NOVEMBER 30, 2023

MUNICIPALITY OF TOA ALTA OCTOBER 2023 MONTHLY REPORT

CIV. NO. 3:21-01087-DRD

NIVIA I. AYALA, PE
TERRATEK ENGINEERING GROUP, PSC
P.O. Box 367445 San Juan, PR 00936

Contents

I. DISTRIBUTION LIST

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dbatlle@cstlawpr.com
jramirez@amrclaw.com
cagosