows that use of geosynthetic clay liner achieves a greater or equal to reduction in infiltration in comparison to 18-inch thick compacted clay rich earthen material.

1.2.3 Alternative Synthetic Grass System

30 TAC §330.457(d)

The alternative synthetic grass final cover will consist of the following from top to bottom:

- HDPE synthetic grass
- Sand infill

- Woven geotextile filter backing
- 50-mil linear low density polyethylene (LLDPE) Super Gripnet® geomembrane with integrated drainage layer

Figure III7-3C, Alternative Synthetic Grass Final Cover Details includes final cover and drainage feature installation details.

Appendix III7B, Alternative Synthetic Grass Final Cover Demonstration shows that ClosureTurf® provides a level of infiltration reduction and wind and water protection that is greater than or equal to the level of protection provided by the standard composite final cover system. In addition, the ClosureTurf® offers other advantages over the standard composite final cover system.

2.0 CLOSURE

Final cover installation will be done in installments as each area of a unit or units attain permitted elevation. Part II, Facility Layout of this application describes the anticipated schedule of development for the facility where landfill units may be incrementally constructed wholly or partially in any sequence for operational feasibility. Figures II-20 – II-25, Operational Sequence I – VI show areas of final cover placement as waste is filled to permitted elevation.

2.1 Maximum Closure Area

30 TAC §330.457(e)(2)

Based on the Figure II-20A, Operational Fill Sequence I of site development discussed in Part II, Facility Layout of this application, the maximum closure area or estimate of the largest area of the MSW landfill facility ever requiring final cover at any time during the active life is approximately 159.1 acres. Figure III7-4, Maximum Closure Area includes the active face and areas with daily or intermediate cover in place.

2.2 Maximum Inventory of Wastes

30 TAC §330.457(e)(3)

The maximum inventory of waste ever on-site over the active life of the facility is both the capacity of the of the facility's waste disposal units and storage or processing units. Waste in storage or processing units at final facility closure will either be disposed in the landfill or transported to an authorized facility, therefore the maximum inventory of waste is the capacity of the combined waste disposal units.

2.2.1 Facility Units

The maximum inventory of waste ever on-site over the active life of the facility is included in Part III3A-1, Volume Calculations of this application. The volume represents the total volume available for in-place solid waste and daily and intermediate cover soils. Wastes accepted for disposal in accordance with

Part II, Waste Acceptance Plan are typically compacted in place at the working face as they are received.

2.2.2 Storage or Processing Units

Waste in storage or processing units at final facility closure will either be disposed in the landfill or transported to an authorized facility. Closure for the storage and processing units at the site is addressed as follows:

- Mulch area: Brush will be mulched used for erosion control applications.
- Liquid waste stabilization area: Upon closure, the waste remaining in the stabilization basin will be properly stabilized and disposed of in the landfill. The stabilization basin will be disposed of within the landfill.
- Whole tire staging area: At time of closure, tires in the staging area will be processed by grinding or other means to reduce size to quartered or split and disposed of in the landfill or another authorized facility.
- Large Item/White Goods Storage Area: Large items/white goods stored on-site at time of closure will be either transported offsite for recycling or disposed of at an authorized facility.
- Reusable materials staging area: Reusable materials will transported off-site for to reusable material end user locations.

2.3 Unit Closure Implementation

30 TAC §330.457(e)(4)

A schedule for completing all activities necessary to satisfy the closure criteria for a waste disposal unit is as follows in accordance with 30 TAC §330.457(f).

2.3.1 Closure Plan Placed in Operating Record by Initial Receipt of Waste

30 TAC §330.457(f)(1)

Because waste is currently received by the facility under TCEQ Permit MSW-956B, the City shall place a copy of this closure plan in the operating record upon issuance of TCEQ Permit MSW-956C.

2.3.2 Closure Notice to TCEQ

30 TAC §330.457(f)(2)

No later than 45 days prior to the initiation of closure activities for an MSW landfill unit, the City shall provide written notification to the TCEQ of the intent to close the unit and place this notice of intent in the operating record.

2.3.3 Begin Closure Activities

30 TAC §330.457(f)(3)

The City shall begin closure activities for each unit no later than 30 days after the date on which the unit receives the known final receipt of wastes or, if the unit has remaining capacity and there is a reasonable likelihood that the unit will receive additional wastes, no later than one year after the most recent receipt of wastes. A request for an extension beyond the one-year deadline for the initiation of closure may be submitted to the TCEQ for review and approval and shall include all applicable documentation necessary to demonstrate that the unit has the capacity to receive additional waste and that the City has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the MSW landfill unit.

2.3.4 Complete Closure Activities

30 TAC §330.457(f)(4)

The City shall complete closure activities for the MSW landfill unit within 180 days following the initiation of closure activities. These activities include placing all the final cover components to design grades and elevations over the waste mass utilizing methods, procedures, and specifications described in the Final Cover Quality Control Plan and installation of any outstanding or replacement of any damaged post-closure monitoring devices such as monitoring wells, gas probes, and the gas collection system. A request for an extension for the completion of closure activities may be submitted to the TCEQ for review and approval and shall include all applicable documentation necessary to demonstrate that closure will, of necessity, take longer than 180 days and all steps have been taken and will continue to be taken to prevent threats to human health and the environment from the unclosed MSW landfill unit.

2.3.5 Following Completion of Closure Activities

30 TAC §330.457(f)(5)

Following completion of all closure activities for the MSW landfill unit, the City shall comply with the post-closure care requirements specified in Part III8, Post-Closure Plan. The City shall submit to the TCEQ by registered mail for review and approval a certification, signed by an independent licensed professional engineer, verifying that closure has been completed in accordance with this closure plan. The submittal to the executive director shall include all applicable documentation necessary for certification of closure. Once approved, this certification shall be placed in the operating record.

2.3.6 TCEQ Closure Acknowledgement

30 TAC §330.457(f)(6)

Following receipt of the required closure documents, as applicable, and an inspection report from the TCEQ's regional office verifying proper closure of the MSW landfill unit according to this closure plan, the TCEQ may acknowledge the termination of operation and closure of the unit and deem it properly closed.

2.4 Final Facility Closure

Certification of final facility closure will be accomplished in accordance with 30 TAC §330.461.

2.4.1 Public Notice

30 TAC §330.461(a)

No later than 90 days prior to the initiation of a final facility closure, the City shall, through a public notice in the newspaper(s) of largest circulation in the vicinity of the facility, provide public notice for final facility closure. This notice shall provide the name, address, and physical location of the facility; the permit, registration, or notification number, as appropriate; and the last date of intended receipt of waste. The City shall also make available an adequate number of copies of the approved final closure and post-closure plans for public access and review.

2.4.2 Written Notification to TCEQ

30 TAC §330.461(a)

No later than 90 days prior to the initiation of a final facility closure, the City shall provide written notification to the TCEQ of the intent to close the facility and place this notice of intent in the operating record.

2.4.3 Facility Closure Sign Posting

30 TAC §330.461(b)

Upon written notification to the TCEQ, the City shall post a minimum of one sign at the main entrance and all other frequently used points of access for the facility notifying all persons who may utilize the facility of the date of closing for the entire facility and the prohibition against further receipt of waste materials after the stated date.

2.4.4 Access Barriers

30 TAC §330.461(b)

Upon written notification to the TCEQ, suitable barriers shall be installed at all gates or access points to adequately prevent the unauthorized dumping of solid waste at the closed facility.

2.4.5 Deed Recordation

30 TAC §330.457(g) & §330.461(c)(1)

Within ten days after closure of all MSW landfill units, the City shall submit to the TCEQ by registered mail a certified copy of an "affidavit to the public" in accordance with the requirements of 30 TAC §330.19, Deed Recordation and place a copy of the affidavit in the operating record. In addition, the City shall record a certified notation of the deed to the facility property, or on some other instrument that is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill facility and use of the land is restricted according to the provisions specified in 30 TAC §330.465 Certification of Post-Closure Care. The City shall submit a certified copy of the modified deed to the TCEQ and place a copy of the modified deed in the operating record.

2.4.6 Certification

30 TAC §330.461(c)(2)

Within ten days after completion of final closure activities, a certification, signed by an independent licensed professional engineer, verifying that final facility closure has been completed in accordance with this closure plan. The submittal to the TCEQ shall include all applicable documentation necessary for certification of final facility closure. Once approved, the certification will be placed in the site's operating record.

Following receipt of the required final closure documents and an inspection report from the TCEQ's regional office verifying proper closure of the facility according to this closure plan, the TCEQ may acknowledge the termination of operation and closure of the facility and deem it properly closed. Post-closure care maintenance will begin immediately upon the date of final closure as approved by the TCEQ. All post-closure land use will comply with 30 TAC §330.463, as indicated in the Post-Closure Plan. Appendix III7C, TCEQ Closure Plan Form, provides guidance to detail the plan for closure of a landfill unit, closure of associated storage or processing units, and final closure of the facility to meet the requirements in 30 TAC Chapter 330, §330.63(h) and 30 TAC Chapter 330 Subchapter K for a MSW Type I facility.

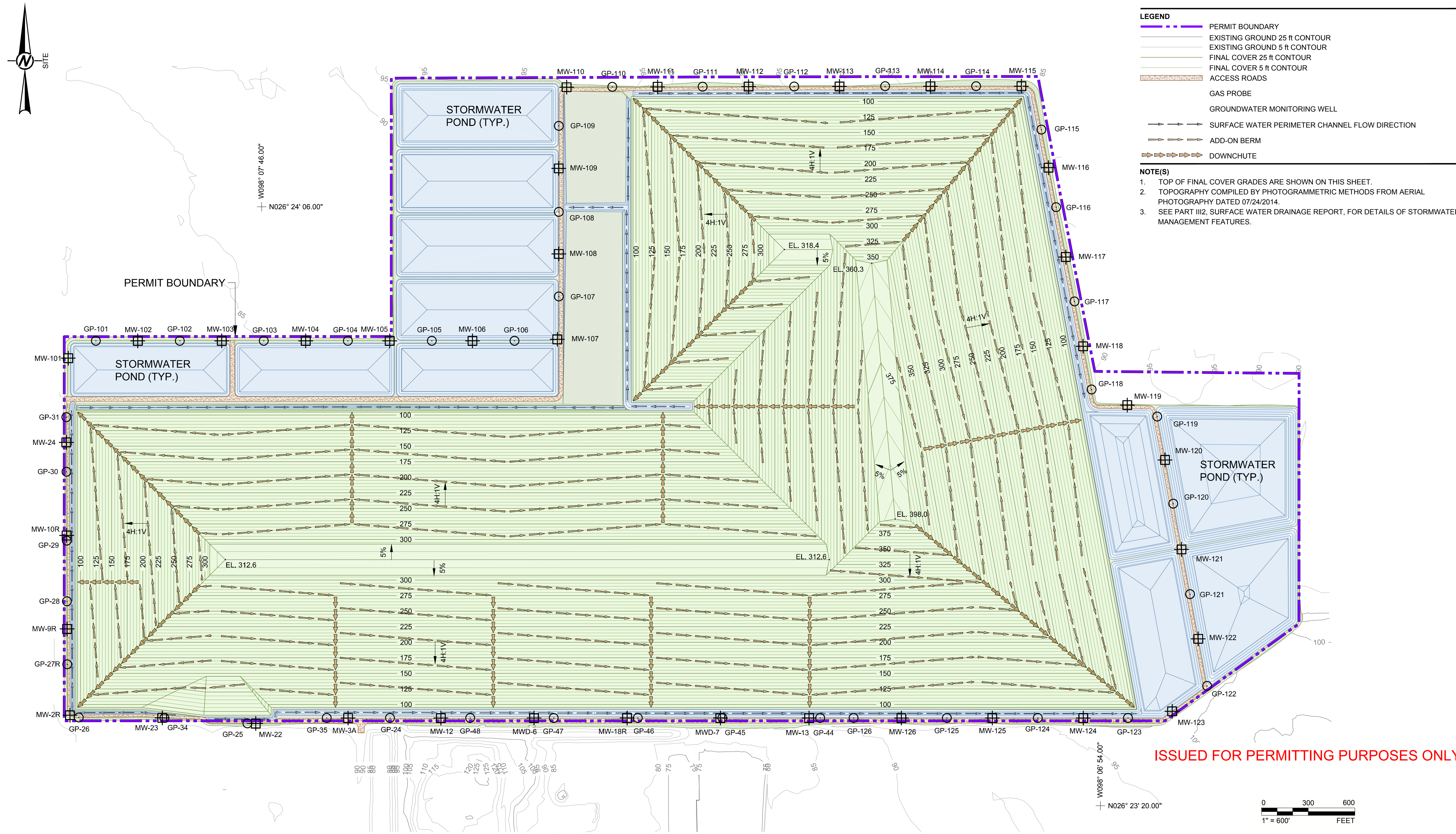
3.0 FINAL COVER QUALITY CONTROL PLAN

30 TAC §330.457(c)

Appendix III7D, Final Cover Quality Control Plan (FCQCP) describes the final cover system design, construction, and evaluation protocol and processes, including the personnel, materials, methods, sampling and testing standards, procedures, and practices to be used in procuring, handling, installing, and evaluating all elements of the final cover system. It establishes the material requirements; personnel qualifications and roles; installation requirements; quality control and quality assurance monitoring, testing, documentation, and reporting programs to be used during construction of each component of the final cover system to assure and to verify that the final cover system is constructed as designed and in accordance with applicable rules and technical standards. The alternative synthetic grass final cover differs considerably from the conventional composite final cover and the alternative composite final cover, therefore a separate FCQCP has been prepared.

- Appendix III7D-1 – Conventional Composite and Alternative Composite Final Cover Systems.
- Appendix III7D-2 – Alternative Synthetic Grass Final Cover System.

FIGURES



LEGEND

- PERMIT BOUNDARY
- EXISTING GROUND 25 ft CONTOUR
- EXISTING GROUND 5 ft CONTOUR
- FINAL COVER 25 ft CONTOUR
- FINAL COVER 5 ft CONTOUR
- ACCESS ROADS
- GAS PROBE
- GROUNDWATER MONITORING WELL
- SURFACE WATER PERIMETER CHANNEL FLOW DIRECTION
- ADD-ON BERM
- DOWNCHUTE

NOTE(S)

1. TOP OF FINAL COVER GRADES ARE SHOWN ON THIS SHEET.
2. TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 07/24/2014.
3. SEE PART III2, SURFACE WATER DRAINAGE REPORT, FOR DETAILS OF STORMWATER MANAGEMENT FEATURES.

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0	2017-07-21	PERMIT AMENDMENT APPLICATION SUBMITTAL	CEI	AA	MX	JBF

SEAL

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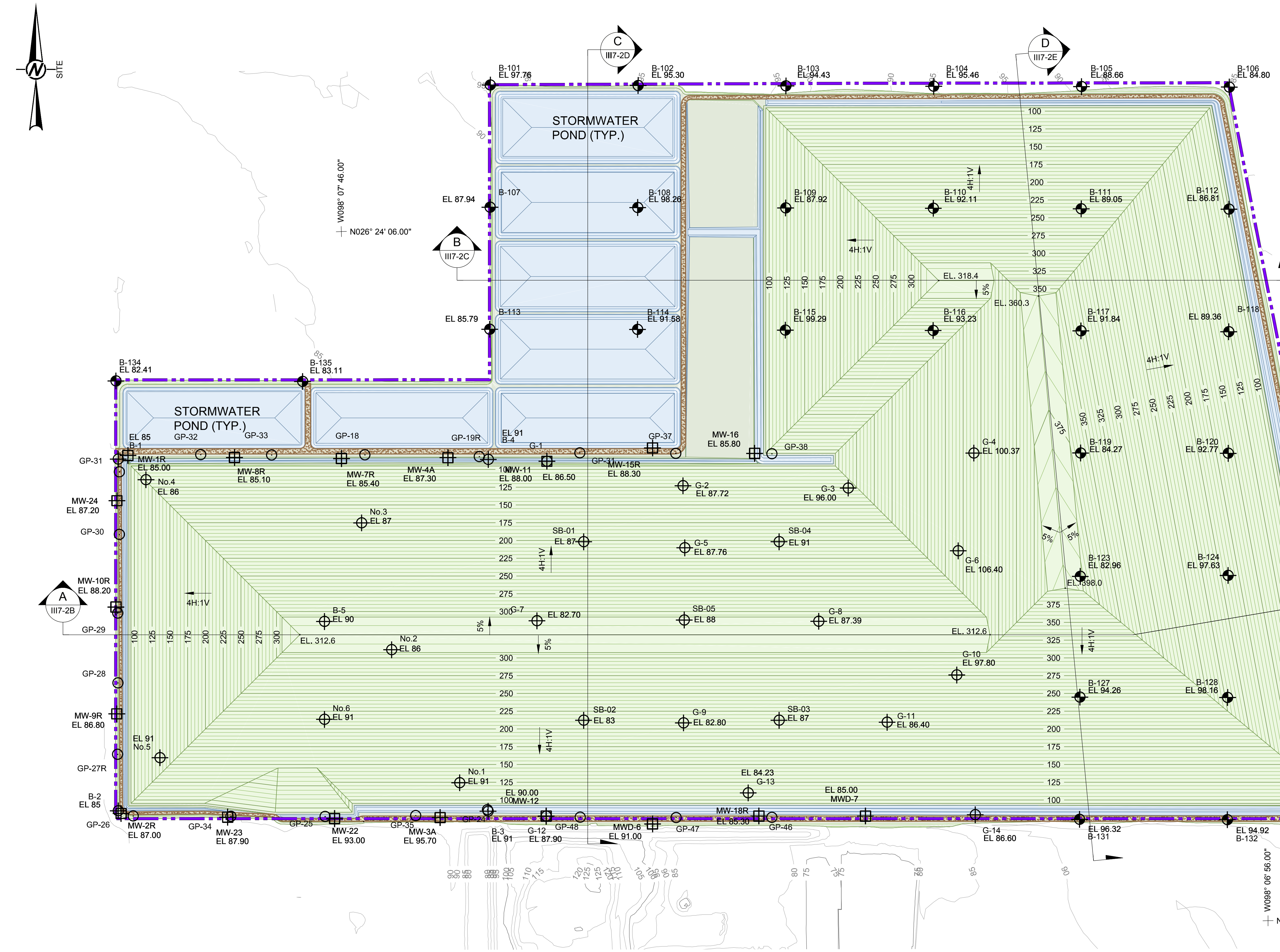
PROJECT

EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE

FINAL CONTOUR MAP

PROJECT NO.	APPLICATION SECTION	REV.	1 of 10	FIGURE
1401491	III7	0		III7-1



LEGEND

- PERMIT BOUNDARY
- EXISTING GROUND 25 ft CONTOUR
- EXISTING GROUND 5 ft CONTOUR
- FINAL COVER 25 ft CONTOUR
- FINAL COVER 5 ft CONTOUR
- ACCESS ROADS
- STORM WATER POND 25 ft CONTOUR
- STORM WATER POND 5 ft CONTOUR
- BORINGS FROM PERVIOUS SUBSURFACE INVESTIGATIONS
- BORINGS FROM 2015 SUBSURFACE INVESTIGATIONS
- MW - 23 EXISTING GROUNDWATER MONITORING WELL
- GP - 24 EXISTING GAS PROBE

NOTE(S)

1. TOP OF FINAL COVER GRADES SHOWN.
2. EXISTING TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 07/24/14.
3. EXISTING GROUNDWATER MONITORING WELLS AND GAS PROBES (AS OF OCTOBER 2016) ARE SHOWN ON THIS DRAWING.

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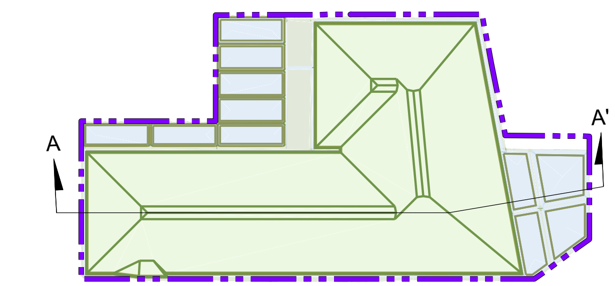
TITLE

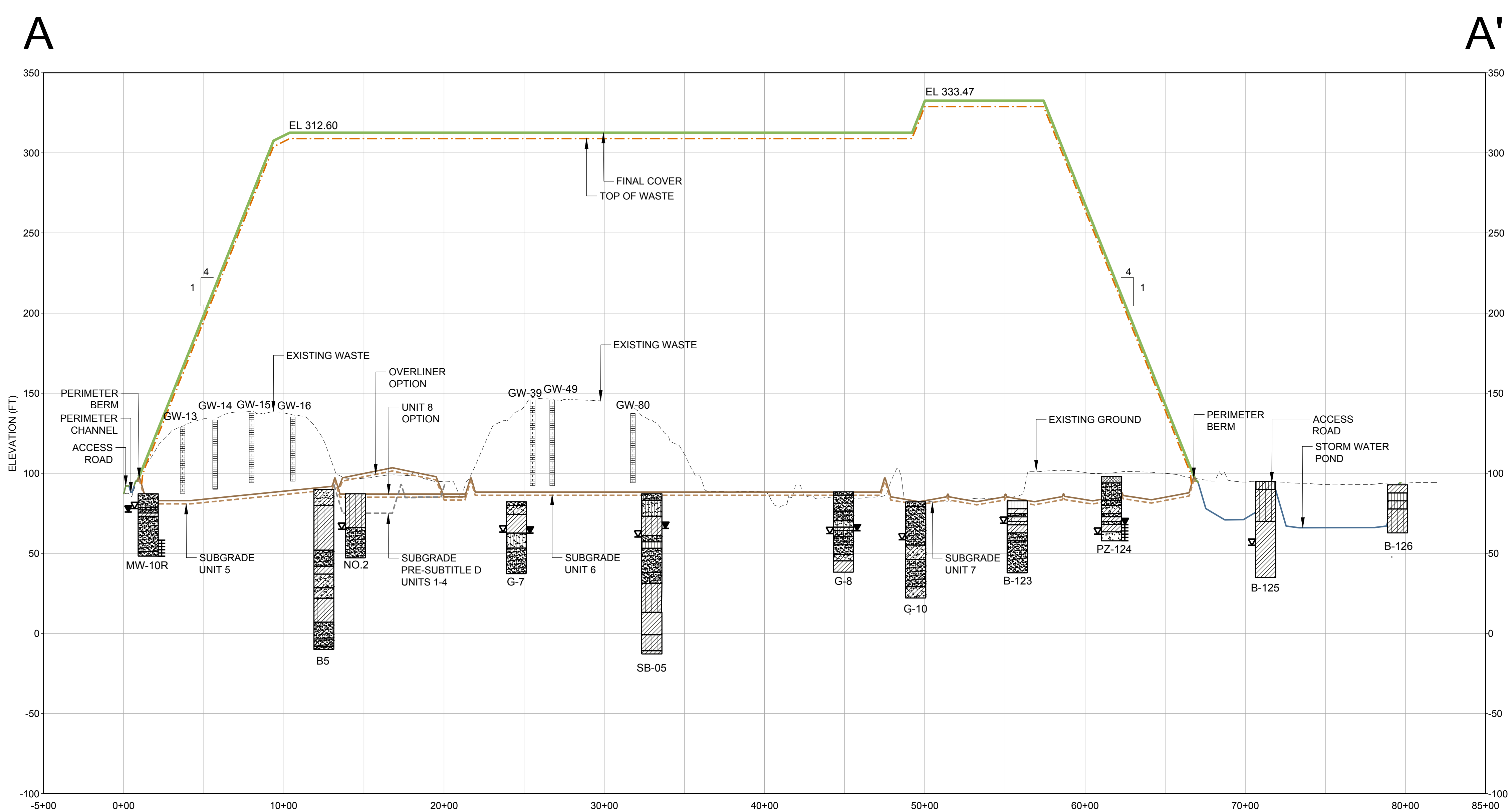
FILL CROSS-SECTIONS LOCATION MAP

PROJECT NO.	APPLICATION SECTION	REV.	2 of 10	FIGURE
1401491	III7	0		III7-2A

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

KEY MAP





SCALE 1" = 800'
VERT. SCALE 1" = 80'

A
III7-2B
FILL CROSS-SECTION A

LEGEND

- FINAL COVER
- TOP OF WASTE
- EXISTING GRADE
- SUBGRADE
- EXISTING SUBGRADE
- STORM WATER POND AND DITCH
- SILT
- SAND
- CLAY
- SILTY SAND
- SILTY CLAY
- SANDY SILT
- SANDY CLAY
- CLAYEY SAND
- CLAYEY SILT
- SANDY SILTY CLAY
- SILTY CLAYEY SAND
- STATIC WATER LEVEL
- INITIAL WATER LEVEL
- SCREENED INTERVAL

NOTE(S)

1. GAS WELL DATA BASED ON INFORMATION FROM DESIGN AND AS BUILT DRAWINGS.
2. EXISTING TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 07/24/2014.
3. THE INITIAL WATER LEVEL IS THAT LEVEL AT THE TIME OF DRILLING AS REPORTED ON THE BORING LOG. THE STATIC WATER LEVEL IS THAT LEVEL SOMETIME AFTER DRILLING AS REPORTED ON THE BORING LOG.
4. THE SIDESLOPES SHOWN ARE NOMINAL; THE ACTUAL SIDESLOPES ON THESE CROSS-SECTIONS WILL VARY DUE TO THE ANGULAR PROJECTION OF THE SECTIONS.
5. GAS WELL LOCATIONS ARE SHOWN ON III6, LANDFILL GAS MANAGEMENT PLAN, FIGURE III6-3
6. MONITORING WELL LOCATIONS ARE SHOWN ON III3, FINAL CONTOUR MAP, FIGURE III3-3.
7. SECTION SHOWN FOR UNIT 8 OPTION IS THROUGH THE INTERCELL BERM.

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0 400 800
1" = 800' FEET

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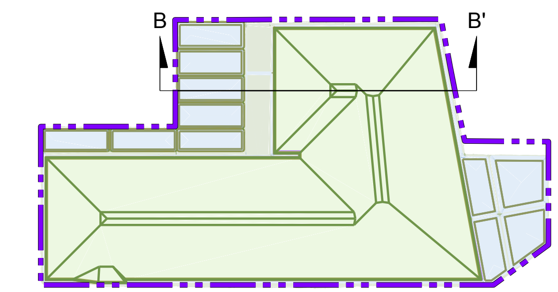
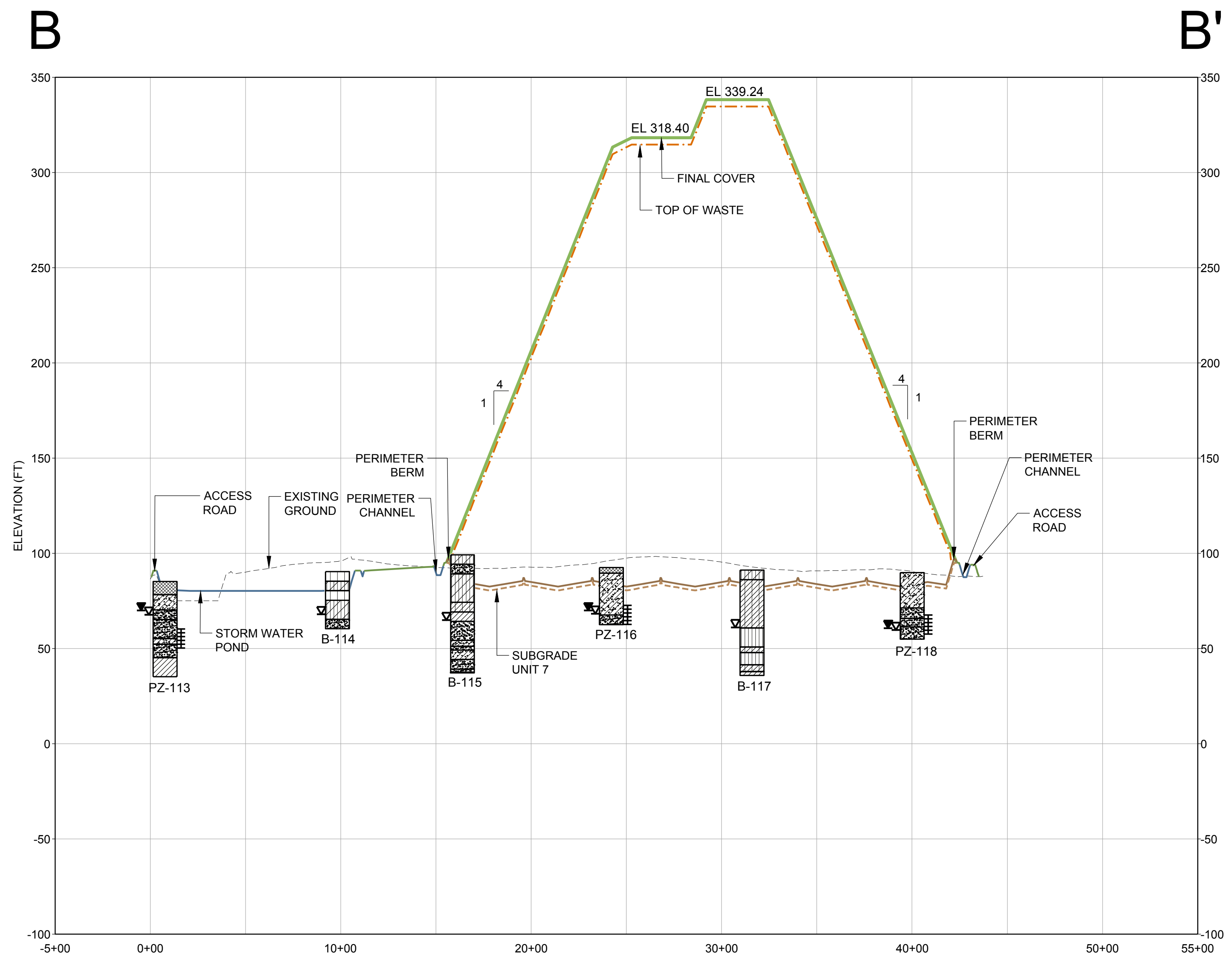
TITLE
FILL CROSS-SECTION A

PROJECT NO.	APPLICATION SECTION	REV.	3 of 10	FIGURE
1401491	III7	0		III7-2B

1 in
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

KEY MAP





SCALE 1" = 800' (B / III7-2C) FILL CROSS-SECTION B
VERT. SCALE 1" = 80'

LEGEND

- FINAL COVER
- TOP OF WASTE
- EXISTING GRADE
- SUBGRADE
- STORM WATER POND AND DITCH
- SILT
- SAND
- CLAY
- SILTY SAND
- SILTY CLAY
- SANDY SILT
- SANDY CLAY
- CLAYEY SAND
- CLAYEY SILT
- SANDY SILTY CLAY
- SILTY CLAYEY SAND
- STATIC WATER LEVEL
- INITIAL WATER LEVEL
- SCREENED INTERVAL

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6. MONITORING WELL LOCATIONS ARE SHOWN ON III3, FINAL CONTOUR MAP, FIGURE III3-3

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0 400 800
1" = 800' FEET

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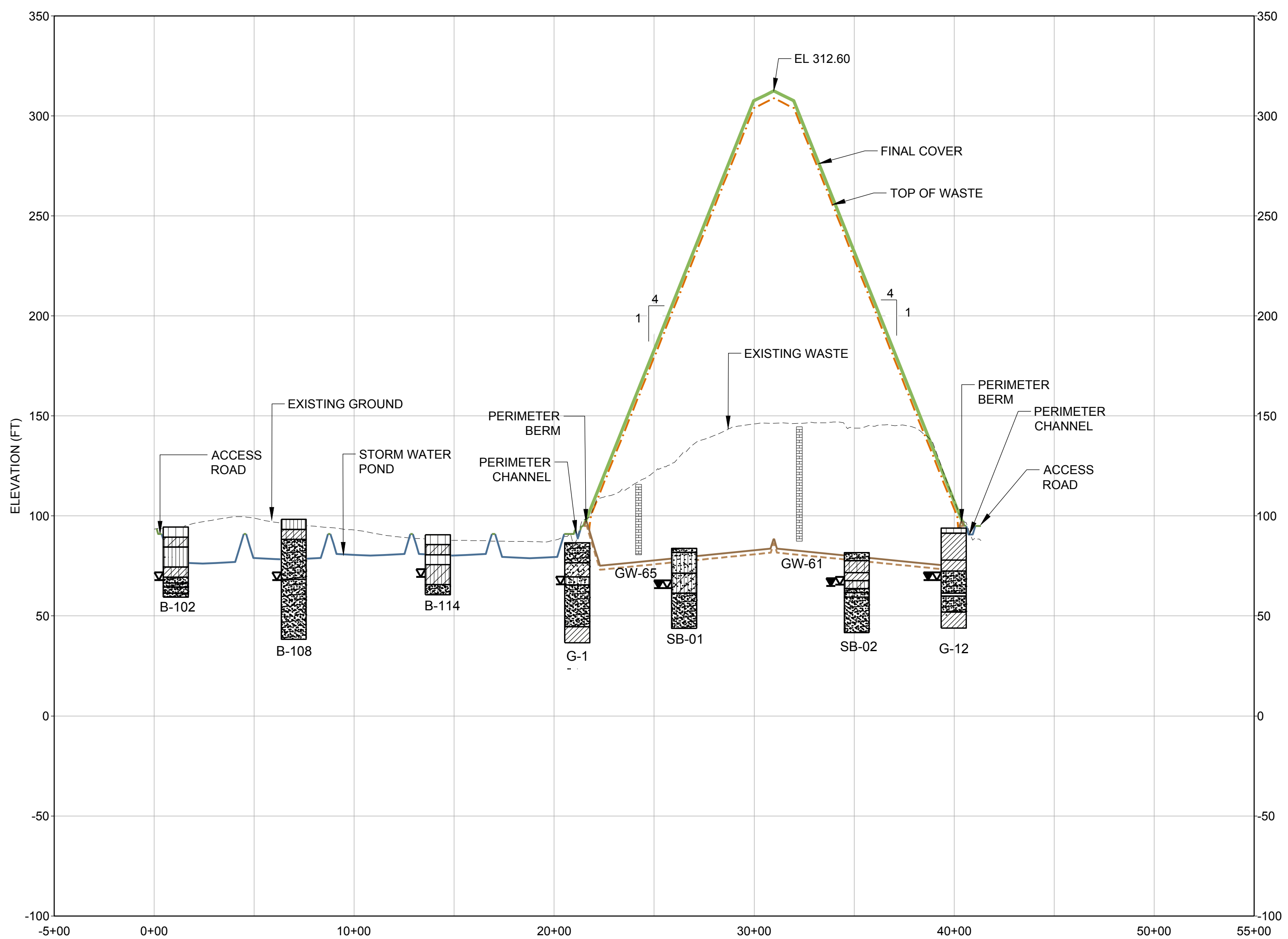
TITLE
FILL CROSS-SECTION B

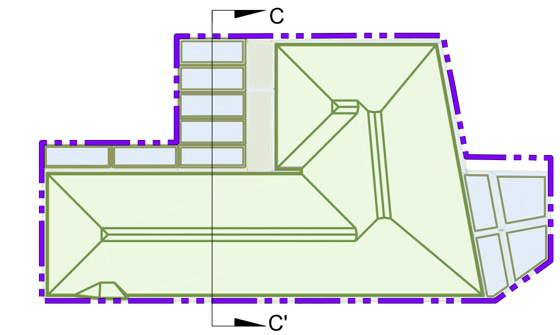
PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	4 of 10	III7-2C

C C'



SCALE 1" = 800'
VERT. SCALE 1" = 80'
C
III7-2D
FILL CROSS-SECTION C

KEY MAP



LEGEND

FINAL COVER
TOP OF WASTE
EXISTING GRADE
SUBGRADE
STORM WATER POND AND DITCH

SILT
SAND
CLAY
SILTY SAND
SILTY CLAY
SANDY SILT
SANDY CLAY
CLAYEY SAND
CLAYEY SILT
SANDY SILTY CLAY
SILTY CLAYEY SAND
STATIC WATER LEVEL
INITIAL WATER LEVEL
SCREENED INTERVAL

NOTE(S)

1. GAS WELL DATA BASED ON INFORMATION FROM DESIGN AND AS BUILT DRAWINGS.
2. EXISTING TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHTOGRAPHY DATED 07/24/2014.
3. THE INITIAL WATER LEVEL IS THAT LEVEL AT THE TIME OF DRILLING AS REPORTED ON THE BORING LOG. THE STATIC WATER LEVEL IS THAT LEVEL SOMETIME AFTER DRILLING AS REPORTED ON THE BORING LOG.
4. THE SIDESLOPES SHOWN ARE NOMINAL; THE ACTUAL SIDESLOPES ON THESE CROSS-SECTIONS WILL VARY DUE TO THE ANGULAR PROJECTION OF THE SECTIONS.
5. GAS WELL LOCATIONS ARE SHOWN ON III6, LANDFILL GAS MANAGEMENT PLAN, FIGURE III6-3
6. MONITORING WELL LOCATIONS ARE SHOWN ON III3, FINAL CONTOUR MAP, FIGURE III3-3.

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0 400 800
1" = 800' FEET

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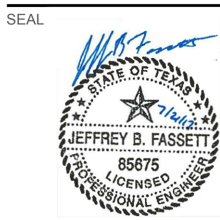

GOLDER ASSOCIATES INC.
TEXAS REGISTRATION F-2578

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CITY OF EDINBURG SOLID WASTE MANAGEMENT

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Golder Associates

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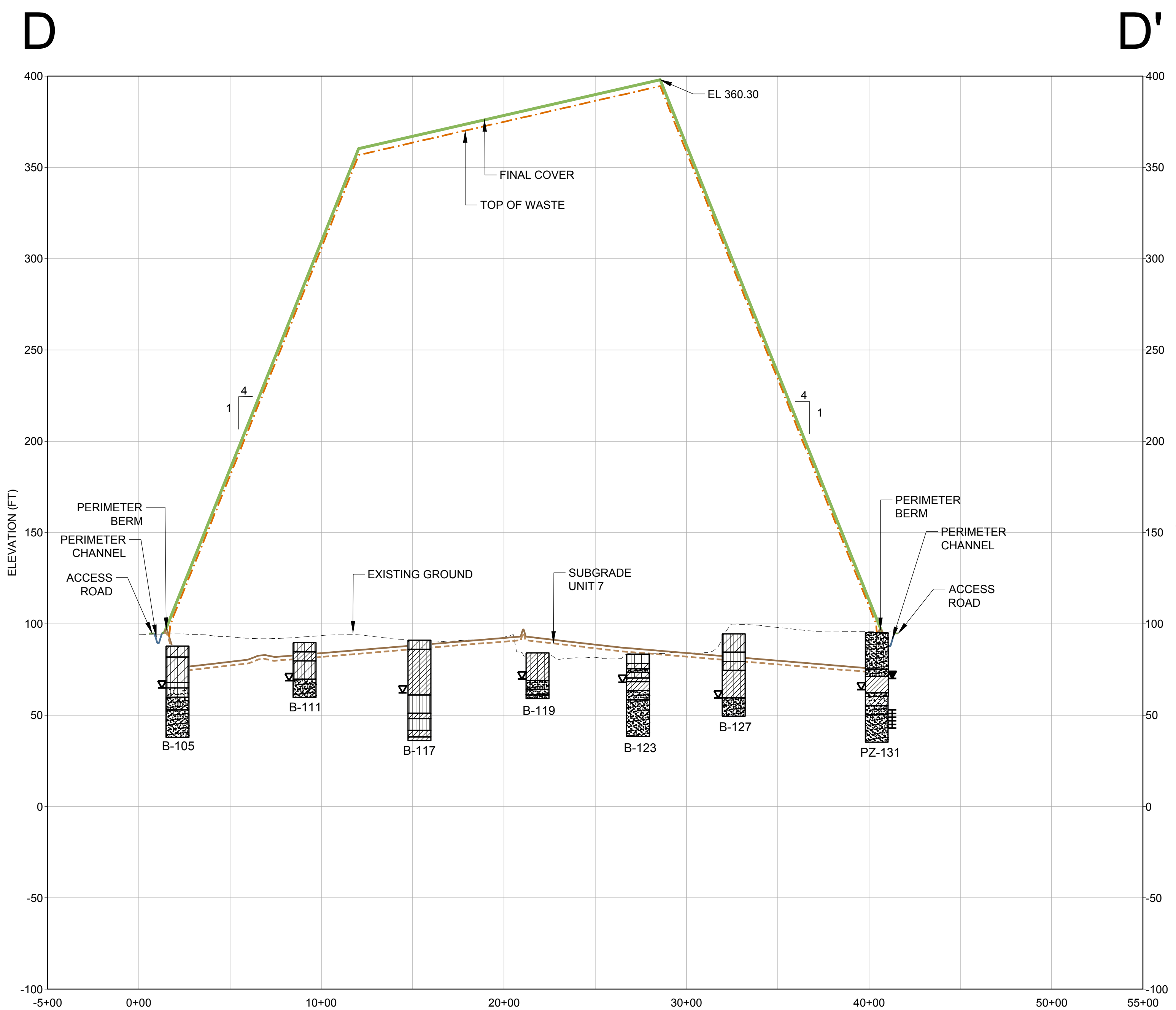
PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
FILL CROSS-SECTION C

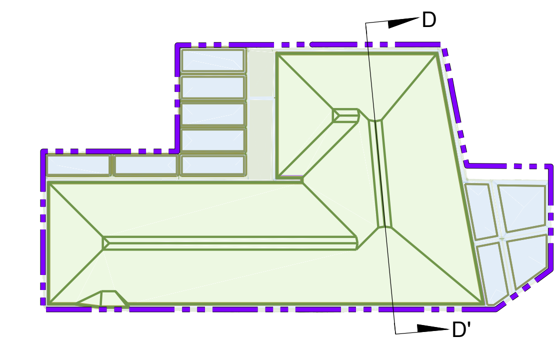
PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	5 of 10	III7-2D

D D'



SCALE 1" = 800'
VERT. SCALE 1" = 80'
D
III7-2E
FILL CROSS-SECTION D

KEY MAP



LEGEND

- FINAL COVER
- TOP OF WASTE
- EXISTING GRADE
- SUBGRADE
- STORM WATER POND AND DITCH

- SILT
- SAND
- CLAY
- SILTY SAND
- SILTY CLAY
- SANDY SILT
- SANDY CLAY
- CLAYEY SAND
- CLAYEY SILT
- SANDY SILTY CLAY
- SILTY CLAYEY SAND
- STATIC WATER LEVEL
- INITIAL WATER LEVEL
- SCREENED INTERVAL

NOTE(S)

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0 400 800
1" = 800' FEET

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PROJECT
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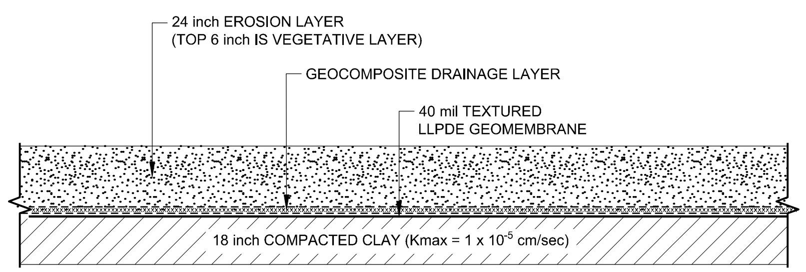
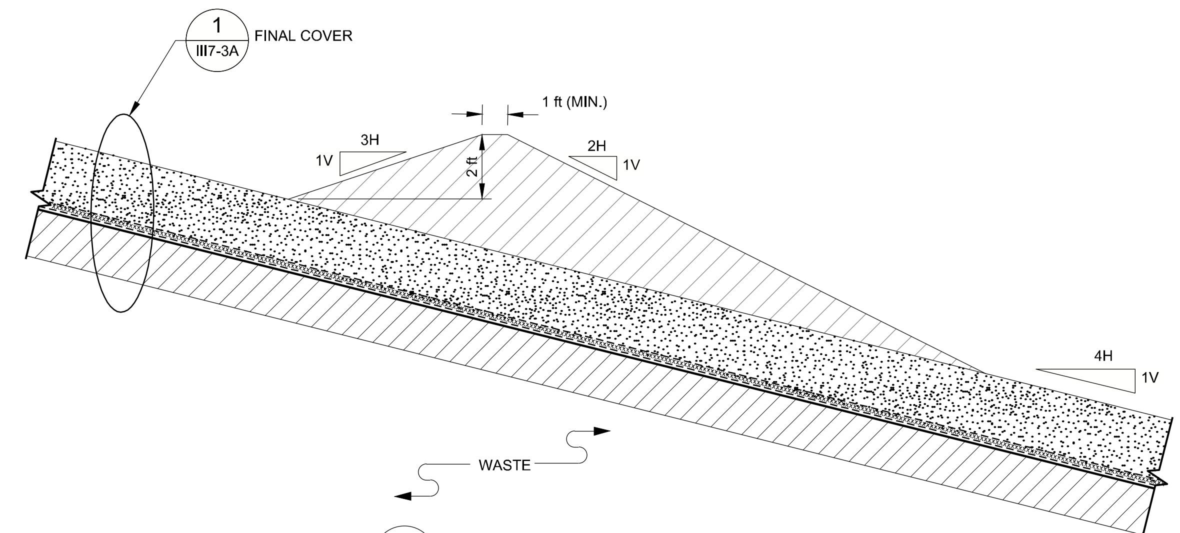
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
FILL CROSS-SECTION D

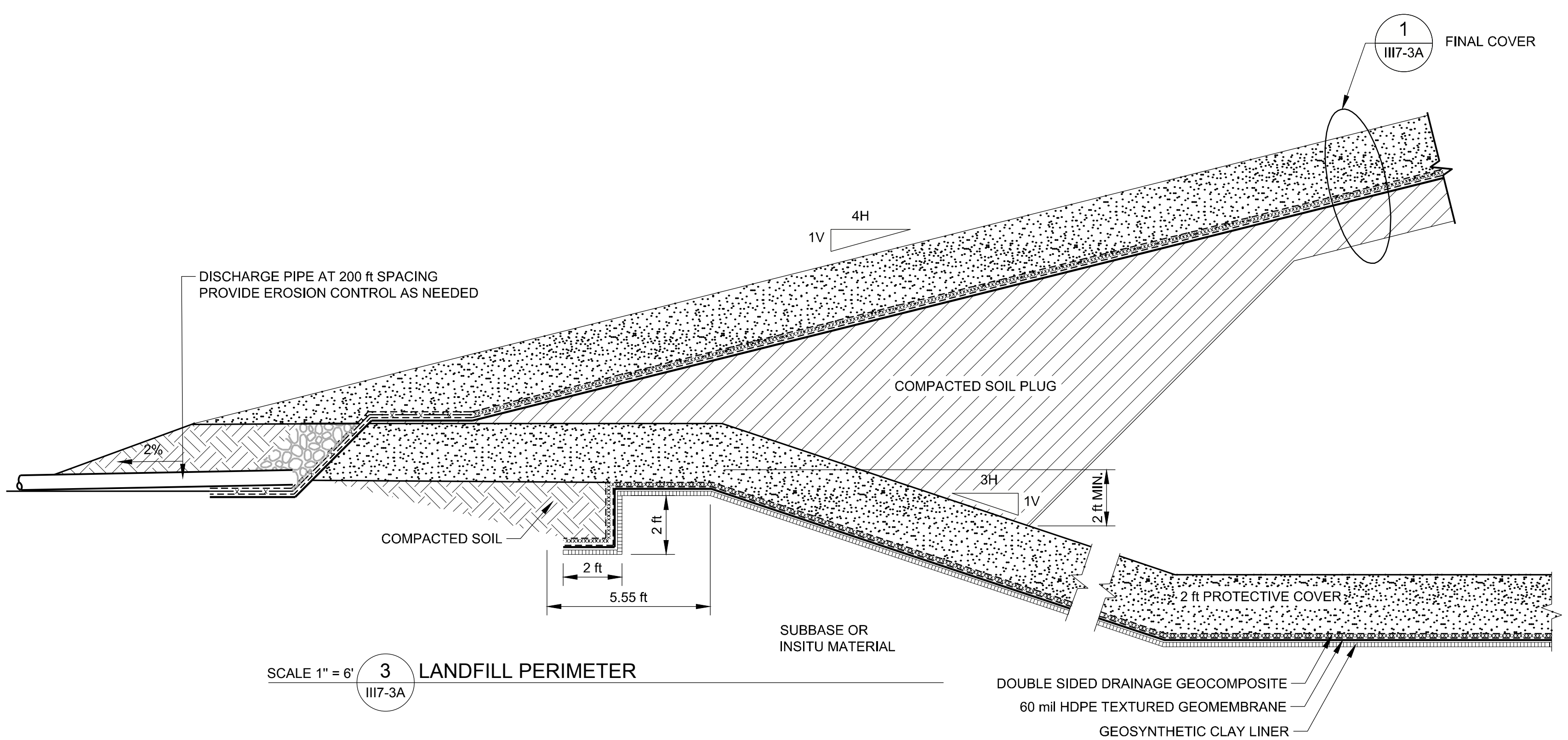
PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	6 of 10	III7-2E



SCALE 1" = 6' 1 III7-3A FINAL COVER



SCALE 1" = 6' 2 III7-3A ADD-ON BERM



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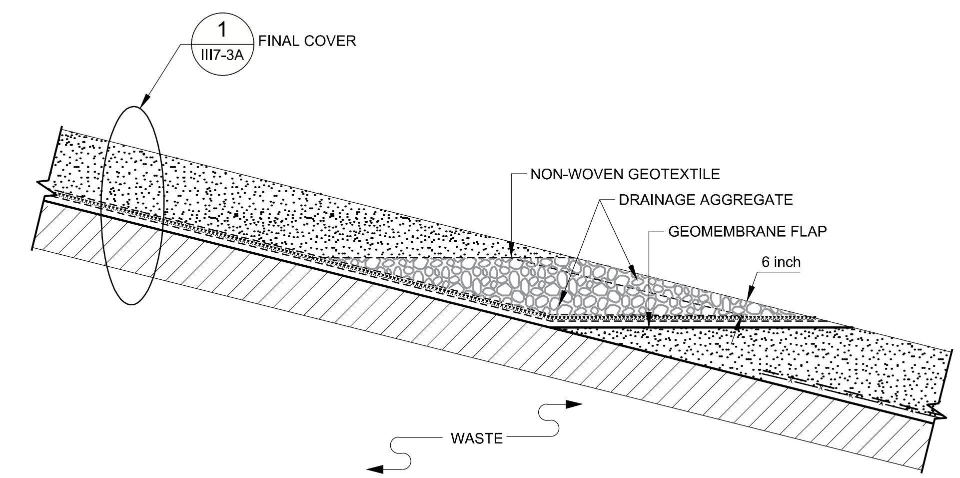

SCALE 1" = 6' 4 III7-3A FINAL COVER DAYLIGHT

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0 3 6
1" = 6' FEET

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EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
CONVENTIONAL COMPOSITE FINAL COVER DETAILS

PROJECT NO.	APPLICATION SECTION	REV.	7 of 10	FIGURE
1401491	III7	0		III7-3A

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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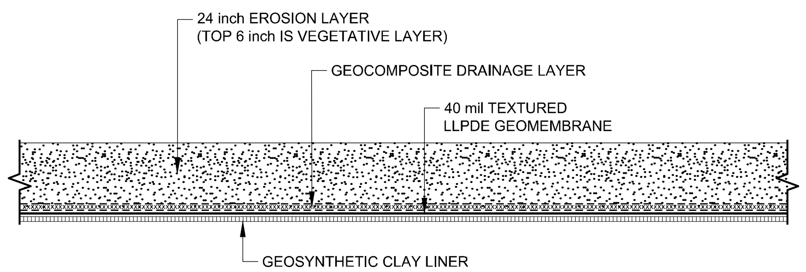

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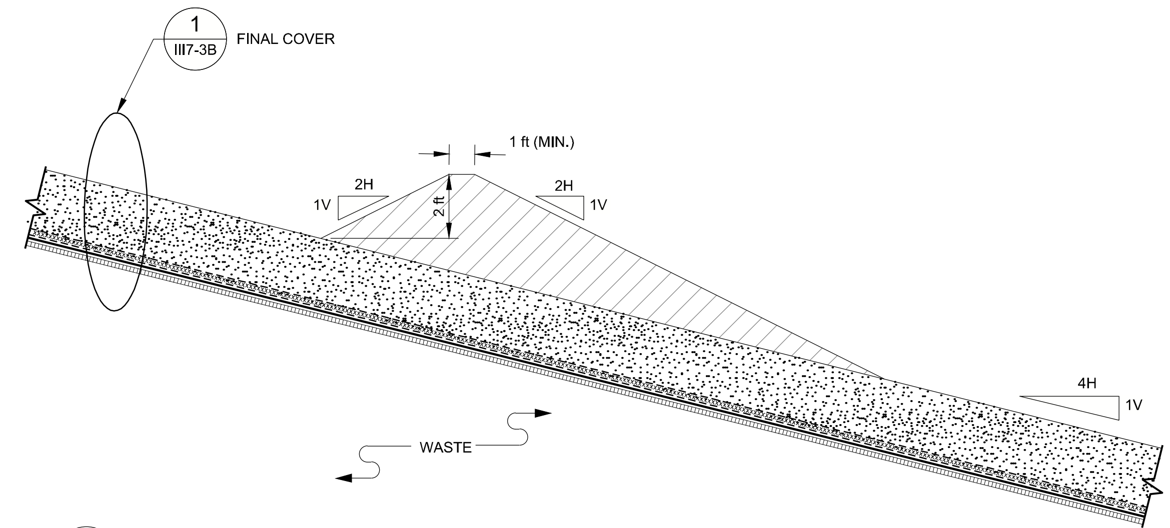

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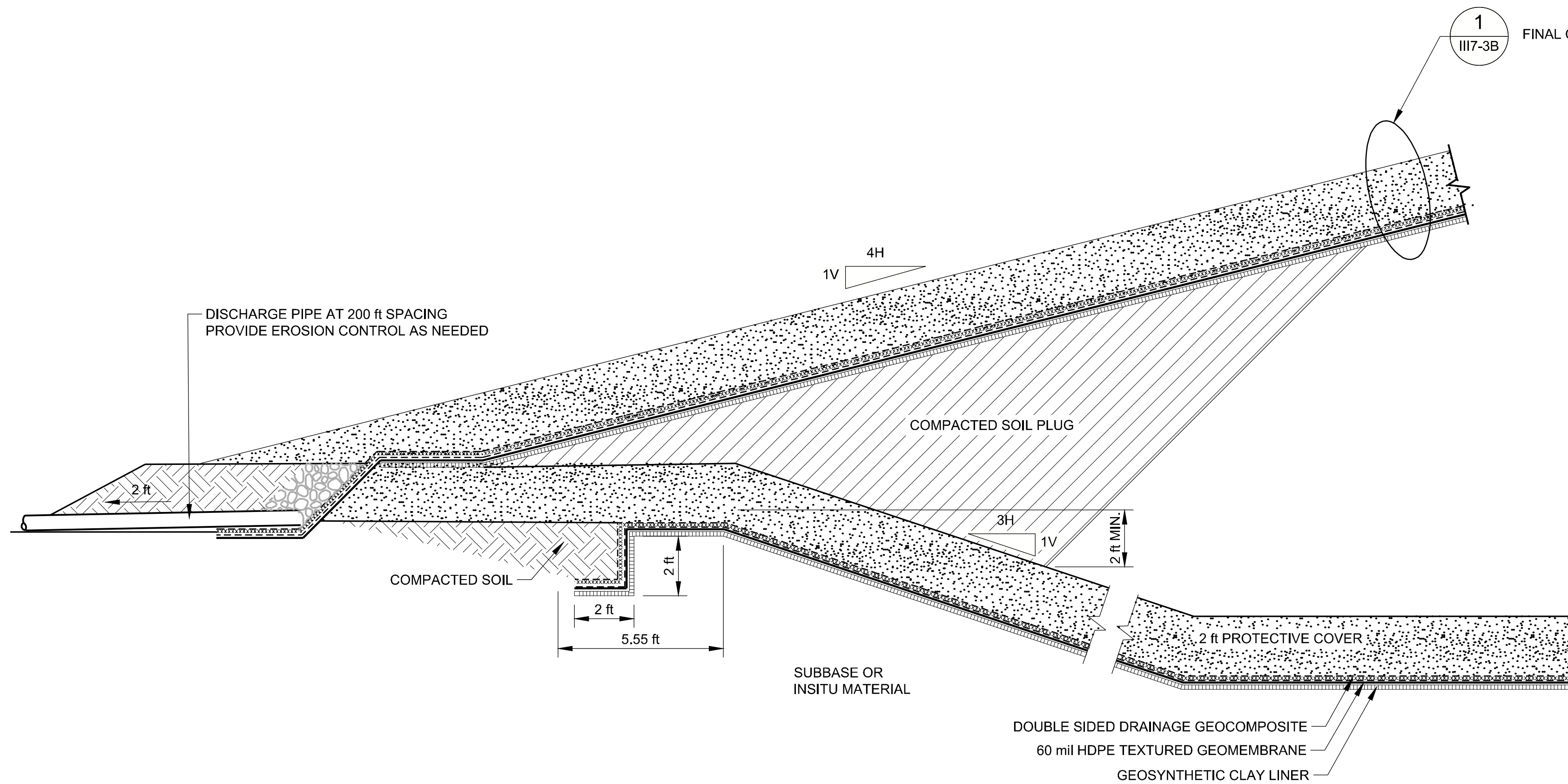

SCALE 1" = 6' 3 III7-3B LANDFILL PERIMETER

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0 3 6
1" = 6' FEET

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PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
ALTERNATIVE COMPOSITE FINAL COVER DETAILS

PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	8 of 10	III7-3B

1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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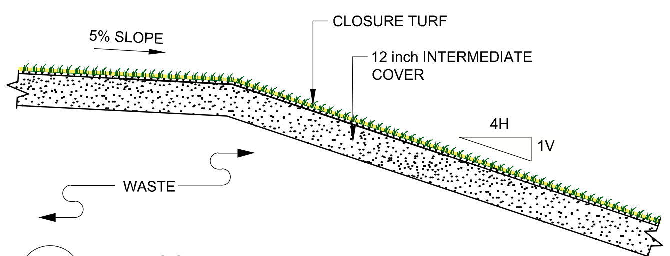
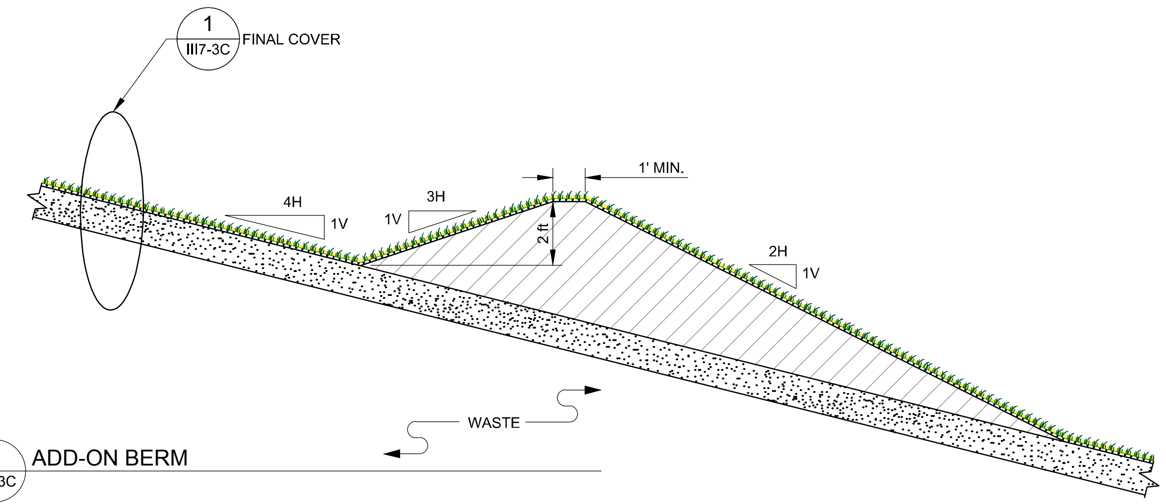
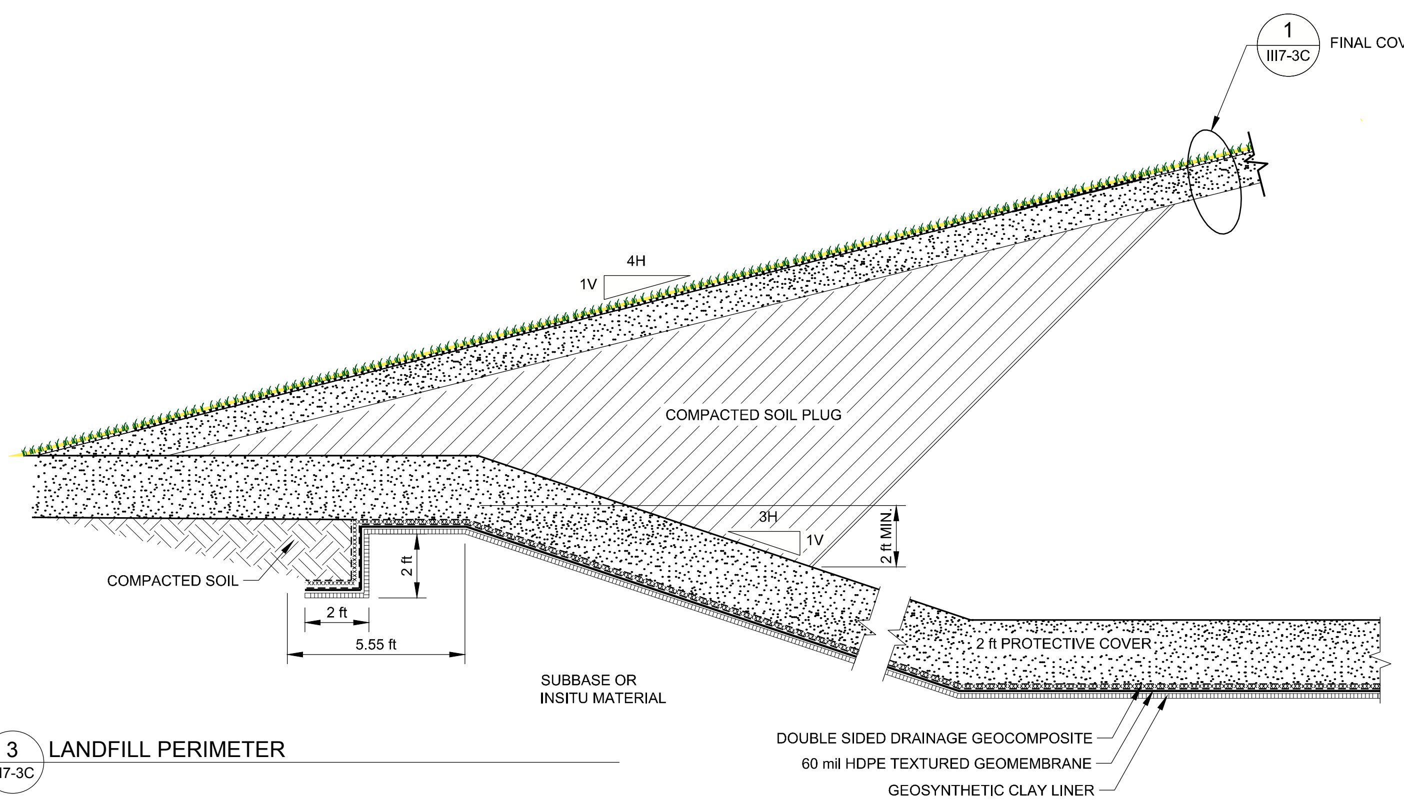


SCALE 1" = 6' 1 III7-3C FINAL COVER



SCALE 1" = 6' 2 III7-3C ADD-ON BERM



SCALE 1" = 6' 3 III7-3C LANDFILL PERIMETER

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0 3 6
1" = 6' FEET

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PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
ALTERNATIVE SYNTHETIC GRASS FINAL COVER DETAILS

PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	9 of 10	III7-3C

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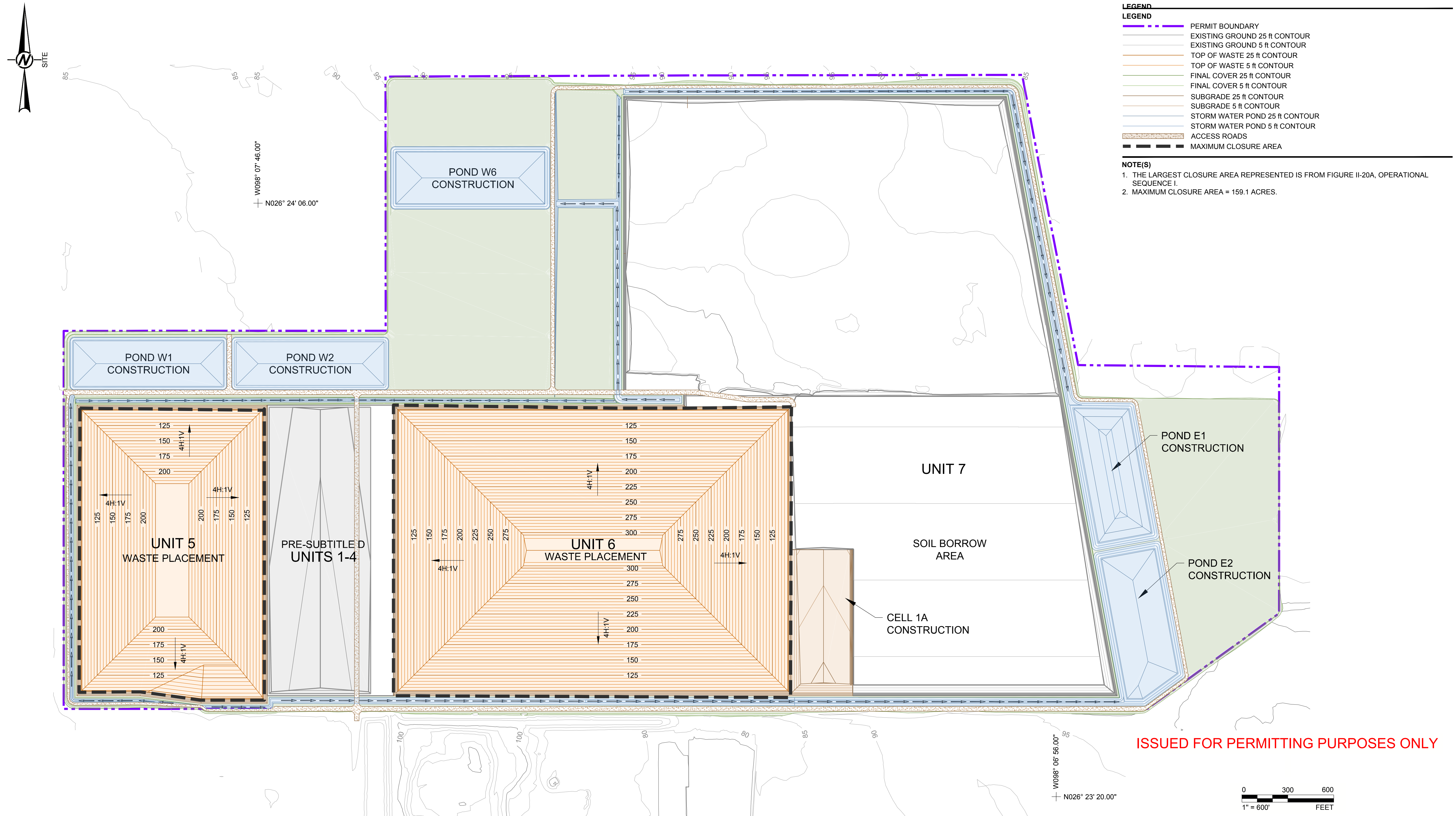

NOTE(S)

1. THE LARGEST CLOSURE AREA REPRESENTED IS FROM FIGURE II-20A, OPERATIONAL SEQUENCE I.
2. MAXIMUM CLOSURE AREA = 159.1 ACRES.

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PROJECT

EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE

MAXIMUM CLOSURE AREA

PROJECT NO.	APPLICATION SECTION	REV.		FIGURE
1401491	III7	0	10 of 10	III7-4

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APPENDIX III7A

ALTERNATIVE COMPOSITE FINAL COVER DEMONSTRATION

CITY OF EDINBURG SOLID WASTE MANAGEMENT

PERMIT AMENDMENT APPLICATION

Part III, Attachment 7, Appendix A

PART III, ATTACHMENT 7, APPENDIX A

ALTERNATE COMPOSITE FINAL COVER DESIGN DEMONSTRATION

STATE OF TEXAS
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PROFESSIONAL ENGINEER
7/21/17

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

Edinburg Regional Disposal Facility

Edinburg, Hidalgo County, Texas

TCEQ Permit MSW-956C

Submitted To: City of Edinburg
Department of Solid Waste Management
8601 North Jasman Road
Edinburg, Texas 78542 USA

Submitted By: Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA

July 2017 **Project No. 1401491**

Golder Associates

Table of Contents

List of Appendices

STATE OF TEXAS
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1.0 INTRODUCTION

This alternative composite final cover design demonstration will demonstrate that the use of geosynthetic clay liner (GCL) will provide equivalent infiltration and protection from wind and water erosion as the conventional composite final cover defined in 30 TAC §330.457(a).

1.1 Alternative Composite Liner System

The alternative composite final cover system is summarized in below.

GCL Alternate Final Cover System	
Sideslopes	**Crest Area**
24-inch thick erosion layer	24-inch thick erosion layer
Double-sided geocomposite drainage layer	Single-sided geocomposite drainage layer
40-mil LLDPE textured geomembrane	40-mil LLDPE smooth geomembrane
GCL	GCL

GCLs are geocomposite materials of low hydraulic conductivity used frequently in liner systems. Several manufacturers produce GCLs with varying characteristics. In general, GCLs are manufactured by placing powdered or granulated bentonite on a geotextile or geomembrane substrate. The bentonite layer is typically 7 to 10 mm thick (following hydration) and is placed at a unit weight of approximately 0.8 pounds per square feet (lb/ft^2). The GCLs with a geotextile substrate also have a covering geotextile, which is often needle-punched, connecting the underlying geotextile to increase the structural integrity. Non-woven and woven geotextiles of various weights are used.

Typically, the permeability of the bentonite component of GCLs ranges from less than 1 x 10^{-9} to 5 x 10^{-9} cm/sec.

2.0 EQUIVALENCY

2.1 Leakage Rate Estimates

The leakage through composite liners can be estimated using the “Giroud equation”, presented in Giroud et al, 1997. The method requires several assumptions regarding the characteristics of the composite liner. First, it is assumed that permeation through the full area of the geomembrane is insignificant in comparison to rapid leakage through isolated defects or holes. It is also necessary to make assumptions regarding the extent to which intimate contact has been achieved. A composite liner that possesses intimate contact has been constructed such that the geomembrane lies flush with the surface of the underlying clay component, with few or no gaps between the two liners. When intimate contact has been achieved, the effective area of leakage is very small, and the total liner system leakage is minimized. This phenomenon is referred to as “composite action.”

The equation used in the analysis is derived both from theoretical models of fluid flow and from empirical analyses of actual composite liner systems. Flow through a circular defect in a composite liner is calculated as:

$$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$$

where:

Q = rate of leakage through a defect (m^3/sec)
C = Dimensionless constant related to the quality of the intimate contact between the geomembrane and the underlying soil component
h = hydraulic head on the geomembrane (m)
t_s = thickness of the low-permeability soil component (i.e., the CCL or GCL) (m)
a = area of geomembrane defect (m^2)
k_s = permeability of soil component (i.e., CCL or GCL) (m/s)

Using the above equation, the conventional composite final cover system was compared to the alternative composite final cover system for both “good” and “poor” intimate contact and for circular holes with an area of 0.1 and 1.0 cm^2.

As shown on the calculations in Appendix III7AA, Infiltration Rate Comparison – Alternative Composite Final Cover for each condition, the alternative composite final cover had calculated leakage rates approximately 1/250th that of the geomembrane/compacted clay liner system.

2.2 Wind And Water Erosion

The alternative composite final cover surface will be seeded or sodded.

3.0 SUMMARY

Based on this analysis, it is apparent that substituting a GCL for an 18-inch thick compacted clay rich earthen material with a hydraulic conductivity of $1x10^{-5}$ cm/sec provides a level of infiltration reduction and wind and water protection that is greater than or equal to the level of protection provided by the conventional composite final cover system.

APPENDIX III7AA

INFILTRATION RATE COMPARISON – GCL ALTERNATE FINAL COVER

INFILTRATION RATE COMPARISON - GCL ALTERNATIVE FINAL COVER

Made By: JBF
Checked by: CEI
Reviewed by: MX

OBJECTIVE

Compare the infiltration rate through a conventional composite final cover system with the infiltration rate through the alternative composite final cover system.

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The conventional composite final cover system consists of a 40-mil geomembrane overlying a 18-inch thick compacted clay rich material with a maximum hydraulic conductivity of 1 x 10^{-5} cm/s. In the alternative composite final cover system, the compacted clay rich (the infiltration layer) material will be replaced with a geosynthetic clay liner (GCL). In addition, the alternative composite final cover includes a geocomposite drainage layer above the geomembrane.

Infiltration Layer Properties

k =	1.00E-05	cm/s
t =	1.5	ft
h =	18	inches

(assuming saturated cover soil)

GCL Properties

k =	5.00E-09	cm/s
t =	7	mm
h =	0.2	inches

(geocomposite drainage layer sized to prevent head > 0.2 inches when cover soil saturated)

METHOD

Estimate the infiltration rate through each final cover system using the Giroud Equation (Ref. 1). Compare the infiltration rate through composite final cover systems consisting of a geomembrane/clay rich material and a geomembrane/GCL.

Infiltration through composite geomembrane/GCL liner.

$$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$$ Ref 1

where:

C =	0.21	for good contact
	1.15	for poor contact

h = head (m)

t_s = thickness of low permeability soil component (i.e. CCL or GCL) (m)

a = area of hole (m^2)

k_s = hydraulic conductivity of CCL or GCL (m/s)

RESULTS

Leakage Rate Per Defect

Intimate Contact		Good		Poor	
Composite Cover System		GM/Clay	GM/GCL	GM/Clay	GM/GCL
Leakage (m^3/sec)	0.1 cm^2 hole	3.79E-09	1.46E-11	2.07E-08	8.02E-11
	1 cm^2 hole	4.77E-09	1.84E-11	2.61E-08	1.01E-10

Comparison

Intimate Contact	$Q_{GM/Clay}/Q_{GM/GCL}$	
	0.1 cm^2 hole	1 cm^2 hole
Good	259	259
Poor	259	259

CONCLUSION

Based on this analysis, the infiltration rate through an alternative composite final cover system with a GCL will be approximately 1/250th that of the conventional composite final system with a clay rich infiltration layer.

REFERENCE

1) Giroud, J.P., “Equations for Calculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects”, Geosynthetics International, Vol. 4, Nos. 3-4, pp. 335-348, 1997.

APPENDIX III7B

ALTERNATE SYNTHETIC GRASS FINAL COVER DEMONSTRATION

CITY OF EDINBURG SOLID WASTE MANAGEMENT

PERMIT AMENDMENT APPLICATION

Part III, Attachment 7, Appendix B

PART III, ATTACHMENT 7, APPENDIX B

ALTERNATIVE FINAL COVER DESIGN DEMONSTRATION

ALTERNATIVE SYNTHETIC GRASS FINAL COVER

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7/21/17

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Edinburg Regional Disposal Facility

Edinburg, Hidalgo County, Texas

TCEQ Permit MSW-956C

Submitted To: City of Edinburg
Department of Solid Waste Management
8601 North Jasman Road
Edinburg, Texas 78542 USA

Submitted By: Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA

July 2017

Project No. 1401491

Golder Associates

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Registration Number F-2578

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1.0 INTRODUCTION

This alternative synthetic grass final cover design demonstration will demonstrate that ClosureTurf® will provide equivalent infiltration and protection from wind and water erosion as the conventional composite final cover defined in 30 TAC §330.457(a).

1.1 ClosureTurf®

ClosureTurf® is a synthetic grass, geomembrane system developed for landfill final cover applications.

ClosureTurf® consists of the following components (from bottom to top):

- A 50-mil Super Gripnet structured linear low density polyethylene (LLDPE) geomembrane;
- An integrated drainage layer formed with studs on the top of the geomembrane;
- An engineered synthetic turf (comprised of polyethylene fibers tufted through a double layer of woven polypropylene geotextiles; and
- Sand infill.

2.0 EQUIVALENCY

2.1 Leakage Rate Estimates

The leakage through composite liners can be estimated using the "Giroud equation", presented in Giroud et al, 1997. The method requires several assumptions regarding the characteristics of the composite liner. First, it is assumed that permeation through the full area of the geomembrane is insignificant in comparison to rapid leakage through isolated defects or holes. It is also necessary to make assumptions regarding the extent to which intimate contact has been achieved. A composite liner that possesses intimate contact has been constructed such that the geomembrane lies flush with the surface of the underlying clay component, with few or no gaps between the two liners. When intimate contact has been achieved, the effective area of leakage is very small, and the total liner system leakage is minimized. This phenomenon is referred to as "composite action."

The equation used in the analysis is derived both from theoretical models of fluid flow and from empirical analyses of actual composite liner systems. Flow through a circular defect in a composite liner is calculated as:

$$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$$

where:

Q = rate of leakage through a defect (m^3/sec)

C = Dimensionless constant related to the quality of the intimate contact between the geomembrane and the underlying soil component
h = hydraulic head on the geomembrane (m)
t_s = thickness of the low-permeability soil component (i.e., the CCL or intermediate cover) (m)
a = area of geomembrane defect (m^2)
k_s = permeability of soil component (i.e., CCL or intermediate cover) (m/s)

Using the above equation, the conventional composite final cover system was compared to ClosureTurf® for both "good" and "poor" intimate contact and for circular holes with an area of 0.1 and 1.0 cm^2.

As shown on the calculations in Appendix III7BA, Infiltration Rate Comparison – Alternative Synthetic Grass Final Cover for each condition, ClosureTurf® had calculated leakage rates approximately 1/5th that of the conventional composite final cover using geomembrane/compacted clay liner system.

2.2 Wind And Water Erosion

Wind tunnel testing shows that ClosureTurf® can withstand wind speeds greater than 150 mph. The synthetic turf creates a turbulent zone along the surface that prevents the suction force observed with exposed geomembranes.

To control erosion of the infill material, the slope length is limited. Considering three flow regimes (flow within the drainage layer; flow within the sand fill; and surface flow), the manufacturer has developed a chart to determine the maximum flow length for various slopes and rainfall intensities. Assuming the 100-year, 60-minute rainfall event occurs on the 4H:1V final cover slopes, the maximum length between benches or add-on berms is approximately 175 feet. The final cover has been designed with a maximum distance of 160 feet between add-on berms.

In areas of concentrated flow, e.g. at add-on berms, downchutes, and benches, the sand infill is replaced with a sand-cement compound.

2.3 Other Considerations

In addition to providing equivalent infiltration and protection from wind and water erosion, synthetic turf alternate covers offer other advantages over the final cover defined in 30 TAC §330.457(a), including:

- Stability
  The underside of the geomembrane component of ClosureTurf® includes 175-mil long spikes that produce a high interface shear strength between the ClosureTurf® and the underlying soil. Interface shear strength testing indicates that the peak friction angle between the synthetic turf and the geomembrane is 39 degrees. (Watershed Geo, 2016)
- Landfill Gas
  Standard penetrations are provided to create water/air-tight penetrations for gas collection system components. In addition, "malfunction relief valves" are placed one per acre to prevent the development of gas pressure below the geomembrane.

- Settlement
  MSW is a highly compressible material and the compression continues for a long period of time. Soil liners, as in the prescribed final cover system, do not accommodate settlement well; e.g. relatively small strains cause the soil to crack, which can greatly increase the hydraulic conductivity. Each component of the closure ClosureTurf® is able to accommodate settlement without compromising its ability to prevent infiltration.
- Longevity
  Each geosynthetic component of ClosureTurf® has been tested and evaluated for long-term performance. Testing data indicate that the synthetic turf (i.e. the turf fibers and two layers of woven geotextile backing) will retain 65% of its original tensile strength after 100 years of exposure. The geomembrane is estimated to retain 50% of its original tensile strength after more than 250 years of exposure. (Geosyntec, 2015)
- Maintenance
  Since it does not require mowing, the maintenance effort is significantly reduced.

3.0 SUMMARY

Based on this analysis, it is apparent that the alternative synthetic grass final cover provides a level of infiltration reduction and wind and water protection that is greater than or equal to the level of protection provided by the conventional composite final cover system. In addition, the ClosureTurf® offers other advantages over the conventional composite final cover system.

4.0 REFERENCES

Watershed Geo. June 2016. ClosureTurf® Design Guidelines Manual.

Geosyntec Consultants, May 2015. Literature Review and Assessments of ClosureTurf® UV Longevity. Letter report to Watershed Geosynthetics.

APPENDIX III7BA

INFILTRATION RATE COMPARISON – CLOSURE TURF ALTERNATE FINAL COVER

INFILTRATION RATE COMPARISON - CLOSURE TURF ALTERNATIVE FINAL COVER

Made By: JBF
Checked by: CEI
Reviewed by: MX

OBJECTIVE

Compare the infiltration rate through a conventional composite final cover system with the infiltration rate through the ClosureTurf®.

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

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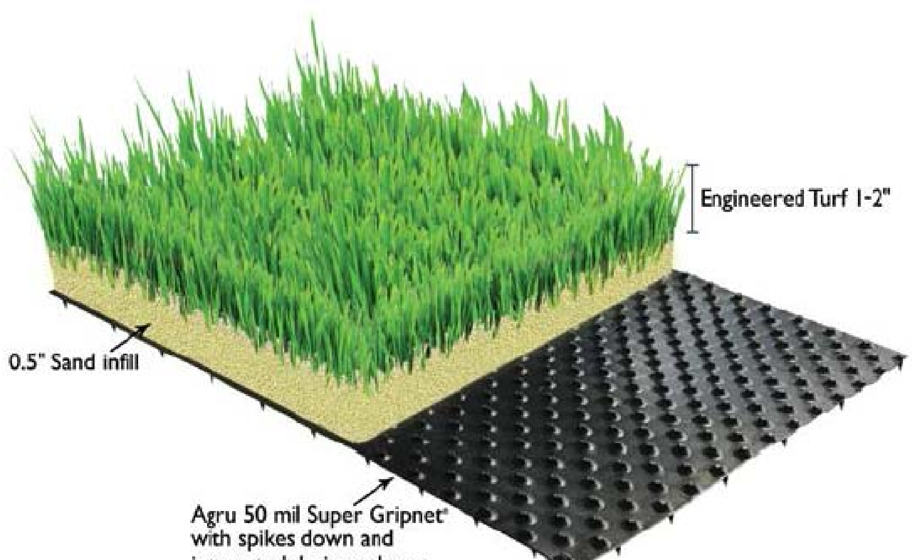
GIVEN

The conventional composite final cover system consists of a 40-mil geomembrane overying a 18-inch thick compacted clay rich material with a maximum hydraulic conductivity of 1 x 10^{-5} cm/s. An option for the alternative synthetic grass alternate final cover system is ClosureTurf® , underlain with a 12-inch thick intermediate cover with hydraulic conductivity of < 1 x 10^{-4} cm/s.

Two types of ClosureTurf® are proposed: integrated drainage layer (IDS)-based for sideslopes and Microspike-based for the upper 5% slopes. The IDS layer consists of a 50-mil LLDPE geomembrane with spikes on the bottom (for stability) and "studs" on the top (for drainage); a geotextile filter/separation layer; 1/2-inch thick layer of sand infill; overlain with synthetic turf. A schematic of the IDS based system is shown below.



METHOD

Estimate the infiltration rate through each liner system using Giroud's Equation (Ref 1). Compare the infiltration rate through conventional composite final cover system and ClosureTurf®.

Infiltration through composite liner.

$$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74} \qquad \text{Ref 1}$$

where:

C = 0.21 for good contact
1.15 for poor contact

h = head (m)

t_s = thickness of low perm soil component (i.e. CCL or intermediate cover) (m)

a = area of hole (m^2)

k_s = hydraulic conductivity of CCL or intermediate cover (m/s)

Conventional Composite Infiltration Layer Properties

k = 1.00E-05 cm/s
t = 1.5 ft
h = 18 inches
(thickness of cover soil)

ClosureTurf® & Intermediate cover

k = 1.00E-04 cm/s
t = 1 ft
h = 0.5 inches
(thickness of sand fill or bound fill)

RESULTS

Leakage Rate Per Defect

Intimate Contact		Good		Poor	
Cover System		Conventiona	Closure Turf®	Conventiona	Closure Turf®
Leakage (m^3/sec)	0.1 cm^2 hole	2.39E-07	4.76E-08	1.31E-06	2.61E-07
	1 cm^2 hole	3.00E-07	5.99E-08	1.65E-06	3.28E-07

Comparison

Intimate Contact	$Q_{prescr.}/Q_{ClosureTurf}$	
	0.1 cm^2 hole	1 cm^2 hole
Good	5.0	5.0
Poor	5.0	5.0

CONCLUSION

Based on this analysis, assuming each liner system has the same number of holes for a given area, the infiltration rate through the ClosureTurf® final cover system will be approximately 1/5th that of the conventional composite final cover system.

REFERENCE

1) Giroud, J.P., "Equations for Calculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects", Geosynthetics International, Vol. 4, Nos. 3-4, pp. 335-348, 1997.

APPENDIX III7BB

MAXIMUM DRAINAGE LENGTH

MAXIMUM DRAINAGE LENGTH

Made By: JBF
Checked by: CEI
Reviewed by: MX

STATE OF TEXAS
7/21/17
JEFFREY B. FASSETT
85675
LICENSED PROFESSIONAL ENGINEER

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

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1.0 OBJECTIVE

Determine the maximum allowable drainage (flow) length for ClosureTurf® .

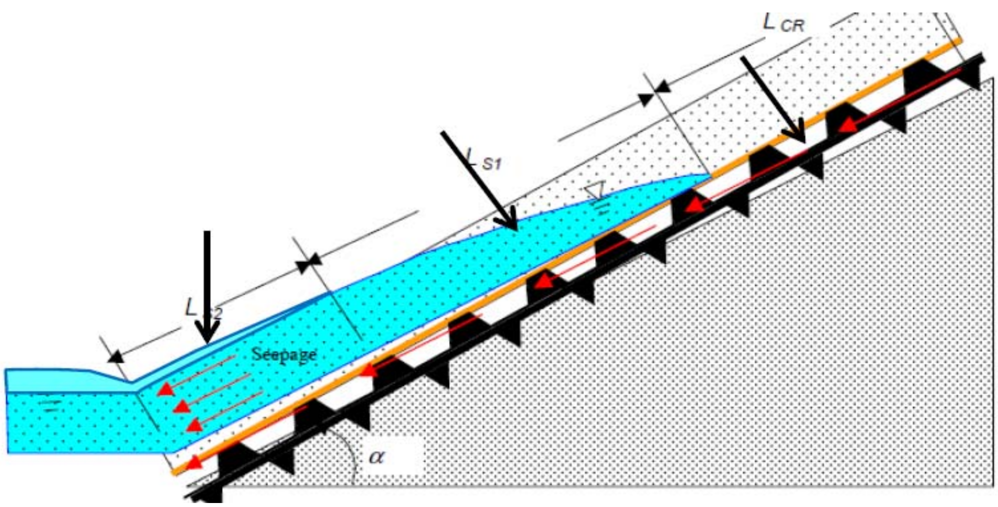
2.0 GIVEN

Slope =	4H:1V =	25%	
100-year, 60-minute storm =	4.35 inches		(Ref. 1)

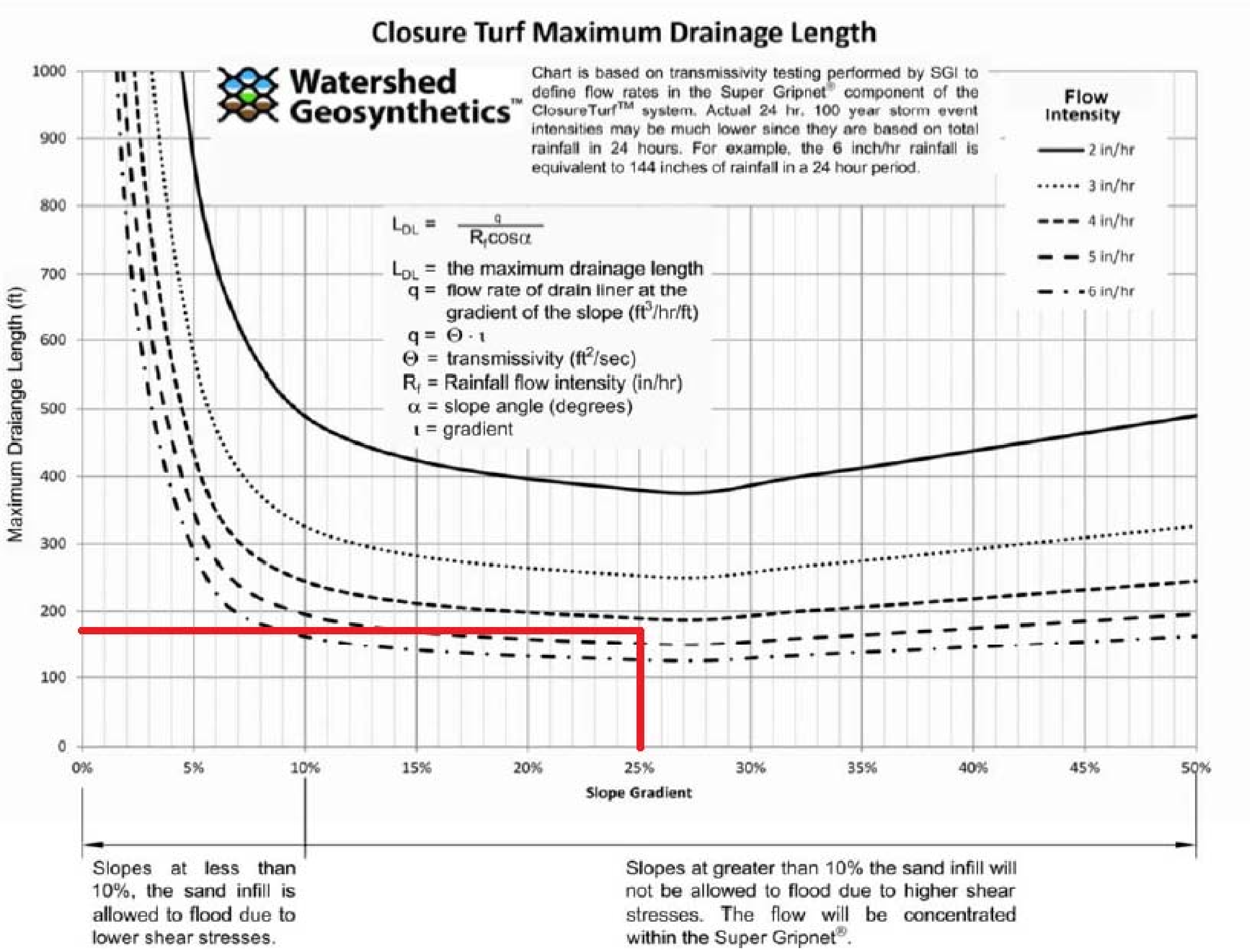
3.0 METHOD

There are three flow regimes to consider:

1) Flow within the drainage layer (i.e. between the "studs" on the upper face of the geomembrane). The head above the geomembrane is equal to the height of the studs at L_{CR}.
2) Flow within the sand infill. The distance between L_{CR} and the point at which the head rises to the top of the sand infill is referred to as L_{S1}.
3) Surface flow. The length of the surface flow is referred to as L_{S2}.



The manufacturer has analyzed the three flow regimes for various slopes and rainfall intensities (Ref. 2) and prepared the chart below. Input the slope (25%) and the rainfall intensity (4.35 in/hr) in the chart.



L_{max} = 175 ft

6.0 CONCLUSIONS

Based on information provided by the manufacturer, the maximum allowable slope length on the 4H:1V slope of the final cover is approximately 175 ft.

7.0 REFERENCES

1. National Oceanic and Atmospheric Administration, "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States", June 1977.
2. Watershed Geo, "ClosureTurf Design Guidelines Manual", September 2015.

APPENDIX III7C

TCEQ CLOSURE PLAN FORM

Texas Commission on Environmental Quality

Closure Plan for Municipal Solid Waste Type I Landfill Units and Final Facility Closure

This form is for use by applicants or site operators of Municipal Solid Waste (MSW) Type I landfills to detail the plan for closure of a landfill unit, closure of associated storage or processing units, and final closure of the facility to meet the requirements in 30 TAC Chapter 330, §330.63(h) and 30 TAC Chapter 330 Subchapter K for a MSW Type I facility.

If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: Edinburg Regional Disposal Facility

MSW Permit No.: MSW-956C

Site Operator/Permittee Name: City of Edinburg

II. Landfill and Other Waste Management Units and Operations Requiring Closure at the Facility

A. Facility Units

Table 1. Description of Landfill Units.

Name or Descriptor of Unit	Operating Status of Unit	Type of Liner System Under Unit	Above Grade Class 1 Disposal Cells in this Unit	Below Grade Class 1 Disposal Cells in this Unit	Other Class 1 Disposal Cells in this Unit (describe)	Size of Unit's Waste Footprint (acres)	Maximum Inventory of Waste Ever in Unit (cubic yards)	Other Necessary Information that Pertains to the Unit
Pre-Subtitle D Units 1 - 4	Inactive	None Few cells have GM	☐	☐	☐	29.2	1,027,858	Final cover soil in place. Certification not found.
Unit 5	Active	Alternative liner	☐	☐	☐	52.9	3,723,273	
Unit 6	Active	Alternative liner	☐	☐	☐	110.8	11,983,781	
Unit 7 and Unit 8 / Overliner	Construction following permit issuance	Alternative liner	☐	☐	☐	213.1	70,566,243	Unit 8 or Overliner option to be constructed
Totals						406.0	87,301,156	

Table 2. Description of Waste Storage or Processing Units or Operations Associated with this Permit.

Type of Storage or Processing Unit or Operation (individual units may be closed at any time prior to or during the final facility closure as described in this plan)	Operational Status of Unit	Size of the Area Used for the Storage or Processing Unit or Operation (Acres)	Maximum Inventory of Waste Ever in Storage or Processing Unit or Operation (indicate cubic yards or tons)	Other Information (enter other necessary information that pertains to the unit)
Mulching	Active	1.0	4,000 - Assumed ☒cubic yards ☐tons	*Waste in storage or processing units will either be disposed in the landfill or transported to an authorized facility. Therefore inventory of waste in storage or processing units or operations is included in capacity of landfill units.*
Liquid Stabilization	Operational following permit issuance	0.04	400 - Assumed ☒cubic yards ☐tons	
Reusable Materials	Active	0.02	200 - Assumed ☒cubic yards ☐tons	
Whole Tire Staging	Active	0.004	40 - Assumed ☒cubic yards ☐tons	
Totals		1.064	4,640	

B. Waste Inventory Summary

Table 3. Maximum Inventory of Wastes Ever On Site.

Item	Quantity (indicate cubic yards or tons)
Maximum inventory of waste in landfill units (total from Table 1)	87,301,156 ☒cubic yards or ☐tons
Maximum inventory of waste in storage or processing units or operations (total from Table 2)	0 ☒cubic yards or ☐tons *Waste in storage or processing units will either be disposed in the landfill or transported to an authorized facility.*
Total Maximum Inventory of Wastes ever on site over the active life of the MSW facility (sum of totals from Tables 1 and 2)	87,301,156 ☒cubic yards or ☐tons

C. Drawings Showing Details of the Waste Management Units at Closure

Table 4. Location of the Drawings showing Details of the Waste Management Units at Closure (outlines, dimensions, maximum elevations of waste and final cover of landfill units, and waste storage or processing units or operations at closure of the facility).

Drawing Location in the SDP	Drawing Figure Number	Drawing Title	Waste Management Units Details Shown
Part III, Attachment 3	III3-1	Facility Layout Plan	e.g., outlines , waste footprints, and dimensions of the landfill unit(s)
Part III, Attachment 7	III7-1	Final Contour Map	e.g., maximum elevations of waste and final cover of the landfill unit(s)
Part III, Attachment 1	III1-2	Schematic View of Various Waste Disposal, Processing, and Storage Areas	e.g., outlines and dimensions of the storage and processing unit(s)

III. Description of the Final Cover System Design

A. Types and Descriptions of the Final Cover Systems

Table 5. Types and Descriptions of the Final Cover Systems Permitted or Proposed for Closure of the Landfill Units.

Landfill Unit Name or Descriptor	Type of Final Cover System	Final Cover System Components Description	Other Information (Enter other information as applicable)
All Units No certified final cover.	Conventional Composite	24-inch erosion layer with upper 6 inches capable of supporting vegetation, double-side geocomposite, 40-mil LLDPE, 18-inch compacted clay $1x10^{-5}$ cm/s	*Three final cover system options are provided for closure for areas in all units*
	Alternative Composite	24-inch erosion layer with upper 6 inches capable of supporting vegetation, double-side geocomposite, 40-mil LLDPE, geosynthetic clay liner	
	Alternative Synthetic Grass	HDPE synthetic grass, sand infill, geotextile, 50-mil LLDPE Super Gripnet® geomembrane	

B. Design Details

Table 6. Design Details of the Final Cover Top and Side Slopes for the Landfill Units.

Landfill Unit Name or Descriptor	Maximum Final Elevation of Waste (feet above mean sea level [ft-msl])	Maximum Elevation of Top of Final Cover (ft-msl)	Minimum Grade of the Final Cover Top Slope (%)	Maximum Grade of the Final Cover Side Slope (%)	Other Information (enter other information as applicable, e.g. above-grade Class 1 Cell Dikes)
All Units Conventional Composite Option	394.5	398.0	5	25	*Three final cover system options are provided for closure for all units. Final cover grades are not to exceed those in Figure III7-1, Final Contour Map*
All Units Alternative Composite Option	396.0	398.0	5	25	
All Units Alternative Synthetic Grass Option	398.0	398.0	5	25	

C. Final Cover Drainage Features

Storm water drainage and erosion and sediment control features incorporated on the final cover of the landfill units to protect the integrity and effectiveness of the final cover system include *(please list and describe the drainage features to be installed on the final cover at or prior to closure for each landfill unit, or list the drainage features and provide cross references on the location(s) of the descriptive and details (drawing) information in other parts of the SDP)*:

Part III2, Surface Water Drainage Report contains details on drainage features to be installed on the final cover prior to closure for each landfill unit which includes add-on berms and downchutes.

Figure III2-2 Post-Development Drainage Plan

Figure III2-3 Drainage Control Details I – Channels and Berms

Figure III2-4 Drainage Control Details II – Stormwater Downchute Details and Crossings

D. Final Cover Vegetation or Other Ground Cover Material

The final cover will be seeded and/or sodded with native plants immediately following the application of the final cover in order to minimize erosion. Other materials, including **mulch and geosynthetic erosion control products,** may be incorporated over the final cover soil surface to ensure sufficient coverage of the ground surface to minimize erosion. The estimated percent ground cover to minimize soil loss and maintain long-term erosional stability of the final cover top and side slopes is: **5% and 25%**. The minimum material specifications for other ground cover materials are summarized in the table below.

For a landfill with water balance final cover design, the percentage vegetation cover (excluding other ground cover types) will not be less than that assumed in the water balance final cover model.

Table 7. Minimum Specification for Ground Cover Materials Other Than Vegetation, if Applicable.

Other Ground Cover Material	Maximum Particle Size (inches)	Minimum Particle Size (inches)	Material Placement Method	Thickness of Layer (inches)	Percentage Coverage (%)	Other (specify)
Mulch	Varies	Varies	Spread	Varies	Varies	
Geosynthetic Erosion Control Products	NA	NA	Install	Varies	Varies	

E. Final Contour Map

Figure **III7-1**, a facility final contour map is attached. The map shows the final contours of the landfill units and the entire facility at closure.

Figures **III7-3A** and **III7-3E** showing the cross–sections of the landfill units at closure are also provided.

The facility final contour and cross-section maps/drawings depict the following information:

(1) Final constructed contours of the landfill at closure.

(2) Top slopes and side slopes of the landfill units.

(3) Surface drainage features.

(4) 100-year floodplain, as applicable.

(5) Constructed features providing protection of/from the 100-year floodplain.

(6) Other (specify):
N/A

IV. Description of the Final Cover System Installation Procedure

A. Mode of Installation

Table 8. Mode of Final Cover Installation on the Landfill Units.

Landfill Unit Name or Descriptor	Largest Area of Unit Ever Requiring Final Cover (Acres)	Check this Column if Final Cover will be Placed in Installments as Permitted Elevation is Reached	Check this Column if Final Cover will be Placed when Entire Unit Area Reaches Permitted Elevation	Final Cover Installation Status
All Units	253.5	☒	☐	Yet to be installed
		☐	☐	
		☐	☐	
		☐	☐	

B. Installation Drawings for Final Cover and Drainage Features

The following attached plan and cross-section drawings show the final cover design details, the largest area requiring final cover, details of the sequence of installation of the final cover system, and all drainage features.

Table 9. List of Attached Installation Drawings for Final Cover and Drainage Features.

Drawing No.	Drawing Title	Description of Information Contained in Drawing
III7-1	Final Contour Map	Plan drawing of final fill and drainage features
III7-2	Fill Cross-Sections	Fill Cross Section Location Map including profiles
III7-3	Final Cover Details	Details of final cover components and drainage features
III7-4	Maximum Closure Area	Area of maximum closure from sequence of site development in Part II

C. Final Cover Quality Control Plan

A final cover quality control plan (FCQCP), Attachment **III7D**, is attached. The FCQCP describes the final cover system design, construction, and evaluation protocol and processes, including the personnel, materials, methods, sampling and testing standards, procedures, and practices to be used in procuring, handling, installing, and evaluating all elements of the final cover system. It establishes the material requirements; personnel qualifications and roles; installation requirements; quality control and quality assurance monitoring, testing, documentation, and reporting programs to be used during construction of each component of the final cover system to assure and to verify that the final cover system is constructed as designed and in accordance with applicable rules and technical standards.

D. Documentation and Reporting of Final Cover System Construction and Testing

The professional of record will document all aspects and stages of the final cover installation, including materials used, equipment and construction methods, and the type and rate of sampling and quality control testing performed. Following completion of construction of the final cover, the site operator/permittee will submit to the TCEQ executive director, a Final Cover System Evaluation Report (FCSER) for each landfill unit.

V. Closure Activities and Completion Schedules for Each Landfill Unit and for the Final Facility Closure

A. Closure of a Landfill Unit

The following activities will be conducted to satisfy the closure criteria for a landfill unit:

(1) Closure Notification to the TCEQ Executive Director:

The site operator will inform the executive director of the TCEQ, in writing, of the intent to close the unit no later than 45 days prior to the initiation of closure activities and place this notice of intent in the operating record.

(2) Stoppage of Waste Acceptance and Commencement of Other Closure Activities for the Unit:

The site operator will stop accepting waste upon receiving the known final receipt of waste. The site operator will ensure that the permitted top elevations of the in-place waste, as depicted in/derived from the unit's final contour map approved by the TCEQ executive director, are not exceeded at any section or part of the landfill unit. The site operator will begin closure activities for the unit no later than:

- Thirty days after the date on which the unit receives the known final receipt of wastes; or

- One year after the most recent receipt of wastes if the unit has remaining capacity and there is a reasonable likelihood that the unit will receive additional wastes.

(3) Request for Extension Beyond the 1-Year Deadline for Commencing Closure Activities for a Unit:

The site operator may submit a written request to the executive director of the TCEQ for review and approval for an extension beyond the one-year deadline for the initiation of closure. The request will include the following:

(a) All applicable documentation necessary to demonstrate that the unit has the capacity to receive additional waste; and

(b) All documentation necessary to demonstrate that the site operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the MSW landfill unit.

(4) Construction of Final Cover:

The site operator will construct the permitted final cover over the waste mass utilizing methods, procedures, and specifications described in the FCQCP. The final constructed contours, elevations, and slopes of the installed final cover will match the permitted final cover contours, elevations, and slopes shown in closure drawings contained in this closure plan.

(5) Construction of Drainage Features:

The site operator will construct the drainage structures shown in drawings referenced or contained in this closure plan or in the facility surface water drainage report.

(6) Completion of Outstanding or Replacement of Damaged Groundwater or Landfill Gas Monitoring Components:

The site operator will complete installation of any outstanding or replacement of any damaged groundwater or landfill gas monitoring system components and landfill gas control systems as needed to maintain current and effective groundwater or landfill gas monitoring and control systems.

(7) Submittal of Final Cover System Evaluation Report (FCSER) to the TCEQ Executive Director:

Following completion of construction of the final cover for the subject landfill unit, the site operator will submit to the TCEQ executive director for review and acceptance, a FCSER for the unit.

(8) Completion of Closure Activities for the Landfill Unit:

The site operator will complete closure activities for the unit within 180 days following the start of closure activities, unless the executive director of the TCEQ grants an extension as described in Item V.A.8(a) below.

(a) Request for Extension of the Completion of Closure Activities for the Landfill Unit:

The site operator may submit a written request for an extension for the completion of closure activities to the TCEQ for review and approval. The extension request will include:

- All applicable documentation necessary to demonstrate that closure will, of necessity, take longer than 180 days; and
- All applicable documentation necessary to document that all steps have been taken and will continue to be taken to prevent threats to human health and the environment from the unclosed MSW landfill unit.

(9) Submittal of Engineer's Certification of Closure to the TCEQ Executive Director and Request of Closure Inspection to TCEQ Regional Office:

Following completion of all closure activities for the landfill unit, the site operator will submit:

(a) Closure Inspection

A written request to the local TCEQ regional office for a closure inspection of the unit.

(b) Closure Certification

A certification, signed by an independent licensed professional engineer, to the executive director of the TCEQ for review and approval verifying that closure has been completed in accordance with this closure plan. The site operator will submit the certification via registered mail, and the submittal will contain all applicable documentation necessary for certification of closure of the unit, including:

- A final cover system evaluation report (FCSER) documenting the installation of the final cover. The FCSER may be submitted as a separate document for review and approval following the completion of the final cover installation. In that case, the certification of closure will be submitted subsequently;
- A final contour map as described under Section III.E that includes the relevant unit; and
- Copy of the letter to the TCEQ regional office requesting a closure inspection of the relevant unit.

(10) TCEQ's Acknowledgement of Termination of Operation and Closure of a Unit:

Upon receipt, the TCEQ executive director will review the closure documents for completeness and accuracy; and following receipt of the closure inspection report from the agency's regional office verifying proper closure of the MSW landfill unit according to this closure plan, the executive director will, in writing, acknowledge the termination of operation and closure of the unit and deem it properly closed. Thereafter, the site operator will comply with the post-closure care requirements described in the post-closure care plan for the unit.

(11) Deed Recordation for Disposed Regulated Asbestos Containing Materials (RACM):

Upon closure of the unit that accepted RACM, the site operator will place a specific notation that the unit accepted RACM in the deed records for the facility with a diagram identifying the RACM disposal areas. Concurrently, the site operator will submit to the TCEQ executive director, a notice of the deed recordation and a copy of the diagram identifying the asbestos disposal areas.

(12) Placement of all Closure Documentation in the Site Operating Record:

Once approved, the closure certification and all other documentation of closure will be placed in the site operating record.

(13) Closure Schedule for the Landfill Unit:

A closure schedule *for Unit Closure Implementation is provided in Closure Plan Report Text*. The schedule shows all the closure activities listed within Section V.A and the timelines for commencing and completing each activity. Also, the schedule shows that closure activities for the landfill unit will be completed within 180 days following the initiation of closure activities as required, unless an extension is granted by the TCEQ executive director.

(14) Other: (enter as applicable).

B. Closure of the Waste Storage or Processing Units or Operations

Closure of the waste storage or processing units or operations authorized under this permit will include removal of all waste, waste residues, and any recovered materials. The facility units and operations will either be dismantled and removed off-site or decontaminated. The site operator will dispose at the landfill or evacuate all materials (including feedstock, in process, and processed) to an authorized facility and disinfect all leachate handling units, tipping areas, processing areas, and post-processing areas. If there is evidence of a release from a unit or operation, the site operator will conduct an investigation, as approved by the TCEQ executive director, into the nature and extent of the release and an assessment of measures necessary to correct an impact to groundwater.

C. Final Closure of the Facility

In addition to the closure activities listed in Section V.A above for closing a landfill unit, the site operator will conduct the following activities for the closure of the entire facility:

(1) Publish Final Closure Notice and Place the closure Plan in a Public Place:

No later than 90 days prior to the initiation of the final facility closure, the site operator will:

(a) Publication of Notice:

The site operator will publish notice in the newspaper(s) of largest circulation in the vicinity of the facility to inform the public of the final closure of the facility. This notice will include:

- The name of the facility;
- The address, and physical location of the facility;
- The facility's permit number; and
- The last date of intended receipt of waste.

(b) Place Copies of the Closure Plan in a Public Place:

The site operator will also make available an adequate number of copies of the approved final closure and post-closure plans for public access and review at the Edinburg City Hall, 415 West University Drive, Edinburg, Texas 78539 (state public place within the area, including address, where the plan will be available for public access and review).

(2) Submit Written Notice of "Intent to Close the Facility" to the TCEQ Executive Director:

The site operator will provide written notification to the TCEQ executive director of the intent to close the facility. This notice will be provided to the executive director no later than 90 days prior to the initiation of the final facility closure, and thereafter be placed in the site operating record.

(3) Post Signs and Install Barriers:

Upon notifying the executive director of the intent to close the facility and no later than 90 days prior to the initiation of final facility closure, the site operator will:

(a) Post Final Closure Signs:

The site operator will post a minimum of one sign at the main entrance and all other frequently used points of access for the facility notifying all persons who may utilize the facility of the date of closing for the entire facility and the prohibition against further receipt of waste materials after the stated date.

(b) Install Barriers:

Also, the site/operator will install suitable barriers at all gates or access points to adequately prevent the unauthorized dumping of solid waste at the closed facility.

(4) Filling of "Affidavit to the Public" and Performance of the Final Deed Recording:

Upon closure of all the landfill units or upon final closure of the facility, the site operator will:

(a) File Affidavit

File with the county deed records an "Affidavit to the Public" in a form provided by the TCEQ executive director that includes an updated metes and bounds description of the extent of the disposal areas at the facility and the restrictions to future use of the land in accordance with applicable provisions under 30 TAC Chapter 330, Subchapter T.

(b) Record a Notation on the Deed

Record a certified notation on the deed to the facility property, or on some other instrument that is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill facility and use of the land is restricted according to the provisions under 30 TAC Chapter 330, Subchapter T.

(c) Place Documents in the Operating Record

Place a copy of the "Affidavit to the Public" and a copy of the modified deed in the site operating record.

(5) Submittal of a Copy of the "Affidavit to the Public" and the "Modified Deed" to the TCEQ Executive Director:

Within ten days after completion of final closure activities of the facility, the site operator will submit the following to the TCEQ executive director by registered mail:

(a) A certified copy of the "Affidavit to the Public";

(b) A certified copy of the modified deed to the facility property; and

(c) A certification, signed by an independent licensed professional engineer, verifying that final facility closure has been completed in accordance with the approved closure plan. The submittal will contain all applicable documentation necessary for certification of final facility closure, including:

- Final Cover System Evaluation Report (FCSER) documenting the installation of the final cover. The FCSER may be submitted earlier as a separate document for review and approval following the completion of the final cover installation. In that case, the certification of closure will be submitted subsequently;
- A final contour map as described under Item III.G above;
- Copy of a letter to the TCEQ regional office requesting a final closure inspection of the facility; and
- Copies of documents verifying newspaper publication of the notice of the final facility closure.

(6) Other

Additional items relating to the schedule for final facility closure, and additional closure activities specific to the final closure of this facility include:

(7) TCEQ's Acceptance of Termination of Operation and Closure of a Landfill Facility:

Following the TCEQ executive director's receipt and completion of the review of the professional engineer's certification of the completion of facility closure and the final closure documents, and receipt of the inspection report from the agency's regional office verifying proper closure of the facility according to this closure plan, the executive director will, in writing, accept the termination of operation and closure of the facility and deem it properly closed. Thereafter, the site operator will comply with the post closure care requirements described in the post closure plan for the facility.

(8) Final Closure Schedule for the Facility:

The attached Closure Plan, Final Closure Schedule, provides the closure schedule for the final facility closure. It incorporates the schedule for closure of a unit as discussed in Section V.A and also shows the commencement and completion timelines for the final closure activities listed within this Section.

VI. Summary of Attachments

A. Drawings and Maps

The following Drawings and Maps are attached as part of this plan.

- Figure III7-1, Final Contour Map.
- Figures III7-2, Cross-Section Drawings of the Landfill Units at Closure.
- Figures III7-3, Final Cover Details.
- Other Drawings/Maps: Figure III7-4 Maximum Closure Area

B. Documents

- Attachment III7A, Alternative Composite Final Cover Demonstration.
- Attachment III7B, Alternative Synthetic Grass Final Cover Demonstration.
- Attachment III7C, Form TCEQ-20720
- Attachment III7D, Final Cover Quality Control Plan (FCQCP).

C. Additional Items Attached (enter as applicable)

VII. Professional Engineer's Statement, Seal, and Signature

Name: Chad E. Ireland Title: Senior Project Geological Engineer

Date: March 2017

Company Name: Golder Associated Inc. Firm Registration Number: F-2578

Professional Engineer's Seal

Signature

APPENDIX III7D

FINAL COVER QUALITY CONTROL PLAN

APPENDIX III7D-1

CONVENTIONAL COMPOSITE AND ALTERNATE COMPOSITE FINAL COVER SYSTEMS

CITY OF EDINBURG SOLID WASTE MANAGEMENT

PERMIT AMENDMENT APPLICATION

Part III, Attachment 7, Appendix D-1

FINAL COVER QUALITY CONTROL PLAN

CONVENTIONAL COMPOSITE AND ALTERNATIVE COMPOSITE FINAL COVER

Edinburg Regional Disposal Facility

Edinburg, Hidalgo County, Texas

TCEQ Permit MSW-956C

STATE OF TEXAS
7/24/17
JEFFREY B. FASSETT
85675
LICENSED
PROFESSIONAL ENGINEER

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

Submitted To: City of Edinburg
Department of Solid Waste Management
8601 North Jasman Road
Edinburg, Texas 78542 USA

Submitted By: Golder Associates Inc.
500 Century Plaza Drive, Suite 190
Houston, TX 77073 USA

July 2017

Project No. 1401491

Golder Associates

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INTENDED FOR PERMITTING PURPOSES ONLY

1.0 PURPOSE

1.1 Purpose

This Final Cover Quality Control Plan (FCQCP), is prepared under the direction of a licensed professional engineer, and it is the basis for the type and rate of quality control testing performance and reported in the final cover system evaluation report (FCSER) as required in 30 TAC §330.457. The plan provides operating personnel adequate procedural guidance for assuring continuous compliance with applicable rules and technical standards. The plan specifies construction methods employing good engineering practices for installation and testing of components of the conventional composite and alternative composite final cover system including infiltration layer, geosynthetic clay liner (GCL), geomembrane (GM), drainage layer, and erosion layer.

1.2 Final Cover Quality Control Testing Procedures

The liner quality control testing procedures, including sampling frequency, are provided in this FCQCP. All field sampling and testing, both during construction and after completion, shall be performed by a person acting in compliance with the provisions of the Texas Engineering Practice Act and other applicable state laws and regulations. The professional of record (POR) who signs the FCSER or his representative should be on site during all liner construction. Quality control of construction and quality assurance of sampling and testing procedures should follow the latest technical guidelines of the TCEQ.

2.0 FINAL COVER SYSTEM COMPONENTS

The final cover system options at the facility includes a conventional composite final cover system meeting the requirements of §330.457(a)(1) and an alternative composite final cover system meeting the requirements of §330.457(d). This FCQCP applies to both the conventional composite final cover system as well as an alternative composite final cover system with a GCL component for the infiltration layer. FCQCPs for other alternative final cover systems are presented separately.

The conventional composite final cover consist of (from top to bottom):

- Erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation.
- Double-sided geocomposite (geotextile/geonet/geotextile) drainage layer.
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane that has a permeability less than or equal to the permeability of the bottom liner system.
- 18-inch thick compacted clay rich earthen material with a hydraulic conductivity of $1x10^{-5}$ cm/sec or less (infiltration layer).

The alternative composite final cover will consist of (from top to bottom):

- Erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation.
- Double-sided geocomposite (geotextile/geonet/geotextile) drainage layer.
- 40-mil LLDPE textured geomembrane that has a permeability less than or equal to the permeability of the bottom liner system.
- Reinforced GCL (infiltration layer).

The construction and testing requirements for the conventional composite final cover system infiltration layer are described in §2.0, Final Cover System Components of this FCQCP. The construction and testing requirements of the GCL infiltration layer in the alternative composite final cover system is described in §3.0, Cohesive Soil Cover of this FCQCP.

3.0 COHESIVE SOIL COVER (INFILTRATION LAYER)

This section outlines generally acceptable construction practices and specifications and the minimum quality control testing requirements for cohesive soil covers, serving as the infiltration layer in the final cover system.

3.1 Pre-construction Material Evaluation

The first step in constructing a cohesive soil cover is to pre-qualify the soil materials that are selected for final cover construction. Cohesive soil cover material may be obtained from in situ soil strata that will be excavated as the final cover is constructed or from a select borrow source. Representative samples from either source shall be subject to the minimum pre-construction testing program shown in Table III7D-1.

Table III7D-1: Cohesive Soil Cover Materials Pre-construction Testing Schedule

TEST	METHOD USED	FREQUENCY(1)
Soil Classification	ASTM D2487	1 per soil type
Particle-Size Analysis	ASTM D422 or D1140	1 per soil type
Atterberg Limits	ASTM D4318	1 per soil type
Hydraulic Conductivity(2)	ASTM D5084(3)	1 per soil type
Conventional Proctor Test	ASTM D698	1 per soil type
Moisture Content	ASTM D2216	1 per soil type

NOTES:

(1) If either the liquid limit (LL) or plastic limit (PI) varies by more than 10 points from other samples, the soil is considered a different soil type.

(2) Conduct this test on a remolded sample that is compacted at or less than 95% of the maximum dry density and at the optimum moisture content as determined from the conventional Proctor test or compacted at or less than 90% for modified Proctor test at one percent dry of the optimum. If pre-construction samples are compacted at higher or lower densities and/or respective moisture contents, then these values will govern for field control. Pre-construction tests should represent the "worst-case" condition in the field concerning hydraulic conductivity results.

(3) Testing procedures in Appendix VII of the US Army Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative method. Permeability tests will be conducted using tap water or 0.05N calcium sulfate solution as the permeant fluid. Distilled or deionized water is not acceptable.

Where soil types vary substantially and are not segregated, representative blends of those soil types anticipated to be utilized for cohesive soil cover construction should also be sampled and tested. The material tested shall comply with the following minimum material specifications:

Plasticity Index	≥ 15
Liquid Limit	≥ 30
Percent Passing No. 200 Sieve	≥ 30
Particle Size	≤ 1 inch
Hydraulic Conductivity	≤ 1 x 10^{-5} cm/sec

The Proctor moisture-density curves shall be developed for each type of soil determined suitable as cohesive soil cover material and shall be used during the construction phase as a performance reference for compaction and moisture control. Rocks and stones in soil for liner construction shall be limited to no more than 1 inch in diameter and no more than 10% by weight.

The POR should consider the potential adverse effects on and/or inconsistencies of results due to laboratory drying procedures, as some materials may exhibit variation in results for Proctor and Atterberg limits tests. Samples should not be oven-dried nor dried back more than 2 to 3 percent below the lowest anticipated moisture content needed to develop the Proctor moisture-density relationship. The zero air voids line shall be computed and included along with the Proctor curves, indicating the specific gravity value used.

Pre-construction samples to be run for hydraulic conductivity testing shall be molded at or less than the optimum moisture content and at or less than 95 percent of the maximum dry density according to the conventional Proctor test (ASTM D698). These points should represent reasonable worst-case conditions for hydraulic conductivity results on appropriately compacted soils. If higher moisture contents or dry densities are used for the hydraulic conductivity tests, then the higher values will be used for field control during placement. However, if lower moisture or density values are used and confirmed to achieve acceptable hydraulic conductivities, field control will still be based on the minimum compaction requirements in §3.2.4, Minimum Compaction Requirements of this FCQCP. .

As a general rule, a minimum of one series of pre-construction tests should be performed for every 15,000 to 20,000 cubic yards (CY) of soil to be used in cohesive soil cover construction, unless soil types are limited and easily distinguished. As soil is usually made available subsequent to excavation during final cover construction, additional pre-construction samples should be taken and tests performed when soils vary or as soon as the initial pre-construction test results appear inappropriate or questionable. If and when the same borrow source is utilized for the soil supply of more than one final cover area, results from previous tests may be used to supplement the pre-construction data.

3.2 Soil Cover Construction Specifications and Practices

The cohesive soil cover shall be constructed in accordance with the requirements included in this section. Also, certain construction practices shall be utilized as described herein when appropriate.

3.2.1 Working Surface Preparation

Subgrade preparation prior to receiving final cover will include compacting the near surface waste or intermediate cover to prepare the working surface. Depressions in the surface where ponded water is observed will be prepared by removing the water and filling the depression to maintain an adequate slope.

Stability of the working surface prior to placement of the final cover shall be determined by the POR by visual inspection to confirm that deflection and pumping characteristics are minimized and the strength of the surface material is adequate. The lines and grades shall be determined by survey methods prior to subsequent final cohesive soil cover construction.

The prepared subgrade shall be tied into the first cohesive soil cover lift in a manner deemed suitable by the POR such that the integrity of the first lift will be maintained.

3.2.2 Work Area Selection and Sizing

Work areas for cohesive soil cover construction should be selected, sized, and sequenced so that work on each lift can begin and be completed in the same day. The area worked at any one time should be of such size that placement, processing, and compaction will be uniform, with minimal variation caused by weather conditions. It is critical that completed lifts be tested and covered with the next loose lift before that completed lift dries out in the sun or becomes damaged by heavy precipitation. Furthermore, the selection of size and shape of work areas shall be consistent, so that uniform construction techniques and equipment can be selected. Adequate numbers of quality control personnel will be provided to suit the pace of construction so proper monitoring and documentation is performed.

3.2.3 Lift Placement and Processing

Reduction of soil clods, uniform moisture distribution, and consistent placement thickness are key elements to achieving uniform compaction of cohesive soil covers. Cohesive soil cover material shall be placed in loose lifts, generally not exceeding 8 inches after spreading and leveling and/or processing, with the expectation that the finished lift, following compaction, will be about 6 inches or less. In no case will the loose lift thickness, after spreading and leveling, be greater than the length of the compactor feet. The intent of limiting the loose thickness is to achieve good interlift bonding and to minimize bridging or layering effects.

The loose lift of soil shall be mechanically processed, either in-place or in a separate processing area, to break down the original soil structure and to reduce clod size. Additional processing, if necessary, will be used to blend variable soil types within the loose lift and incorporate additional water. The goal of processing is to yield a relatively uniform mass of soil that is devoid of original structure that may contribute to excess hydraulic conductivity. Processing may be achieved by discing, grading, compacting, or pulverizing. Pneumatic-tired or tracked equipment will not generally be acceptable to provide processing action, although this equipment may be used to pull the other acceptable implements.

Moisture adjustment may be required, particularly during dry seasons, and reasonable practices shall be used to distribute added water uniformly within the lift. Care shall be taken to prevent over-watering and ponding of water within the loose lift, as this excess water is difficult to redistribute. Drying back of overly wet soils during processing can result in clods having dry, crusting surfaces, which may not bond together adequately. If such drying is allowed, then additional effort will be necessary to assure even moisture distribution and hydration. Hydration times shall be evaluated and determined if acceptable by the POR.

3.2.4 Minimum Compaction Requirements

Processed loose lifts shall be leveled prior to compaction to provide uniform compaction effort over the lift. Each lift shall be compacted to the moisture and density requirements established for the project and as set forth in the provisions of this FCQCP. Lifts shall be compacted to at least 95 percent of the maximum dry density with a corresponding moisture content at or up to 5 percent above optimum determined by conventional Proctor test results (ASTM D698) conducted on similar representative material. The above criteria shall be utilized, unless pre-construction hydraulic conductivity tests were performed at higher or lower densities or moisture contents, in which case these density and moisture values will be used as field compaction minimums. The soil liner density must be expressed as a percentage of the maximum dry density and at the corresponding optimum moisture content as discussed in this section.

In the event that subsequent laboratory testing of samples from an area of constructed cohesive soil cover indicate an alternate moisture density curve is appropriate for the soil type, the CQA monitor will switch to the appropriate curve as necessary. It is recognized that laboratory test results become available often several days after construction of an area of cohesive soil cover. If the laboratory testing data indicates that the area constructed using the incorrect moisture-density curve meets the permeability requirements (i.e., less than or equal to 1×10^{-5} cm/sec), the area will be considered acceptable as cohesive soil cover.

Cohesive soil covers shall not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a footed roller; however, this practice is not encouraged. All cohesive soil covers shall be compacted with a pad-footed or prong-footed roller only. Bulldozers, pneumatic rollers or scrapers, and flat-wheeled rollers will not be permitted for compaction.

Construction survey control should be conducted routinely during lift placement to verify that loose and finished lifts are of the proper thickness to ensure uniform compaction.

3.2.5 Lift Bonding and Cohesive Soil Cover Tie-in

Interlift bonding shall be accomplished prior to placing the subsequent loose lift. Compactors shall be of sufficient weight and foot length to penetrate the current lift when loose and provide bonding to the previous lift.

When lifts of the cohesive soil cover are not constructed continuously, a vertical construction joint may occur. To remove the vertical construction joint(s), the edge of the adjoining section shall be cut back or flattened to permit offsetting of the tie-in for subsequent lifts. For each 6-inch lift, the edge should be cut back at least 2.5 feet or graded to a maximum slope of 5H:1V, and then the corresponding adjoining lift should be placed against the existing finished lift. The new loose lift and at least 2 feet of the adjoining existing lift will be processed together, and then recompacted, so that the existing cohesive soil cover edge is tied to new construction without superimposed vertical construction joints. This tie-in procedure shall be repeated lift-by-lift until all corresponding adjacent lifts are constructed to the required elevation. The cut back edge of the existing cohesive soil cover may be done all at once or one lift at a time.

3.3 Construction Monitoring and Conformance Testing

Quality assurance of recompacted cohesive soil covers shall consist of monitoring the work as cohesive soil cover construction proceeds and laboratory and field testing to assure that material conformance and construction performance specifications are achieved.

3.3.1 Monitoring and Observations

Full-time quality assurance monitoring and testing will be performed during the course of cohesive soil cover construction. The work will be performed by a POR described in §1.2, Final Cover Quality Control Testing Procedures of this FCQCP or by a CQA monitor working under the general supervision of the POR. The CQA monitor will be on-site at all times when cover construction is ongoing, so that all relevant activities can be observed and documented. The POR will visit the site periodically as construction progress warrants. Such visits will be frequent enough so that the POR is fully knowledgeable of the construction methods and performance, so that the POR can determine that quality control monitoring and testing activities are adequate to meet the terms and intent of this FCQCP.

Visual observation shall include, but not be limited to, the following:

- Moisture content and distribution, particle size, and other physical properties of the soil during processing, placement, and compaction.
- Type and level of compaction effort, including roller type and weight, drum size, foot length and face area, and number of passes.
- Action of compaction equipment on soil surface (i.e., foot penetration, rolling, pumping, or shearing).
- Maximum clod size and breakdown of soil structure.
- Method of bonding lifts together and making cohesive soil cover tie-ins.
- Stones or other inclusions, which may damage overlying geosynthetic components or adversely affect compaction, lift bonding, and in-place testing/sampling.
- Areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred.

3.3.2 Construction Testing

30 TAC §330.457(c)

During cohesive soil cover construction, the minimum testing and sampling program presented in Table III7D-2 shall be conducted to determine that adequate compaction and material conformance are being achieved.

Table III7D-2: Cohesive Soil Cover Construction Testing Schedule

TEST	METHOD	MINIMUM FREQUENCY(2)(3)
Field Moisture/Density Test	ASTM D6938, D2937, or D1556	1 per 8,000 ft^2, per 6-inch lift
Percent Finer Than No. 200 Sieve	ASTM D1140 or D422	1 per 100,000 ft^2, per 6-inch lift
Atterberg Limits	ASTM D4318	1 per 100,000 ft^2, per 6-inch lift
Hydraulic Conductivity(1)	ASTM D5084	1 per acre (evenly distributed through all lifts), per 6-inch lift

NOTES:
(1) Testing shall be conducted on undisturbed samples. Testing procedures in Appendix VII of the US Army Corps of Engineers Manual EM 1110-2-1906, November 30, 1970, Laboratory Soils Testing, may be used as an alternative.
(2) A voluntary increase in the number of any tests performed does not in turn require a commensurate increase in the other testing requirements to meet the above program.
(3) A minimum of one of each of the designated tests must be conducted for each lift of cohesive soil cover regardless of surface area.

Typically, field moisture-density tests will be performed using a nuclear density gage (ASTM D6938). Other acceptable test methods include the Sand Cone Method (ASTM D1556) or Drive Cylinder Test (ASTM D2937). Questions concerning the accuracy of any single field moisture-density test shall be addressed by retesting in the same general location. Periodic checks using the various test methods may be performed to verify the field moisture-density test results. Alternatively, field moisture-density checks may be performed using laboratory measurements of tube samples obtained adjacent to the field test locations.

The percent finer than No. 200 sieve, Atterberg limits, and hydraulic conductivity tests will be performed on samples generally obtained with a thin-walled tube sampler. If more material is needed, the extra material can be obtained from cuttings at the same location. These construction test samples will be obtained from the recently completed lift, taken one lift at a time, so that sample penetrations only go through one lift and do not penetrate from one lift into the next. Undisturbed samples will generally be sent to the geotechnical laboratory in the sampling tube, which will be properly sealed to preserve the moisture content and integrity of the sample.

3.3.3 Failure Repairs

Sections of cohesive soils covers that do not pass either the density or moisture requirements in the field shall be reworked and retested until the section in question does pass. All field density results shall be reported in the Final Cover System Evaluation Report (FCSER), whether they indicate passing or failing values.

In the event of a failed moisture-density test, additional tests will be performed between the failed test and the nearest adjacent passing test locations. If those additional tests pass, then the area between the failed test and the additional passing tests will be reworked and retested until passing. If the additional tests fail, then additional tests will be performed halfway between the initial additional tests and the adjacent passing tests to further define the failing area. This procedure will be repeated until the failing area is defined, reworked, and retested with passing results.

3.3.4 Cohesive Soil Cover Perforations

When taking field densities and undisturbed samples, all holes dug or created in the cohesive soil cover for density probes or samples must be backfilled with bentonite or a bentonite-rich soil material. This backfill will be tamped in the hole to remove pockets of air or loose soil, and to assure a tight compact seal.

3.3.5 Cover Thickness Verification

Cohesive soil cover thickness verification shall be determined by survey methods. The verification points for record purposes shall be on a grid not exceeding 10,000 square feet per grid. If the area under evaluation is less than 10,000 square feet, a minimum of two grid points is required for verification. The selected grid shall be the same for both beginning and finished elevations of the cohesive soil cover, so that minimum thicknesses can be calculated and verified.

3.3.6 Post-Construction Care of Cohesive Soil Cover

The integrity of the cohesive soil cover shall be maintained by moistening to prevent the material from desiccating. Conversely, the cohesive soil cover shall be kept free of standing water. Damage caused by rain shall be repaired, and if the lift must be reworked, as determined by the POR, then appropriate retesting (including field moisture-density and permeability tests) shall be performed.

4.0 GEOSYNTHETIC CLAY LINER

This section presents general procedures, quality control testing requirements, and installation procedures for the geosynthetic clay liner (GCL) used in the alternative composite final cover to replace the cohesive soil (infiltration) layer. The GCL approved for use at the site consists of sodium bentonite encapsulated between two geotextile layers, needle-punched or stitched-bonded together.

4.1 Pre-Installation Material Evaluation

4.1.1 Manufacturer's Quality Control Certificates

Prior to the installation of the GCL, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in accordance with project-specific testing methods and subject to the minimum testing frequency shown in Table III7D-3. The owner may require more frequent testing at his discretion.

The quality control testing may be performed in the manufacturing plant. The POR shall review the test results prior to accepting the GCL to ensure that the certified minimum properties meet the values presented in Table III7D-3.

4.1.2 Conformance Testing

In addition to the manufacturer's quality control certificates, samples of rolls of GCL will be obtained for conformance testing. The samples shall be tested by an independent third party laboratory in accordance with Table III7D-4. The POR shall review the test results to ensure that they meet the values presented in Table III7D-3.

The POR shall compare measured shear strength values to those used in the stability analyses included in Part III3B-2E, Final Cover System Stability. If the measured interface shear strength is less than the values used in the analyses, the stability of the final cover system shall be reassessed and revised calculations shall be included in the Final Cover System Evaluation Report (FCSER).

In order to prevent premature hydration, the GCL rolls shall be shipped in plastic wrapping that shall remain intact until material installation. Upon delivery of the GCL, storage and handling procedures shall be documented. The rolls will be stacked, stored, and handled in accordance with ASTM D5888 or manufacturer's recommendations.

Table III7D-3: GCL QC Submittal Frequency & Material Specifications

Bentonite					
Property	**Qualifier**	**Unit**	**Value**	**Test Method(1)**	**Frequency**
Fluid Loss	max.	ml	18	ASTM D5891	1 per 50 tons or every truck or railcar
Free Swell	min.	ml	24	ASTM D5890	
Geotextile					
Property	**Qualifier**	**Unit**	**Value**	**Test Method(1)**	**Frequency**
Mass per Unit Area	—	g/cc	—	ASTM D5261	1 per 200,000 ft^2
Tensile Properties:	—	lb	—	ASTM D4632	
GCL Product					
Property	**Qualifier**	**Unit**	**Value**	**Test Method(1)**	**Frequency**
Bentonite Mass	min.	lb/ft^2	0.8	ASTM D5993	1 per 40,000 ft^2
Bentonite Moisture Content	—	%	—	ASTM D5993	
Grab Tensile Strength	—	lb	—	ASTM D6768	1 per 200,000 ft^2
Hydraulic Flux	max.	m^3/m^2-s	1 x 10^{-8}	ASTM D5887	1 per week for each production line(2)

Notes:
1. Updated methods may be implemented based on a review by the POR.
2. Report last 20 test values, ending on production date of supplied GCL.
3. For those properties that do not indicate a value, the GCL material must meet the manufacturer's minimum specification.

Table III3D-4: GCL Conformance Test Schedule

TEST	**METHOD(1)**	**FREQUENCY**
Bentonite Mass/Unit Area	ASTM D5993	Not less than 1 test per 100,000 ft^2
Hydraulic Flux	ASTM D5887	
Direct Shear	ASTM D6243	1 test per GM/adjoining materials

Notes:
1. Updated methods may be implemented based on a review by the POR.

4.2 Installation Procedures

4.2.1 GCL Subgrade Preparation

Surfaces to be lined should be smooth and free of all rocks greater than 0.75-inch diameter (or as recommended by the manufacturer, if less than 0.75 inches), sharp/angular objects, sticks, roots, or debris of any kind. The surface should provide a firm, unyielding foundation for the GCL with no sudden, sharp, or abrupt changes or break in grade. The subgrade surface shall be prepared by rolling with a smooth-drum roller to minimize the roughness and press down protruding soil or rock particles prior to GCL deployment. Loose rocks and/or dry soil particles that could damage the GCL shall be removed. Excessive voids or dimples shall be filled with soil.

The GCL subgrade should be moisture conditioned prior to placing the GCL in final covers. Research has shown that the subgrades with water contents above 10%, or greater than the optimum water content, promotes hydration and osmotic swell in GCLs. These conditions result in GCLs that maintain their low hydraulic conductivities regardless of the amount cation exchange that occurs (Scalia and Benson 2011).

Although the subgrade shall be moist, standing water will not be allowed.

4.2.2 GCL Deployment

Equipment used to deploy GCL must not cause excessive rutting of the subgrade. Deployed GCL panels should contain no folds or excessive slack. Installation personnel must not smoke or wear damaging shoes on GCL. GCL should not be placed during excessive winds. In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the GCL. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on the GCL.

Panels should be overlapped and seamed, as recommended by the manufacturer. End-to-end seams on sideslopes should be kept to a minimum. If end-to-end seams are necessary (i.e., if the GCL roll lengths are insufficient to cover the entire slope length), a minimum overlap of 5 feet will be required. Alternatively, seams may be glued, as recommended by the manufacturer. In addition, end-to-end seams may be placed only in the lower half of the slope and must be staggered.

GCL deployment shall be limited to the amount that can be covered with the overlying geomembrane liner the same day. GCL deployment shall not be undertaken during precipitation or when there is an impending threat of precipitation.

Following deployment, the CQA monitor shall visually examine the entire surface of the GCL for even bentonite distribution, thin spots, or other panel defects. All defects will be recorded and repaired in accordance with this FCQCP. The QA/QC representative shall also verify the following:

- Adequately moist subgrade
- Proper overlap during deployment
- Seams between GCL panels are constructed per manufacturer's recommendations
- Defects are patched and overlapped properly
- The bentonite has not become excessively hydrated

Excessively hydrated GCL shall be removed and replaced. Geomembrane shall not be placed on excessively hydrated GCL.

GCL panels shall be given an identification code, mapped, and logged to record relevant installation information.

4.2.3 GCL Repairs

Torn or otherwise damaged geosynthetic facing must be patched with the same type of geosynthetic. The geosynthetic patch must extend at least 12 inches beyond the damaged area and must be heat bonded, or otherwise attached to the main GCL to avoid shifting during placement of overlying geosynthetics. If the GCL damage includes loss of bentonite, the patch must consist of full GCL extending at least 12 inches beyond the damaged area. Lapping procedures must be the same as specified for original laps of GCL panels.

4.2.4 GCL Protection

The overlying geosynthetics and soil layers shall be deployed in such a manner as to ensure that the GCL is not damaged. Textured geomembranes shall not be dragged across previously installed GCL. A smooth rubsheet shall be placed between the GCL and textured geomembrane to prevent damage. The rubsheet will be removed when the geomembrane is in position. Other methods may be employed at the POR's discretion.

To avoid local bentonite displacement, and the possible impact on the hydraulic performance of a GCL, the soil cover material should be placed over the geomembrane and geocomposite overlying the GCL as soon as practicable following completion of the geomembrane and drainage system construction.

5.0 GEOMEMBRANE LINER

This section presents general procedures, quality control testing requirements, and construction specifications for geomembrane liner construction. Both the conventional composite final cover system and the alternative composite final cover system will include the following components:

- 40-mil, textured LLDPE geomembrane with the option to install smooth LLDPE on the upper portion of the final cover, which is sloped at 5%;
- A geocomposite drainage layer composed of a geonet and filter geotextiles heat-bonded to both sides; and
- 18-inch protective cover soil. The upper 6 inches is an erosion control layer and must be capable of sustaining native plant growth.

5.1 Pre-installation Material Evaluation

5.1.1 Manufacturer's Quality Control Certificates

Prior to installing any geomembrane, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in the manufacturing plant using the test methods and frequencies listed in the most recent version of the Geosynthetic Research Institute (GRI) test method GM17, "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes," included in Attachment 1. The owner may require more frequent testing at his/her discretion.

The POR shall review the test results prior to accepting the geomembrane to assure that the certified minimum properties meet the minimum values for geomembranes, as determined by the most recent GRI test method GM17.

The rolls delivered to the site shall be inventoried, recording the manufacturer's name and product identification, and the roll thickness, number and dimensions. Manufacturer's certificates should be cross-referenced to rolls delivered on-site.

Resumes of the installer's supervisor(s) or Master Seamer(s) shall be obtained to verify that adequate seaming experience will be utilized on the project. The installer's supervisor or Master Seamer shall have had experience totaling a minimum of 2,000,000 square feet of geomembrane installation.

Upon delivery of geosynthetic materials, storage and handling procedures shall also be documented. Rolls of geosynthetic materials shall be handled and stored in such a way as not to damage the material. As a general rule, rolls of geosynthetic materials should not be stacked more than four rolls high.

5.1.2 Conformance Testing

In addition to the manufacturer's quality control certificates, samples of the delivered rolls of geomembrane will be obtained either at the manufacturing facility or upon delivery to the site for conformance testing. The test samples shall be obtained for conformance testing in accordance with the testing schedule shown in Table III7D-5.

Table III7D-5: Geomembrane Conformance Test Schedule

TEST	METHOD(1)	FREQUENCY
Thickness (laboratory measurement)	ASTM D5199 (Smooth) or ASTM D5994 (Textured)	Not less than 1 test per 100,000 ft^2 with not less than 1 per resin lot
Density	ASTM D1505 or D792	
Carbon black content(5)	ASTM D4218	
Carbon black dispersion	ASTM D5596	
Tensile properties	ASTM D6693, Type IV	
Direct Shear(2)(3)(4)	ASTM D6243	1 test per GM/adjoining materials

Notes:

1. Updated ASTM or GRI methods may be implemented based on a review by the POR.
2. Direct shear testing shall be performed on the soil or GCL/geomembrane/geocomposite sandwich. Soak interface and apply normal stresses of 100, 200 and 400 psf for at least 1 hour prior to shearing at a displacement rate of 0.04 in/min.
3. The testing results shall be compared to the values used in the final cover system stability analyses included in the Appendix III3B-2E. If the measured interface shear strength is less than the values used in the analyses, the stability of the final cover system shall be reassessed and revised calculations shall be included in the FCSER.
4. Test results from materials used during one construction event may be used in subsequent events provided the materials used are the same and approved by the POR.
5. Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

5.2 Installation Procedures

5.2.1 Geomembrane Deployment

The geomembrane shall be installed in direct and uniform contact with the cohesive soil coder or GCL. The geomembrane shall not be placed during inclement weather such as high winds or rain.

Geomembrane seaming should generally not take place when ambient temperatures are below 32 degrees Fahrenheit (°F), unless preheating is used. For extrusion welding, preheating will be required if the temperature is below 32°F. For fusion welding, preheating may be waived if the installer demonstrates that quality welds may be obtained without preheating. Seaming shall not be permitted at ambient temperatures above 104°F, unless the installer can demonstrate that seam quality is not compromised.

In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geomembrane. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the geomembrane. Only those sections that are to be placed and seamed in one day should be unrolled. Panels left unseamed should be anchored with sandbags or other suitable weights. In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented up and down, not across the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.

Panels should be overlapped as recommended by the manufacturer as appropriate for the type of seam welding to be performed; however, overlapping shall be no less than 2 inches. Field seaming shall only be performed by the method(s) approved by the manufacturer, either by extrusion welding or double-tracked fusion welding. No seaming shall take place without the installer's supervisor or Master Seamer and CQA monitor being present. Fishmouths or wrinkles at the seam overlap shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut shall be seamed and/or patched. Seams shall extend to the outside edge of panels placed in the anchor trench.

Panel layout and field seams shall be given an identification code, mapped, and logged to record relevant installation information. Inspection and testing records shall be logged as well as repair and retest data. Section 5.0 includes a list of items to be documented during geomembrane construction and testing.

5.3 Installation Monitoring and Testing

5.3.1 Trial Seams

Each day prior to commencing field seaming, trial seams shall be made on pieces of geomembrane material to verify that conditions are adequate for production seaming. Trial seams shall be made at the beginning of each seaming period and shift (generally, at least twice each day) for each combination of production seaming machine and operator to be used that day. The trial test seam shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Four 1-inch wide specimens shall be die-cut from the trial seam sample. Two specimens shall be tested in the field for shear and two for peel (test both inner and outer welds for dual track fusion welding) and shall be compared to the minimum seam strength requirements specified in the most current version of the Geosynthetic Institute, GRI Test Method GM19. The current versions of the GRI test methods are included in Attachment 1.

If any of the trial seam specimens fail, the entire trial seam operation shall be repeated. If an additional specimen fails during the second trial seam, the seaming machine and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Additional trial seams shall be made at each occurrence of significantly different environmental conditions, including, but not limited to, temperature, humidity, and dust, and after any machine is turned off for more than 30 minutes.

5.3.2 Non-Destructive Testing

Continuous, non-destructive testing shall be performed on all seams by the installer. All leaks must be isolated and repaired by following the procedures described in this FCQCP.

Air Pressure Testing – ASTM D5820. The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 pounds per square inch (psi), if possible. The air pump must then be shut off and the air pressure observed after 2 minutes. A loss of less than 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss greater or equal to 4 psi indicates the presence of a seam leak that must then be isolated and repaired by following the procedures described in this FCQCP. The POR or his/her qualified representative must observe and record all pressure gauge readings.

Vacuum-Box Testing – ASTM D5641. Apply a vacuum of approximately 4 to 8 psi to all extrusion welded seams that can be tested in this manner. The seam must be observed for leaks for at least 10 seconds while subjected to this vacuum. The POR or his/her qualified representative must observe 100 percent of this testing.

Other Testing. Other non-destructive testing must have prior written approval from the TCEQ.

5.3.3 Destructive Seam Testing

Destructive samples shall be taken at a minimum frequency of one test location, selected randomly, within each 500 linear feet of seam length, inclusive of both primary longitudinal and cross seams, cap strips, and repairs 20 square feet in total area or larger. Each test sample should be of sufficient length and 12 inches wide with the seam located in the middle. Test specimens, approximately 1 inch wide, shall be cut from both ends of the sample for field testing (peel and shear). The remaining sample should be cut into three parts (one for quality assurance laboratory testing, one for installer quality control laboratory testing, and one for archive storage to be maintained at a location selected by the owner).

The field tests shall be conducted on a certified calibrated tensiometer capable of maintaining a constant extension rate of 2 inches per minute. If one of the field test specimens from the ends of the destructive sample fails, then the seam will be considered to have failed, and repairs shall be initiated, as described below. If both specimens pass, then a sample for laboratory testing will be sent to the quality assurance laboratory for testing in both peel and shear. Seam strengths for LLDPE geomembranes shall meet the minimum values specified in the most current version of the Geosynthetic Institute, GRI Test Method GM19, "Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes."

Destructive test results for both field and laboratory tests shall include qualitative data, including the location of the failure and locus-of-break code as described in ASTM D6392. Peel tests on double-tracked fusion welds shall be performed on both inside and outside tracks of the weld. Seam break classifications for extrusion and fusion welds are shown on Figures III7A-1 and III7A-2, respectively.

At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed to conduct field testing, independent laboratory testing, and archiving of enough material to retest the seam when necessary. Destructive seam testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the geomembrane. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the POR or his/her qualified representative.

Weld Acceptance Criteria: For LLDPE seams (both smooth and textured), the minimum passing criteria for destructive seam testing are described in the Geosynthetic Institute, GRI Test Method GM19. The POR must use the most current version of GM19 when evaluating welded seams.

Seam Failure Delineation: When a sample fails a destructive test, the installer shall trace the welding path to an intermediate location at least 10 feet in each direction, or a distance determined by the POR, from the point of the failed test in each direction and take 1-inch wide specimens for an additional set of field tests. If these additional samples pass the tests, then two laboratory destructive samples shall be taken adjacent to the intermediate locations or at locations determined by the POR or his/her representative. If these laboratory samples pass the tests, then the seam shall be repaired between these locations. If either sample fails, then the process shall be repeated to establish a zone where the seam should be repaired. All acceptable repaired seams shall be bounded by two locations from which samples passing laboratory destructive tests have been taken.

Seam Failure Repairs: Any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test shall be repaired. Repair methods may include spot welding (extrusion) for minor flaws and punctures; patches for larger holes and tears; capping for large lengths of failed seams or panel damage; and extrusion welding of outer flap to repair of an inadequate fusion seam (less than 100-foot cumulative length) that has an exposed edge.

For any repair method, the following provision shall be satisfied:

- Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair;
- All surfaces shall be clean and dry at the time of repair;
- Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches;
- All repairs shall be non-destructively tested, as previously described; and
- All seaming equipment, personnel, and operation procedures used in repair work shall meet the same requirements as for new seaming operations.

The POR or his/her qualified representative shall observe all non-destructive testing of repairs and shall record the number of each repair, type, date, and test outcome. Repairs that pass the non-destructive tests shall be taken as an indication of an adequate repair. Repairs more than 150 feet long shall also be required to have a destructive test performed. Repairs that fail the initial retest shall be redone and retested until a passing test results. All work and testing of repairs shall be fully documented in a repair log.

When placing overlying material on the geomembrane, effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. In no case shall the geomembrane be allowed to fold over on itself.

6.0 DRAINAGE LAYER

The geocomposite drainage layer shall conform to the material and performance properties specified in Table III7D-6. Manufacturers' certificates of material and performance characteristics shall be obtained and documented at the minimum frequency shown on Table III7D-6, with not less than 1 per resin lot. Geosynthetic drainage material conformance testing will consist of transmissivity testing on each material type using the test set-up described in Table III7D-6.

The drainage layer is a double-sided geocomposite that consists of a geonet with a non-woven geotextile heat-bonded on both sides deployed over the final cover area. The double-sided geocomposite shall be anchored in an anchor trench at the perimeter of the final cover area or as shown on Figures III7-2A and III7-2B. The geonet core of the geocomposite will be tied together using plastic ties placed at a frequency of one per 5 feet along the length of the panel and every 6 inches along the ends of the panels. The upper geotextile panels will be secured by either overlapping and heat bonding or field sewn.

Only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geotextile. Personnel working on the geotextile shall not smoke, wear damaging shoes, or engage in any activity that damages the geotextile or underlying geosynthetics.

Table III7D-6: Geocomposite Drainage Layer Specifications(1)

GEOCOMPOSITE					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Transmissivity	Min.	m^2/sec	2.6 x 10^{-4}	ASTM D4716(2)	200,000 ft^2
Ply Adhesion	Min.	lb/in	0.5	ASTM D7005	200,000 ft^2
GEONET CORE					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Thickness	Min.	mils	200	ASTM D5199	200,000 ft^2
Density (black resin)	Min.	g/cm^3	0.940	ASTM D1505	200,000 ft^2
Carbon Black Content	Range	%	2 to 3	ASTM D4218	200,000 ft^2
GEOTEXTILE					

Property	Qualifier	Unit	Value	Test Method	Frequency
Mass per Unit Area	MARV	oz/yd^2	6	ASTM D5261	200,000 ft^2
AOS		US Sieve (mm)	70 (0.210)	ASTM D4751	540,000 ft^2
Puncture Resistance		lb	435	ASTM D6241	540,000 ft^2
Grab Tensile Strength		lb	160	ASTM D4632	540,000 ft^2

Notes:
(1) Appendix III3B-2E shall be referenced to determine the suitability of the alternate materials.
(2) The transmissivity shall be measured at a minimum gradient of 0.25 under a minimum normal pressure of 1,000 psf with a minimum seating period of 1 hour. If the measured transmissivity is less than this value, the geocomposite must be daylighted at certain intervals. See Appendix III3-B-2E-2 for details.

7.0 EROSION LAYER

The soil cover layer will consist of an 24-inch thick single protective/erosion layer. See Section 2.0 of this plan for a detailed description of the final cover system.

Soil cover does not require compaction control; however, it should be stable for construction traffic. Care shall be exercised in placement so as not to shift, wrinkle, or damage any underlying geosynthetic layers, and the placement methods shall be documented. Soil cover placement shall be monitored by the POR or his/her representative on a full-time basis.

Only the geocomposite should be placed in direct contact with the geomembrane. Light equipment, such as low ground pressure dozers (less than 5 psi contact pressure), shall be used to place the soil cover and a minimum of 12-inches of material shall be maintained between the dozer and the underlying geosynthetics. If possible, cover should be placed during the coolest weather available. Soil cover material shall be deployed in “fingers” along the geosynthetics to control the amount of slack and minimize wrinkles and prevent folds. Soil cover shall generally be placed in an upslope direction on sideslopes.

The final thickness of the soil cover layer shall be a minimum of 24-inches directly above the geocomposite drainage layer. The required thickness of the layer shall be verified by survey techniques on an established grid system with not less than one verification point per 10,000 square feet of surface area. A minimum of two verification points is required.

The soil used as the soil cover layer will be capable of sustaining native plant growth and must be seeded or sodded immediately after completion of the final cover (weather permitting). Temporary or permanent erosion control materials (i.e., mulches, containment meshes, geomatting systems, etc.) may be used to minimize erosion and aid establishment of vegetation. An alternative erosion layer may also be constructed (subject to the approval of TCEQ) consisting of cobbles, riprap, or other hard armor systems for areas where establishing vegetative cover has proven difficult.

Other quality assurance for the soil cover layer should consist of continuous observation by the POR or his/her representative during construction; inspection of any manufacturer's or supplier's material test data and certification; and performing any additional test believed necessary by the POR to verify that the layer has been constructed in accordance with the closure plan.

8.0 FINAL COVER SYSTEM EVALUATION REPORT

Upon completion of all required final cover construction and evaluation, the POR shall prepare and submit in triplicate the FCSER, prepared in accordance with this plan, to the TCEQ for review and approval.

Each FCSER will include a discussion of the construction of the final cover elements and a cover placement map, which not only shows the covered area being submitted for approval, but also the areas covered by all previous FCSER submittals with the dates of acceptance by the TCEQ. The map should depict the site grid system, graphic scale, and north arrow. It may be a print from a master drawing that is annotated and updated with each new submittal. The FCSER shall be signed and/or sealed by the POR performing the evaluation and counter-signed by the site operator or his/her authorized representative.

The construction documentation will contain a narrative describing the conduct of work and testing programs required by the FCQCP, "as-built" or record drawings, and appendices of field and laboratory testing. Constructed cover details ("as-builts"), where applicable, will be depicted and will show slopes, widths, and thickness for compaction lifts as determined from the field documentation. The construction documentation report will contain or discuss the following information at a minimum.

Table III3D-7: FCSER Content

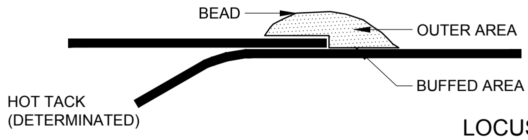
Cohesive Soil Cover	Pre-construction soil test results
	Summary of construction material conformance tests results
	Summary of field moisture-density control test methods and results
	Summary of hydraulic conductivity test results
	Cohesive soil cover construction practices
	Placement and processing methods
	Observations of soil conditions prior to and after compaction, including soil structure, clod size, and presence of inclusions
	Compaction methods, equipment type, compactor weight and foot length, and number of passes
	Lift tie-in and bonding observations
	Repair of failed and damaged lifts
	Any and all deviations from the permitted design
	Thickness Verification
	Post-construction care of cohesive soil cover

Geosynthetic Clay Liner	Roll shipment and receipt information
	Manufacturer's quality control certificates and results
	Storage and handling information
	Conformance test sampling and test results
	Subgrade acceptance
	Panel deployment, identification, and placement
	Equipment placed or operated on GCL
	100 percent visual inspection for defects, damage, etc.
	Seaming methods
	Repairs, including patch size and shape
Geomembrane Liner	Roll shipment and receipt information
	Manufacturer's quality control certificates and results
	Storage and handling information
	Conformance test sampling and test results
	Seamer's names and resumes of experience and qualifications
	Subgrade acceptance
	Panel deployment, identification, and placement
	Seam preparation, orientation, and identification
	Equipment placed or operated on geomembrane
	100 percent visual inspection for defects, damage, etc.
	Trial seam tests for each combination of seaming equipment and personnel
	Seaming methods, times, temperature, and equipment shutdowns and startups
	Continuous 100 percent non-destructive seam testing, methods, criteria, and results
	Destructive testing methods, criteria, and results
	Repairs, including preparation and procedures, failure delineation, patch size and shape, and retesting
	Material properties and placement of drainage materials and soil cover
	Confirmation of the interface friction angle for the geomembrane/adjoining material interface and a recalculation of the factor of safety, if needed.
Record Drawings	Layout plan
	Previous covered areas
	As-built cohesive soil cover drawings, showing sample and test locations, and thickness
	As-built GCL panel layout drawings
	As-built geomembrane panel layout drawings, showing location of destructive test samples, patches, and repairs
	As-built drawings showing elevations of soil cover to confirm its thickness

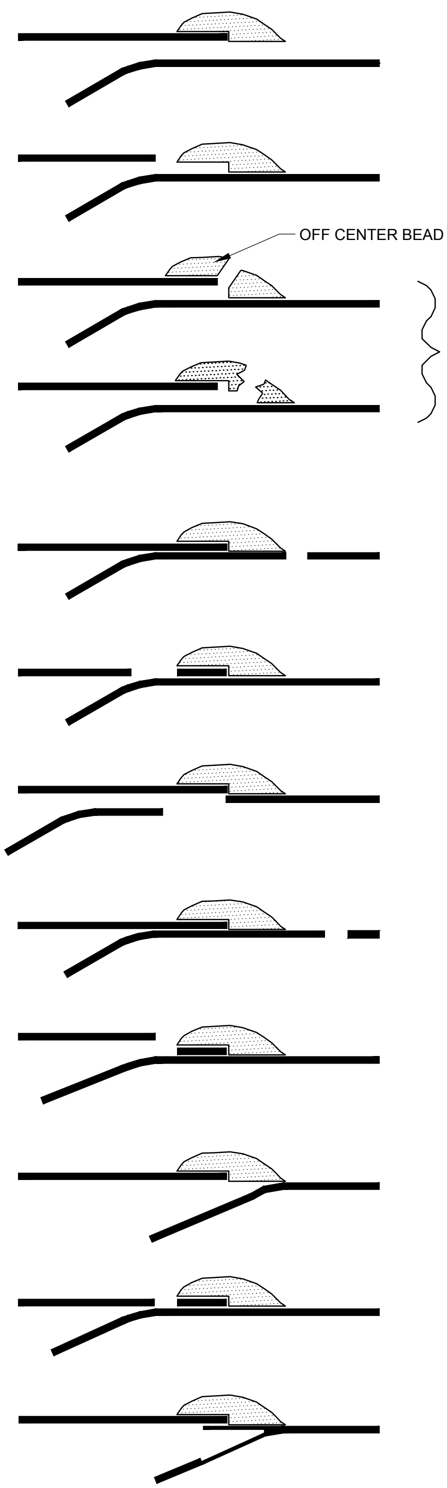
9.0 REFERENCES

Scalia, J.S. and C.H. Benson, 2011. Hydraulic Conductivity of Geosynthetic Clay Liners Exhumed from Landfill Final Covers with Composite Barriers, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 137, No. 1.

FIGURES



UNTESTED SPECIMEN
EXTRUSION WELD WITH LEISTER HEAT SEAM



TYPES OF BREAK	LOCUS-OF-BREAK CODE	BREAK DESCRIPTION
	AD1	FAILURE IN ADHESION. SPECIMENS MAY ALSO DELAMINATE UNDER THE BEAD AND BREAK THROUGH THE THIN EXTRUDED MATERIAL IN THE OUTER AREA.
	AD2	FAILURE IN ADHESION
	AD-WLD	BREAKS THOUGH THE FILLET. BREAKS THOUGH THE FILLET RANGE FROM BREAKS STARTING AT THE EDGE OF THE TOP SHEET TO BREAKS THOUGH THE FILLET AFTER SOME ADHESION FAILURE BETWEEN THE FILLET AND THE BOTTOM SHEET.
	SE1	BREAK AT SEAM EDGE IN THE BOTTOM SHEET. SPECIMENS MAY BREAK ANYWHERE FROM THE BEAD/OUTER AREA EDGE TO THE OUTER AREA/BUFF AREA. (APPLICABLE TO SHEAR ONLY).
	SE2	BREAK AT SEAM EDGE IN THE TOP SHEET. SPECIMENS MAY BREAK ANYWHERE FROM THE BEAD/OUTER AREA EDGE TO THE OUTER AREA/BUFF AREA. (APPLICABLE TO SHEAR ONLY).
	SE3	BREAK AT SEAM EDGE IN THE BOTTOM SHEET. (APPLICABLE TO PEEL ONLY).
	BRK1	BREAK IN THE BOTTOM SHEETING. A "B" IN PARENTHESIS FOLLOWING THE CODE MEANS THE SPECIMEN BREAK IN THE BUFFED AREA. (APPLICABLE TO SHEAR ONLY).
	BRK2	BREAK IN THE TOP SHEETING. A "B" IN PARENTHESIS FOLLOWING THE CODE MEANS THE SPECIMEN BREAK IN THE BUFFED AREA. (APPLICABLE TO SHEAR ONLY).
	AD-BRK	BREAK IN THE BOTTOM SHEETING AFTER SOME ADHESION FAILURE BETWEEN THE FILLET AND THE BOTTOM SHEET. (APPLICABLE TO PEEL ONLY).
	HT	BREAK AT THE EDGE OF THE HOT TACK FOR SPECIMENS WHICH COULD NOT BE DELAMINATED IN THE HOT TACK.
	SIP	SEPARATION IN THE PLANE OF THE SHEET.

CLIENT
CITY OF EDINBURG SOLID WASTE MANAGEMENT

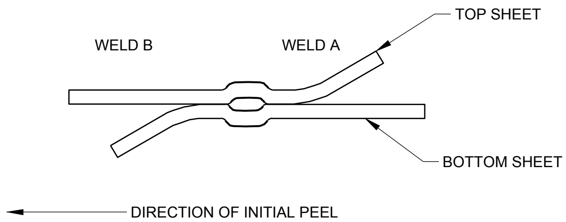
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-21
DESIGNED	CEI
PREPARED	AA
REVIEWED	MX
APPROVED	JBF

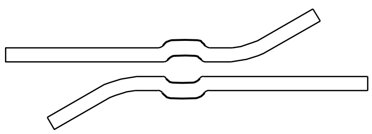
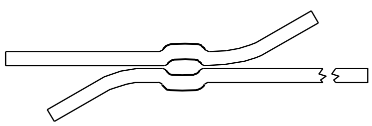
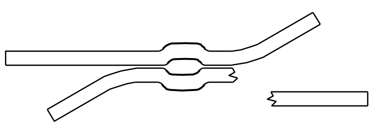
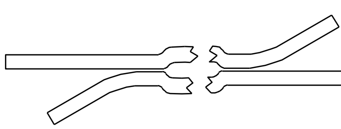
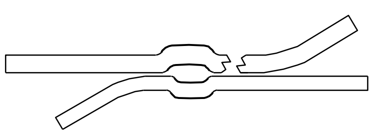
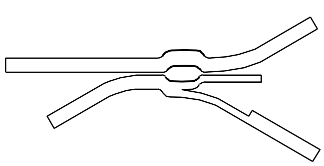
PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
EXTRUSION WELD SEAM BREAK CLASSIFICATION

PROJECT NO.	APPLICATION SECTION	REV.	FIGURE
1401491	III7D1	0	III7D-1



SCHEMATIC OF UNTESTED SPECIMEN

TYPES OF FAILURE	LOCUS-OF-BREAK CODE	BREAK
	AD	ADHESION FAILURE
	BRK	BREAK IN SHEETING. BREAK CAN BE IN EITHER TOP OR BOTTOM SHEET.
	SE1	BREAK AT OUTER EDGE OF SEAM. BREAK CAN BE IN EITHER TOP OR BOTTOM SHEET.
	SE2	BREAK AT INNER EDGE OF SEAM THROUGH BOTH SHEETS.
	AD-BRK	BREAK IN FIRST SEAM AFTER SOME ADHESION FAILURE BREAK CAN BE IN EITHER THE TOP OF BOTTOM SHEET
	SIP	SEPARATION IN THE PLANE OF THE SHEET. BREAK CAN BE IN EITHER TOP OF BOTTOM SHEET.

CLIENT
CITY OF EDINBURG SOLID WASTE MANAGEMENT

PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-21
DESIGNED	CEI
PREPARED	AA
REVIEWED	MX
APPROVED	JBF

TITLE
FUSION WELD SEAM BREAK CLASSIFICATION

PROJECT NO.	APPLICATION SECTION	REV.	FIGURE
1401491	III7D1	0	III7D-2

ATTACHMENT 1

GEOSYNTHETIC RESEARCH INSTITUTE (GRI) TEST METHODS

GRI Test Method GM17

Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Revision 12: November 4, 2015
Revision schedule on pg. 11

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.) • break strength - lb/in. • break elongation - %	D 6693 Type IV	 76 800	 114 800	 152 800	 190 800	 228 800	 304 800	 380 800	 456 800	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	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.) — or — (b) 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 *(5)* (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 *(6)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 7238 D 3895 D 5885	 N. R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 per formulation

(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.) • break strength – N/mm • break elongation - %	D 6693 Type IV	 13 800	 20 800	 27 800	 33 800	 40 800	 53 800	 66 800	 80 800	9,000 kg
2% Modulus – N/mm (max.)	D 5323	210	315	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)* (c) Standard OIT (min. ave.) — or — (d) 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 *(5)* (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 *(6)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 7238 D 3895 D 5885	 N. R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	per formulation

(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.

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.)	D 7466	16	16	16	16	16	16	16	16	Every 2nd roll *(1)*
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 *(2)* (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 *(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	45,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) *(5)* (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 *(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	35 60	35 60	35 60	35 60	35 60	35 60	35 60	35 60	per 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)* 35	N.R. *(8)* 35	N.R. *(8)* 35	N.R. *(8)* 35	N.R. *(8)* 35	N.R. *(8)* 35	N.R. *(8)* 35	N.R. *(8)* 35	per formulation

(1) Alternate the measurement side for double sided textured sheet
(2) 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.

(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 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.)	D 7466	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	Every 2nd roll *(1)*
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 *(2)* (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	315	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 *(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 *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) *(5)* (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 *(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	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per 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)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	per formulation

(1) Alternate the measurement side for double sided textured sheet

(2) 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.

(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.

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.
Revision 10:	November 14, 2014: Increased asperity height of textured sheet from 10 to 16 mils (0.25 to 0.40 mm).
Revision 11:	April 13, 2015: Unit conversion error was corrected for 0.75 mm (30 mil) thickness for the property of 2% modulus. The test value was changed from 370 N/mm to 315 N/mm in the SI (Metric) units tables to agree with the English units tables.
Revision 12:	November 4, 2015: Removed Footnote (1) on asperity height from tables.

GRI Test Method GM19

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Original: February 28, 2002
Revision 8: February 12, 2015
Revision schedule is on pg. 13

GRI Test Method GM19*

Standard Specification for

Seam Strength and Related Properties of Thermally Bonded Polyolefin 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 addresses the required seam strength and related properties of thermally bonded polyolefin geomembranes; in particular, high density polyethylene (HDPE), linear low density polyethylene both nonreinforced (LLDPE) and scrim reinforced (LLDPE-R) and flexible polypropylene both nonreinforced (fPP) and scrim reinforced (fPP-R).

1.2 Numeric values of seam strength and related properties are specified in both shear and peel modes.

Note 1: This specification does not address the test method details or specific testing procedures. It refers to the relevant ASTM test methods where applicable.

1.3 The thermal bonding methods focused upon are hot wedge (single and dual track) and extrusion fillet.

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*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 5-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.

Note 2: Other acceptable, but less frequently used, methods of seaming are hot air and ultrasonic methods. They are inferred as being a subcategory of hot wedge seaming.

1.4 This specification does not suggest a specific distance between destructive seam samples to be taken in the field, i.e., the sampling interval. A separate GRI Standard Practice is focused on this issue, see GRI-GM29.

1.5 This specification is only applicable to laboratory testing.

1.6 This specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

D6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
D7747 Standard Test Method for Determining Integrity of Seams Produced Using Thermo-Fusion Methods for Reinforced Geomembranes by the Strip Tensile Method

2.2 EPA Standards

EPA 600/2.88/052 (NTIS PB-89-129670)
Lining of Waste Containment and Other Containment Facilities

2.3 GRI Standards

GM13 Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GM14 Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes
GM17 Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GM18 Test Properties and Testing Frequency for Flexible Polypropylene (fPP and fPP-R) Geomembranes
GM20 Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts
GM25 Test Property and Testing Frequency for Scrim Reinforced Linear Low Density Polyethylene Geomembranes
GM29 Practice for Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and Nondestructive Testing

3. Definition

3.1 Geomembrane, n – An essentially impermeable geosynthetic composed of one or more synthetic sheets used for the purpose of liquid, gas or solid containment.

3.2 Hot Wedge Seaming – A thermal technique which melts the two opposing geomembrane surfaces to be seamed by running a hot metal wedge or knife between them. Pressure is applied to the top or bottom geomembrane, or both, to form a continuous bond. Seams of this type can be made with dual bond tracks separated by a nonbonded gap. These seams are referred to as dual hot wedge seams or double-track seams.

3.3 Hot Air Seaming – This seaming technique introduces high-temperature air or gas between two geomembrane surfaces to facilitate localized surface melting. Pressure is applied to the top or bottom geomembrane, forcing together the two surfaces to form a continuous bond.

3.4 Ultrasonic Seaming - A thermal technique which melts the two opposing geomembrane surfaces to be seamed by running a ultrasonically vibrated metal wedge or knife between them. Pressure is applied to the top or bottom geomembrane, or both, to form a continuous bond. Some seams of this type are made with dual bond tracks separated by a nonbonded gap. These seams are referred to as dual-track seams or double-track seams.

3.5 Extrusion Fillet Seaming – This seaming technique involves extruding molten resin at the edge of an overlapped geomembrane on another to form a continuous bond. A depreciated method called “extrusion flat” seaming extrudes the molten resin between the two overlapped sheets. In all types of extrusion seaming the surfaces upon which the molten resin is applied must be suitably prepared, usually by a slight grinding or buffing.

4. Significance and Use

4.1 The various methods of field fabrication of seams in polyolefin geomembranes are covered in existing ASTM standards mentioned in the referenced document section. What is not covered in those documents is the numeric values of strength and related properties that the completed seam must meet, or exceed. This specification provides this information insofar as minimum, or maximum, property values are concerned when the field fabricated seams are sampled and laboratory tested in shear and peel. A separate GRI standard, GRI-GM29 (DRAFT), provides guidance as to the spacing that destructive samples should be taken in typical field installation projects.

5. Sample and Specimen Preparation

5.1 The spacing for taking field seam samples for destructive testing is provided in GRI-GM29 (DRAFT), a standard-of-practice. The process describes a progression from the most restrictive interval of 1 per 500 feet (1 per 150 m) to the complete use and reliance of the electrical leak location survey (ELLS) method. Intermediate between these extremes are variations depending upon the installers experience and performance.

5.2 The size of field seam samples is to be according to the referenced test method, e.g., ASTM D6392 or site-specific CQA plan.

5.3 The individual test specimens taken from the field seam samples are to be tested according to the referenced test method, i.e., ASTM D6392 for HDPE, LLDPE and fPP, and ASTM D751 (modified to a 150 mm + seam width gage length) for fPP-R. The specimens are to be conditioned prior to testing according to these same test methods and evaluated accordingly.

6. Assessment of Seam Test Results

6.1 HDPE seams – For HDPE seams (both smooth and textured), the strength of four out of five 1.0 inch (25 mm) wide strip specimens in <u>shear</u> should meet or exceed the values given in Tables 1(a) and 1(b). The fifth must meet or exceed 80% of the given values. In addition, five out five specimens should meet the shear percent elongation, calculated as follows, and exceed the values given in Tables 1(a) and 1(b):

$$E = \frac{L}{L_o}(100) \tag{1}$$

where

E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original average length (usually 1.0 in. or 25 mm)

Note 3: The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

For HDPE seams (both smooth and textured), the strength of four out of five 1.0 in. (25 mm) wide strip specimens tested in <u>peel</u> should meet or exceed the values given in Tables 1(a) and 1(b). The fifth must meet or exceed 80% of the given values.

In addition, the peel separation (or incursion) should not exceed the values given in Tables 1(a) and 1(b) for all five out of five specimens. The value shall be based on the proportion of area of separated bond to the area of the original bonding as follows:

$$S = \frac{A}{A_o}(100) \qquad (2)$$

where

S = separation (%)
A = average area of separation, or incursion (in^2 or mm^2)
A_0 = original bonding area (in^2 or mm^2)

Note 4: The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk > 25%
Extrusion Fillet: AD1, AD2
Exception: AD-WLD (unless strength is achieved)

Note 5: Separation-in-plane (SIP) is a locus-of-break where the failure surface propagates within one of the seamed sheets during destructive testing (usually in the peel mode). It is not merely a surface skin effect producing a few ductile fibrils (sometimes called ductile drawdown). SIP is acceptable if the required strength, shear elongation and peel separation criteria are met.

In this regard, five out of five specimens shall result in acceptable break patterns.

6.2 LLDPE seams – For LLDPE seams (smooth, textured and scrim reinforced), the strength of four out of five 1.0 in. (25 mm) wide strip specimens in shear should meet or exceed the values given in Tables 2(a) through 2(d). The fifth must meet or exceed 80% of the given values. Note that the unreinforced specimens are 1.0 in. (25 mm) wide strips and the scrim reinforced specimens are 4.0 in. (100 mm) wide grab tests. In addition, the shear percent elongation, calculated as follows, should exceed the values given in Tables 2(a) through 2(d). All five out of five should meet the shear elongation requirement.

$$E = \frac{L}{L_o}(100) \qquad (1)$$

where
E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original average length (usually 1.0 in. or 25 mm)

Note 3 (Repeated): The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

Shear elongation is not relevant to scrim reinforced geomembranes and as such is listed as "not applicable" in Tables 2 (c) and (d).

For LLDPE seams (smooth, textured and scrim reinforced), the strength of four out of five 1.0 in. (25 mm) wide strip specimens tested in peel should meet or exceed the values given in Tables 2(a) through 2(d). The fifth must meet or exceed 80% of the given values.

In addition, the peel separation (or incursion) should not exceed the values given in Tables 2(a) through 2(d). All five out of five specimens shall meet the peel separation value. The value shall be based on the proportion of area of separated bond to the area of the original bonding as follows:

$$S = \frac{A}{A_o}(100) \tag{2}$$

where

S = separation (%)
A = average depth of separation, or incursion (in.^{2} or mm^2)
A_0 = original bonding distance (in.^{2} or mm^2)

Note 4 (Repeated): The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk > 25%
Extrusion Fillet: AD1, AD2
Exception: AD-WLD (unless strength is achieved)

Note 5 (Repeated): Separation-in-plane (SIP) is a locus-of-break where the failure surface propagates within one of the seamed sheets during destructive testing (usually in the peel mode). It is not merely a surface skin effect producing a few ductile fibrils (sometimes called ductile drawdown). SIP is acceptable if the required strength, shear elongation and peel separation criteria are met.

In this regard, five out of five specimens shall result in acceptable break patterns.

6.3 fPP Seams – For fPP seams (both nonreinforced and scrim reinforced), the strength of four out of five specimens in <u>shear</u> should meet or exceed the values given in Tables 3(a) and 3(b). The fifth must meet or exceed 80% of the given values. Note that the unreinforced specimens are 1.0 in. (25 mm) wide strips and the scrim reinforced specimens are 4.0 in. (100 mm) wide grab tests. In addition, the shear percent elongation on the unreinforced specimens, calculated as follows, should exceed the values given in Tables 3(a) and 3(b). All five out of five specimens should meet the shear elongation requirement.

$$E = \frac{L}{L_o}(100) \qquad (1)$$

where
E = elongation (%)
L = extension at end of test (in. or mm)
L_o = original gauge length (usually 1.0 in. or 25 mm)

Note 3 (Repeated): The assumed gage length is considered to be the unseamed sheet material on either side of the welded area. It generally will be 1.0 in. (25 mm) from the edge of the seam to the grip face.

Shear elongation is not relevant to scrim reinforced geomembranes and as such is listed as "not applicable" in Tables 3(a) and 3(b).

For fPP seams (both nonreinforced and scrim reinforced), the strength of four out of five specimens in <u>peel</u> should meet or exceed the values given in Tables 3(a) and 3(b). The fifth must meet or exceed 80% of the given values. Note that the unreinforced specimens are 1.0 in. (25 mm) wide strips and the scrim reinforced specimens are grab tests. In addition, the peel percent separation (or incursion) should not exceed the values given in Tables 3(a) and 3(b). All five out of five specimens should meet the peel separation value. The values should be based on the proportion of area of separated bond to the area of the original bonding as follows.

$$S = \frac{A}{A_o}(100) \qquad (2)$$

where

S = separation in (%)
A = average depth of separation, or incursion (in.^{2} or mm^2)
A_o = original bonding distance (in.^{2} or mm^2)

Note 4 (Repeated): The area of peel separation can occur in a number of nonuniform patterns across the seam width. The estimated dimensions of this separated area is visual and must be done with care and concern. The area must not include squeeze-out which is part of the welding process.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, SIP is an acceptable break code);

Hot Wedge: AD and AD-Brk > 25%
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Note 5 (Repeated): Separation-in-plane (SIP) is a locus-of-break where the failure surface propagates within one of the seamed sheets during destructive testing (usually in the peel mode). It is not merely a surface skin effect producing a few ductile fibrils (sometimes called ductile drawdown). SIP is acceptable if the required strength, shear elongation and peel separation criteria are met.

In this regard, five out of five specimens shall result in acceptable break patterns.

7. Retest and Rejection

7.1 If the results of the testing of a sample do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the construction quality control or construction quality assurance plan for the particular site under construction.

8. Certification

8.1 Upon request of the construction quality assurance officer or certification engineer, an installer's certification that the geomembrane was installed and tested in accordance with this specification, together with a report of the test results, shall be furnished at the completion of the installation.

Table 1(a) – Seam Strength and Related Properties of Thermally Bonded **Smooth and Textured** High Density Polyethylene (HDPE) Geomembranes **(English Units)**

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams[(1)]							
shear strength[(2)], lb/in.	57	80	100	120	160	200	240
shear elongation at break[(3)], %	50	50	50	50	50	50	50
peel strength[(2)], lb/in.	45	60	76	91	121	151	181
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
shear strength[(2)], lb/in.	57	80	100	120	160	200	240
shear elongation at break[(3)], %	50	50	50	50	50	50	50
peel strength[(2)], lb/in.	39	52	65	78	104	130	156
peel separation, %	25	25	25	25	25	25	25

Notes for Tables 1(a) and 1(b):

1. Also for hot air and ultrasonic seaming methods
2. Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

Table 1(b) – Seam Strength and Related Properties of Thermally Bonded **Smooth and Textured** High Density Polyethylene (HDPE) Geomembranes **(S.I. Units)**

Geomembrane Nominal Thickness	0.75 mm	1.0 mm	1.25 mm	1.5 mm	2.0 mm	2.5 mm	3.0 mm
Hot Wedge Seams[(1)]							
shear strength[(2)], N/25 mm.	250	350	438	525	701	876	1050
shear elongation at break[(3)], %	50	50	50	50	50	50	50
peel strength[(2)], N/25 mm	197	263	333	398	530	661	793
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
shear strength[(2)], N/25 mm	250	350	438	525	701	876	1050
shear elongation at break[(3)], %	50	50	50	50	50	50	50
peel strength[(2)], N/25 mm	170	225	285	340	455	570	680
peel separation, %	25	25	25	25	25	25	25

Table 2(a) – Seam Strength and Related Properties of Thermally Bonded **Smooth and Textured** Linear Low Density Polyethylene (LLDPE) Geomembranes (English Units)

Geomembrane Nominal Thickness	20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams(1)								
shear strength(2), lb/in.	30	45	60	75	90	120	150	180
shear elongation(3), %	50	50	50	50	50	50	50	50
peel strength(2), lb/in.	25	38	50	63	75	100	125	150
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams								
shear strength(2), lb/in.	30	45	60	75	90	120	150	180
shear elongation(3), %	50	50	50	50	50	50	50	50
peel strength(2), lb/in.	22	34	44	57	66	88	114	136
peel separation, %	25	25	25	25	25	25	25	25

Notes for Tables 2(a) and 2(b):

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing

Table 2(b) – Seam Strength and Related Properties of Thermally Bonded **Smooth and Textured** Linear Low Density Polyethylene (LLDPE) Geomembranes (S.I. Units)

Geomembrane Nominal Thickness	0.50 mm	0.75 mm	1.0 mm	1.25 mm	1.5 mm	2.0 mm	2.5 mm	3.0 mm
Hot Wedge Seams(1)								
shear strength(2), N/25 mm	131	197	263	328	394	525	657	788
shear elongation(3), %	50	50	50	50	50	50	50	50
peel strength(2), N/25 mm	109	166	219	276	328	438	547	657
peel separation, %	25	25	25	25	25	25	25	25
Extrusion Fillet Seams								
shear strength(2), N/25 mm	131	197	263	328	394	525	657	788
shear elongation(3), %	50	50	50	50	50	50	50	50
peel strength(2), N/25 mm	95	150	190	250	290	385	500	595
peel separation, %	25	25	25	25	25	25	25	25

Table 2(c) – Seam Strength and Related Properties of Thermally Bonded **Scrim Reinforced** Linear Low Density Polyethylene (LLDPE-R) Geomembranes (English Units)

Geomembrane Nominal Thickness	36 mil(4)	45 mil(4)
Hot Wedge Seams(1)		
shear strength(2), lb	200	200
shear elongation(3), %	n/a	n/a
peel strength(2), lb	20	20
peel separation, %	n/a	n/a
Extrusion Fillet Seams		
shear strength(2), lb	200	200
shear elongation(3), %	n/a	n/a
peel strength(2), lb	20	20
peel separation, %	n/a	n/a

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing
4. Values are based on grab tensile strength and elongation per D7747 for laboratory tested specimens

Table 2(d) – Seam Strength and Related Properties of Thermally Bonded **Scrim Reinforced** Linear Low Density Polyethylene (LLDPE-R) Geomembranes (S.I. Units)

Geomembrane Nominal Thickness	36 mil(4)	45 mil(4)
Hot Wedge Seams(1)		
shear strength(2), N	890	890
shear elongation(3), %	n/a	n/a
peel strength(2), N	90	90
peel separation, %	n/a	n/a
Extrusion Fillet Seams		
shear strength(2), N	890	890
shear elongation(3), %	n/a	n/a
peel strength(2), N	90	90
peel separation, %	n/a	n/a

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing
4. Values are based on grab tensile strength and elongation per D7747 for laboratory tested specimens

Table 3(a) – Seam Strength and Related Properties of Thermally Bonded **Nonreinforced and Scrim Reinforced** Flexible Polypropylene (fPP) Geomembranes (English Units)

Geomembrane Nominal Thickness	30 mil-NR	40 mil-NR	36 mil-R(4)	45 mil-R(4)
Hot Wedge Seams(1)				
shear strength(2), lb/in. (NR); lb (R)	25	30	200	200
shear elongation(3), %	50	50	n/a	n/a
peel strength(2), lb/in. (NR); lb (R)	20	25	20	20
peel separation, %	25	25	n/a	n/a
Extrusion Fillet Seams				
shear strength(2), lb/in. (NR); lb (R)	25	30	200	200
shear elongation(3), %	50	50	n/a	n/a
peel strength(2), lb/in. (NR); lb (R)	20	25	20	20
peel separation, %	25	25	n/a	n/a

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing
4. Values are based on grab tensile strength and elongation per D7747 for laboratory tested specimens

Table 3(b) – Seam Strength and Related Properties of Thermally Bonded **Nonreinforced and Scrim Reinforced** Flexible Polypropylene (fPP) Geomembranes (S.I. Units)

Geomembrane Nominal Thickness	0.75 mm-NR	1.0 mm-NR	0.91 mm-R(4)	1.14 mm-R(4)
Hot Wedge Seams(1)				
shear strength(2), N/25 mm (NR); N (R)	110	130	890	890
shear elongation(3), %	50	50	n/a	n/a
peel strength(2), N/25 mm (NR); N (R)	85	110	90	90
peel separation, %	25	25	n/a	n/a
Extrusion Fillet Seams				
shear strength(2), N/25 mm (NR); N (R)	110	130	890	890
shear elongation(3), %	50	50	n/a	n/a
peel strength(2), N/25 mm (NR); N (R)	85	110	90	90
peel separation, %	25	25	n/a	n/a

1. Also for hot air and ultrasonic seaming methods
2. Values listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values
3. Elongation measurements should be omitted for field testing
4. Values are based on grab tensile strength and elongation per D7747 for laboratory tested specimens

Adoption and Revision Schedule
for
Seam Specification per GRI-GM19

"Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes"

Adopted: February 18, 2002

Revision 1: May 15, 2003; Increased selected shear and peel test requirements, per the following:

Material	Test	Seam Type	Current GM19	Proposed GM19	Difference
HDPE	Shear	Hot Wedge Extrusion	95% yield 95% yield	95% yield 95% yield	no change no change
	Peel	Hot Wedge Extrusion	62% yield 62% yield	72% yield 62% yield	16% increase no change
LLDPE	Shear	Hot Wedge Extrusion	1300 psi break 1300 psi break	1500 psi break 1500 psi break	15% increase 15% increase
	Peel	Hot Wedge Extrusion	1100 psi break 1100 psi break	1250 psi break 1100 psi break	14% increase no change

Revision 2: January 28, 2005; added Note 6 (in three locations) stating that incursion is measured on an area basis and not depth as in ASTM D6392.

Revision 3: June 4, 2010; Removed Note 6 on peel incursion since ASTM D6392 (2008) now uses area of incursion whereas previously they used linear length of incursion. Thus ASTM is now in agreement with GM19 in this regard.

Revision 4: November 15, 2010; Added Note 6 (in three locations) stating what separation-in-plane (SIP) is, and is not, and that it is acceptable if the required strength, shear elongation and peel separation criteria are met.

Revision 5: July 12, 2011; AD1 and AD2 breaks are now unacceptable even if strength is achieved.

Revision 6: October 3, 2011; Added LLDPE-R to the various geomembrane types, in particular, Tables 2(c) and 2(d) and made editorial changes.

Revision 7: November 3, 2013; clarified issues of 4 out of 5 passing strength and 5 out of 5 passing locus-of-break, shear elongation and peel separation.

Revision 8: February 12, 2015; upgraded standards and terminology

APPENDIX III7D-2

ALTERNATIVE SYNTHETIC GRASS FINAL COVER SYSTEM

CITY OF EDINBURG SOLID WASTE MANAGEMENT

PERMIT AMENDMENT APPLICATION

Part III, Attachment 7, Appendix D-2

FINAL COVER QUALITY CONTROL PLAN

CLOSURE TURF® ALTERNATIVE FINAL COVER

Edinburg Regional Disposal Facility

Edinburg, Hidalgo County, Texas

TCEQ Permit MSW-956C

STATE OF TEXAS
JEFFREY B. FASSETT
85675
LICENSED
PROFESSIONAL ENGINEER
7/2/17

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

Submitted To: City of Edinburg
Department of Solid Waste Management
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July 2017

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INTENDED FOR PERMITTING PURPOSES ONLY

1.0 PURPOSE

1.1 Purpose and Scope

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

This FCQCP was developed to address the construction and quality control testing of soil and geosynthetic components of the alternative final cover system in compliance with the Subtitle D requirements. Construction and testing of all final cover system components must be according to this FCQCP.

A copy of a current version of this FCQCP must be maintained on-site at all times with the Site Operating Record. The FCQCP shall be available for reference by the Texas Commission on Environmental Quality's (TCEQ's) inspector and construction and testing personnel. Revisions to this FCQCP shall receive written approval from the TCEQ before implementation.

1.2 Final Cover System

The proposed alternative final cover system at the Edinburg Regional Disposal Facility will consist of a synthetic grass, geomembrane system developed for landfill final cover applications. The proposed alternative final cover system is summarized in below.

ClosureTurf® Alternative Final Cover
HDPE synthetic grass
½-inch thick sand infill
Woven geotextile filter/backing
50-mil linear low density polyethylene (LLDPE) Super Gripnet® geomembrane with integrated drainage layer

1.3 General Responsibilities

The owner/operator is responsible for fully implementing this FCQCP. The site manager (SM) or designated alternative will be responsible for contracting with a qualified Professional of Record (POR) prior to initiating final cover construction. Each phase of the final cover evaluation shall be conducted by or under the supervision of the POR. The POR shall be an independent third party professional engineer (PE) licensed in the State of Texas with experience in civil or geotechnical engineering and soils testing. A qualified construction quality assurance (CQA) monitor performing daily quality assurance/quality control (QA/QC) observation and testing shall be under the direct supervision of the POR. The POR or his/her qualified representative(s) shall provide full-time monitoring.

2.0 GEOMEMBRANE EVALUATION

This section presents general procedures, quality control testing requirements, and construction specifications for geomembrane liner construction.

2.1 Pre-installation Material Evaluation

2.1.1 Manufacturer's Quality Control Certificates

Prior to installing any geomembrane, the manufacturer or installer shall provide the POR with quality control certificates signed by a responsible party employed by the manufacturer. Each quality control certificate shall include roll identification numbers, testing procedures, and results of quality control tests. The quality control tests shall be performed in the manufacturing plant using the test methods and frequencies listed in the most recent version of the Geosynthetic Research Institute (GRI) test method GM17, "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes," included in Appendix III7D-1. The owner may require more frequent testing at his/her discretion.

The POR shall review the test results prior to accepting the geomembrane to assure that the certified minimum properties meet the minimum values for geomembranes, as determined by the most recent GRI test method GM17.

The rolls delivered to the site shall be inventoried, recording the manufacturer's name and product identification, and the roll thickness, number and dimensions. Manufacturer's certificates should be cross-referenced to rolls delivered on-site.

Resumes of the installer's supervisor(s) or Master Seamer(s) shall be obtained to verify that adequate seaming experience will be utilized on the project. The installer's supervisor or Master Seamer shall have had experience totaling a minimum of 2,000,000 square feet of geomembrane installation.

Upon delivery of geosynthetic materials, storage and handling procedures shall also be documented. Rolls of geosynthetic materials shall be handled and stored in such a way as not to damage the material. As a general rule, rolls of geosynthetic materials should not be stacked more than four rolls high.

In addition to the manufacturer's quality control certificates, samples of the delivered rolls of geomembrane will be obtained either at the manufacturing facility or upon delivery to the site for conformance testing. The test samples shall be obtained for conformance testing in accordance with the testing schedule shown in Table III7D2-1.

Table III7D2-1: Geomembrane Conformance Test Schedule

TEST	METHOD(1)	FREQUENCY
Thickness (laboratory measurement)	ASTM D5199 (Smooth) or ASTM D5994 (Textured)	Not less than 1 test per 100,000 ft^2 with not less than 1 per resin lot
Density	ASTM D1505 or D792	
Carbon black content(2)	ASTM D4218	
Carbon black dispersion	ASTM D5596	
Tensile properties	ASTM D6693, Type IV	

Notes:

1. Updated ASTM or GRI methods may be implemented based on a review by the POR.
2. Other methods such as D1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D4218 (muffle furnace) can be established.

2.2 Installation Procedures

2.2.1 Subgrade Preparation

Surfaces to be lined should be smooth and free of all rocks greater than 0.75-inch diameter (or as recommended by the manufacturer, if less than 0.75 inches), sharp/angular objects, sticks, roots, or debris of any kind. The surface should provide a firm, unyielding foundation for the geomembrane with no sudden, sharp, or abrupt changes or break in grade. The subgrade surface shall be prepared by rolling with a smooth-drum roller to minimize the roughness and press down protruding soil or rock particles prior to geomembrane deployment. Loose rocks and/or dry soil particles that could damage the geomembrane shall be removed. Excessive voids or dimples shall be filled with soil. The geomembrane shall not be deployed over any standing water.

2.2.2 Geomembrane Deployment

The geomembrane shall be installed in direct and uniform contact with the subgrade. The geomembrane shall not be placed during inclement weather such as high winds or rain.

Geomembrane seaming should generally not take place when ambient temperatures are below 32 degrees Fahrenheit (°F), unless preheating is used. For extrusion welding, preheating will be required if the temperature is below 32°F. For fusion welding, preheating may be waived if the installer demonstrates that quality welds may be obtained without preheating. Seaming shall not be permitted at ambient temperatures above 104°F, unless the installer can demonstrate that seam quality is not compromised.

In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the geomembrane. If the POR observes any potential damage done to the liner by the support equipment, use of the equipment will cease and the damage will be repaired. Personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the geomembrane. Only those sections that are to be placed and seamed in one day should be unrolled. Panels left unseamed should be anchored with sandbags or other suitable weights. In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented up and down, not across the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.

Panels should be overlapped as recommended by the manufacturer as appropriate for the type of seam welding to be performed; however, overlapping shall be no less than 2 inches. Field seaming shall only be performed by the method(s) approved by the manufacturer, either by extrusion welding or double-tracked fusion welding. No seaming shall take place without the installer's supervisor or Master Seamer and CQA monitor being present.

To avoid excessive wrinkling, the geomembrane requires acclimation to ambient temperature before seaming operations. The geomembrane will be allowed to acclimate and wrinkles worked toward the toe of slope prior to seaming.

Fishmouths or wrinkles at the seam overlap shall be cut along the ridge of the wrinkle to achieve a flat overlap. The cut shall be seamed and/or patched. Seams shall extend to the outside edge of panels placed in the anchor trench.

Panel layout and field seams shall be given an identification code, mapped, and logged to record relevant installation information. Inspection and testing records shall be logged as well as repair and retest data. Section 4.0 includes a list of items to be documented during geomembrane construction and testing.

2.3 Installation Monitoring and Testing

2.3.1 Trial Seams

Each day prior to commencing field seaming, trial seams shall be made on pieces of geomembrane material to verify that conditions are adequate for production seaming. Trial seams shall be made at the beginning of each seaming period and shift (generally, at least twice each day) for each combination of production seaming machine and operator to be used that day. The trial test seam shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Four 1-inch wide specimens shall be die-cut from the trial seam sample. Two specimens shall be tested in the field for shear and two for peel (test both inner and outer welds for dual track fusion welding) and shall be compared to the minimum seam strength requirements specified in the most current version of the Geosynthetic Institute, GRI Test Method GM19. The current versions of the GRI test methods are included in Appendix III7D-1.

If any of the trial seam specimens fail, the entire trial seam operation shall be repeated. If an additional specimen fails during the second trial seam, the seaming machine and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Additional trial seams shall be made at each occurrence of significantly different environmental conditions, including, but not limited to, temperature, humidity, and dust, and after any machine is turned off for more than 30 minutes.

2.3.2 Non-Destructive Testing

Continuous, non-destructive testing shall be performed on all seams by the installer. All leaks must be isolated and repaired by following the procedures described in this FCQCP.

> Air Pressure Testing – ASTM D5820. The ends of the air channel of the dual-track fusion weld must be sealed and pressured to approximately 30 pounds per square inch (psi), if possible. The air pump must then be shut off and the air pressure observed after 2 minutes. A loss of less than 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends. A loss greater or equal to 4 psi indicates the presence of a seam leak that must then be isolated and repaired by following the procedures described in this FCQCP. The POR or his/her qualified representative must observe and record all pressure gauge readings.
>
> Vacuum-Box Testing – ASTM D5641. Apply a vacuum of approximately 4 to 8 psi to all extrusion welded seams that can be tested in this manner. The seam must be observed for leaks for at least 10 seconds while subjected to this vacuum. The POR or his/her qualified representative must observe 100 percent of this testing.
>
> Other Testing. Other non-destructive testing must have prior written approval from the TCEQ.

2.3.3 Destructive Seam Testing

Destructive samples shall be taken at a minimum frequency of one test location, selected randomly, within each 500 linear feet of seam length, inclusive of both primary longitudinal and cross seams, cap strips, and repairs 20 square feet in total area or larger. Each test sample should be of sufficient length and 12 inches wide with the seam located in the middle. Test specimens, approximately 1 inch wide, shall be cut from both ends of the sample for field testing (peel and shear). The remaining sample should be cut into three parts (one for quality assurance laboratory testing, one for installer quality control laboratory testing, and one for archive storage to be maintained at a location selected by the owner).

The field tests shall be conducted on a certified calibrated tensiometer capable of maintaining a constant extension rate of 2 inches per minute. If one of the field test specimens from the ends of the destructive sample fails, then the seam will be considered to have failed, and repairs shall be initiated, as described below. If both specimens pass, then a sample for laboratory testing will be sent to the quality assurance laboratory for testing in both peel and shear. Seam strengths for LLDPE geomembranes shall meet the minimum values specified in the most current version of the Geosynthetic Institute, GRI Test Method GM19, "Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes."

Destructive test results for both field and laboratory tests shall include qualitative data, including the location of the failure and locus-of-break code as described in ASTM D6392. Peel tests on double-tracked fusion welds shall be performed on both inside and outside tracks of the weld. Seam break classifications for extrusion and fusion welds are shown on Figures III7D2-1 and III7D2-2, respectively.

At a minimum, a destructive test must be done for each welding machine used for seaming or repairs. A sufficient amount of the seam must be removed to conduct field testing, independent laboratory testing, and archiving of enough material to retest the seam when necessary. Destructive seam testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the geomembrane. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the POR or his/her qualified representative.

<u>Weld Acceptance Criteria</u>: For LLDPE seams (both smooth and textured), the minimum passing criteria for destructive seam testing are described in the Geosynthetic Institute, GRI Test Method GM19. The POR must use the most current version of GM19 when evaluating welded seams.

<u>Seam Failure Delineation</u>: When a sample fails a destructive test, the installer shall trace the welding path to an intermediate location at least 10 feet in each direction, or a distance determined by the POR, from the point of the failed test in each direction and take 1-inch wide specimens for an additional set of field tests. If these additional samples pass the tests, then two laboratory destructive samples shall be taken adjacent to the intermediate locations or at locations determined by the POR or his/her representative. If these laboratory samples pass the tests, then the seam shall be repaired between these locations. If either sample fails, then the process shall be repeated to establish a zone where the seam should be repaired. All acceptable repaired seams shall be bounded by two locations from which samples passing laboratory destructive tests have been taken.

<u>Seam Failure Repairs</u>: Any portion of the geomembrane exhibiting a flaw or failing a destructive or non-destructive test shall be repaired. Repair methods may include spot welding (extrusion) for minor flaws and punctures; patches for larger holes and tears; capping for large lengths of failed seams or panel damage; and extrusion welding of outer flap to repair of an inadequate fusion seam (less than 100-foot cumulative length) that has an exposed edge.

For any repair method, the following provision shall be satisfied:

- Surfaces of the geomembrane that are to be repaired using extrusion methods shall be ground no more than one hour prior to the repair.
- All surfaces shall be clean and dry at the time of repair.

- Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of approximately 3 inches.
- All repairs shall be non-destructively tested, as previously described.
- All seaming equipment, personnel, and operation procedures used in repair work shall meet the same requirements as for new seaming operations.

The POR or his/her qualified representative shall observe all non-destructive testing of repairs and shall record the number of each repair, type, date, and test outcome. Repairs that pass the non-destructive tests shall be taken as an indication of an adequate repair. Repairs more than 150 feet long shall also be required to have a destructive test performed. Repairs that fail the initial retest shall be redone and retested until a passing test results. All work and testing of repairs shall be fully documented in a repair log.

When placing overlying material on the geomembrane, effort must be made to minimize wrinkle development. If possible, cover should be placed during the coolest weather available. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. In no case shall the geomembrane be allowed to fold over on itself.

3.0 SYNTHETIC TURF EVALUATION

3.1 Manufacturer's Quality Control

The synthetic turf shall conform to the material and performance properties specified in Table III7D2-2. Manufacturers' certificates of material and performance characteristics shall be obtained and documented at the minimum frequency shown on Table III7D2-2, with not less than 1 per resin lot.

Synthetic turf material conformance testing will consist of transmissivity testing with the underlying structured geomembrane using the test set-up described in Table III7D2-2.

Table III7D2-2: Synthetic Turf Specifications

SYNTHETIC TURF					
Property	**Qualifier**	**Unit**	**Value**	**Test Method**	**Frequency**
Transmissivity (with underlying structured geomembrane)	Min.	m^2/sec	2.5 x 10^{-3}	ASTM D4716$^{(1)}$	200,000 ft^2
Puncture	Min.	lb	900	ASTM D6241	200,000 ft^2
Tensile	MARV	lb/ft	1000	ASTM D4595	200,000 ft^2

Notes:
(1) The transmissivity shall be measured at a minimum gradient of 0.25 under a minimum normal pressure of 50 psf with a minimum seating period of 1 hour.

3.2 Surface Preparation

Prior to synthetic turf installation, the surface of the geomembrane shall be checked for irregularities, protrusions, stones, debris, geomembrane grindings or other material that could damage or impede surface water flow.

3.3 Deployment

In general, only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the synthetic turf. If the POR observes any potential damage done to the synthetic turf or underlying geomembrane by the support equipment, use of the equipment will cease and the damage will be repaired. Personnel working on the synthetic turf shall not smoke, wear damaging shoes, or engage in any other activity likely to damage the synthetic turf or geomembrane. Only those sections that are to be placed and seamed in one day should be unrolled.

In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented up and down, not across the slope). In corners and odd-shaped geometric locations, the number of field seams should be minimized.

The synthetic turf shall be deployed with the turf filaments point upslope a majority of the time. Observe that the turf is laid substantially smooth and substantially free of tension, stress, folds, wrinkles, or creases. The synthetic turf shall not be placed during inclement weather such as high winds or rain.

The panels shall be deployed to insure proper flipping in order to expose the turf surface up after seaming operations. After the first panel of the project is deployed, deployment will be done on the adjacent turf panel to avoid damage. Panels left unseamed should be anchored with sandbags or other suitable weights.

3.4 Synthetic Turf Seaming

Synthetic turf field seaming shall only be performed by the method(s) approved by the manufacturer, either by sewing or double-tracked fusion welding. No seaming shall take place without the installer's supervisor or Master Seamer and CQA monitor being present.

Each day prior to commencing field seaming, trial seams shall be made on pieces of synthetic turf material to verify that conditions are adequate for production seaming. Trial seams shall be made at the beginning of each seaming period and shift (generally, at least twice each day) for each combination of production seaming machine and operator to be used that day. The trial test seam shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise.

Trial weld samples must comply with "VISUAL PASSING CRITERIA." Visual passing criteria are verified when a manual peal/pull test is performed and the top turf panel tufts transfer to the bottom turf panel. The transfer of approximately 75% of the tufts constitutes a passing trial weld.

If any of the trial seam specimens fail, the entire trial seam operation shall be repeated. If an additional specimen fails during the second trial seam, the seaming machine and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved. Additional trial seams shall be performed if frequent field seaming problems are experienced or if power to the seaming machines is interrupted sufficiently long to require rewarming.

Any portion of the synthetic turf exhibiting a flaw shall be repaired. Repair methods may include fusing seaming or hand held heat gun for minor flaws and punctures.

3.5 Infill Material

The soil infill layer will consist of a 1/2-inch minimum thick layer of soil meeting the gradation requirements in Table III7D2-3.

Table III7D2-3: Sand Infill Specifications

Sieve	Percent Passing
3/8 inch	100
N0. 4	95 to100
No. 8	80 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	5 to 30
No. 100	0 to 10

Only low ground pressure rubber-tired support equipment approved by the POR may be allowed on the synthetic turf until the sand infill is in place. Personnel working on the geotextile shall not smoke, wear damaging shoes, or engage in any activity that damages the geotextile or underlying geosynthetics.

Conveyor systems and/or Express Blowers are the preferred method to spread and place the sand infill. The method of sand infill deployment shall be approved by the POR prior to construction.

The sand infill will be worked into synthetic turf as infill between the synthetic yarn blades. The final thickness of the sand infill shall be a minimum of ½-inch and less than ¾ inches. Sand infill thickness will be verified at a frequency of 20 measurements per acre of final cover installed. The method for measuring the sand infill thickness will be performed utilizing a digital caliper with depth rod capabilities, or a POR approved alternative measuring device. A standard washer will be utilized as a plate for the point of entry into the sand infill for consistent depth control.

4.0 DOCUMENTATION AND REPORTING

4.1 Final Cover System Evaluation Reports

Upon completion of all required final cover construction and evaluation, the POR shall prepare and submit in triplicate the FCSER, prepared in accordance with this plan, to the TCEQ for review and approval.

Each FCSER will include a discussion of the construction of the final cover elements and a cover placement map, which not only shows the covered area being submitted for approval, but also the areas covered by all previous FCSER submittals with the dates of acceptance by the TCEQ. The map should depict the site grid system, graphic scale, and north arrow. It may be a print from a master drawing that is annotated and updated with each new submittal. The FCSER shall be signed and/or sealed by the POR performing the evaluation and counter-signed by the site operator or his/her authorized representative.

The construction documentation will contain a narrative describing the conduct of work and testing programs required by the FCQCP, “as-built” or record drawings, and appendices of field and laboratory testing. Constructed cover details (“as-builts”), where applicable, will be depicted and will show slopes, and widths as determined from the field documentation.

The construction documentation report will contain or discuss the following information at a minimum.

For geomembrane:

- Roll shipment and receipt information
- Manufacturer’s quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Seamer's names and resumes of experience and qualifications
- Panel deployment, identification, and placement
- Seam preparation, orientation, and identification
- Equipment placed or operated on geomembrane
- 100 percent visual inspection for defects, damage, etc.

- Trial seam tests for each combination of seaming equipment and personnel
- Seaming methods, times, temperature, and equipment shutdowns and startups
- Continuous 100 percent non-destructive seam testing, methods, criteria, and results
- Destructive testing methods, criteria, and results
- Repairs, including preparation and procedures, failure delineation, patch size and shape, and retesting
- Material properties and placement of drainage materials and soil cover

For Synthetic Turf:

- Roll shipment and receipt information
- Manufacturer's quality control certificates and results
- Storage and handling information
- Conformance test sampling and test results
- Subgrade acceptance
- Panel deployment, identification, and placement
- Equipment placed or operated on synthetic turf
- 100 percent visual inspection for defects, damage, etc.
- Seaming methods
- Repairs, including patch size and shape

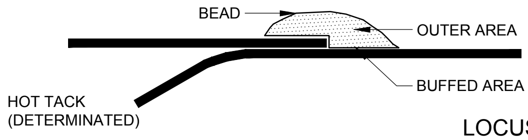
For Sand Infill:

- Sand infill gradation analyses
- Deployment method
- Thickness measurements

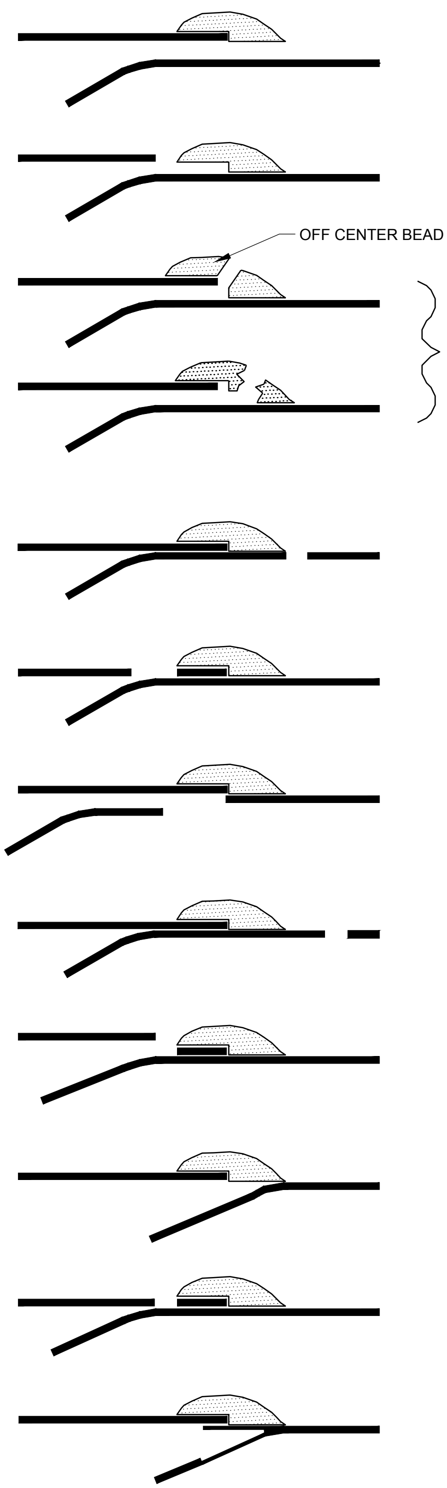
The report shall also include pertinent record drawings including:

- Layout plan
- Previously covered areas
- As-built geomembrane panel layout drawings, showing location of destructive test samples, patches, and repairs
- As-built synthetic turf panel layout drawings
- As-built drawings showing thickness measurements of the sand infill

FIGURES



UNTESTED SPECIMEN
EXTRUSION WELD WITH LEISTER HEAT SEAM



TYPES OF BREAK LOCUS-OF-BREAK CODE	BREAK DESCRIPTION
AD1	FAILURE IN ADHESION. SPECIMENS MAY ALSO DELAMINATE UNDER THE BEAD AND BREAK THROUGH THE THIN EXTRUDED MATERIAL IN THE OUTER AREA.
AD2	FAILURE IN ADHESION
AD-WLD	BREAKS THOUGH THE FILLET. BREAKS THOUGH THE FILLET RANGE FROM BREAKS STARTING AT THE EDGE OF THE TOP SHEET TO BREAKS THOUGH THE FILLET AFTER SOME ADHESION FAILURE BETWEEN THE FILLET AND THE BOTTOM SHEET.
SE1	BREAK AT SEAM EDGE IN THE BOTTOM SHEET. SPECIMENS MAY BREAK ANYWHERE FROM THE BEAD/OUTER AREA EDGE TO THE OUTER AREA/BUFF AREA. (APPLICABLE TO SHEAR ONLY).
SE2	BREAK AT SEAM EDGE IN THE TOP SHEET. SPECIMENS MAY BREAK ANYWHERE FROM THE BEAD/OUTER AREA EDGE TO THE OUTER AREA/BUFF AREA. (APPLICABLE TO SHEAR ONLY).
SE3	BREAK AT SEAM EDGE IN THE BOTTOM SHEET. (APPLICABLE TO PEEL ONLY).
BRK1	BREAK IN THE BOTTOM SHEETING. A "B" IN PARENTHESIS FOLLOWING THE CODE MEANS THE SPECIMEN BREAK IN THE BUFFED AREA. (APPLICABLE TO SHEAR ONLY).
BRK2	BREAK IN THE TOP SHEETING. A "B" IN PARENTHESIS FOLLOWING THE CODE MEANS THE SPECIMEN BREAK IN THE BUFFED AREA. (APPLICABLE TO SHEAR ONLY).
AD-BRK	BREAK IN THE BOTTOM SHEETING AFTER SOME ADHESION FAILURE BETWEEN THE FILLET AND THE BOTTOM SHEET. (APPLICABLE TO PEEL ONLY).
HT	BREAK AT THE EDGE OF THE HOT TACK FOR SPECIMENS WHICH COULD NOT BE DELAMINATED IN THE HOT TACK.
SIP	SEPARATION IN THE PLANE OF THE SHEET.

CLIENT
CITY OF EDINBURG SOLID WASTE MANAGEMENT

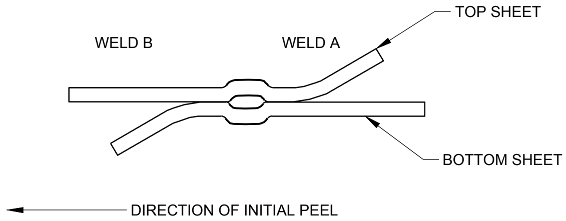
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-21
DESIGNED	PRM
PREPARED	TNB
REVIEWED	JBF
APPROVED	JBF

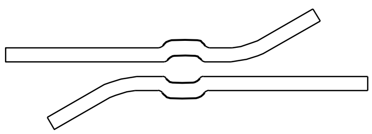
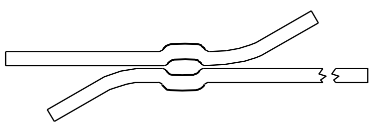
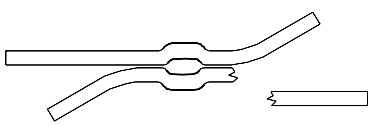
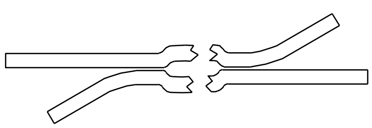
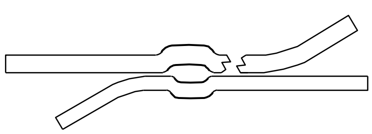
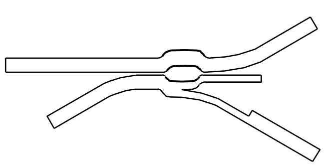
PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

TITLE
EXTRUSION WELD SEAM BREAK CLASSIFICATION

PROJECT NO.	APPLICATION SECTION	REV.	FIGURE
1401491		----	III7D2-1



SCHEMATIC OF UNTESTED SPECIMEN

TYPES OF FAILURE	LOCUS-OF-BREAK CODE	BREAK
	AD	ADHESION FAILURE
	BRK	BREAK IN SHEETING. BREAK CAN BE IN EITHER TOP OR BOTTOM SHEET.
	SE1	BREAK AT OUTER EDGE OF SEAM. BREAK CAN BE IN EITHER TOP OR BOTTOM SHEET.
	SE2	BREAK AT INNER EDGE OF SEAM THROUGH BOTH SHEETS.
	AD-BRK	BREAK IN FIRST SEAM AFTER SOME ADHESION FAILURE BREAK CAN BE IN EITHER THE TOP OF BOTTOM SHEET
	SIP	SEPARATION IN THE PLANE OF THE SHEET. BREAK CAN BE IN EITHER TOP OF BOTTOM SHEET.

ISSUED FOR PERMITTING PURPOSES ONLY

CLIENT
CITY OF EDINBURG SOLID WASTE MANAGEMENT

PROJECT
EDINBURG REGIONAL DISPOSAL FACILITY
PERMIT AMENDMENT APPLICATION TCEQ PERMIT MSW-956C
EDINBURG, HIDALGO COUNTY, TEXAS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-21
DESIGNED	PRM
PREPARED	TNB
REVIEWED	JBF
APPROVED	JBF

TITLE
FUSION WELD SEAM BREAK CLASSIFICATION

PROJECT NO.	APPLICATION SECTION	REV.	FIGURE
1401491		----	III7D2-2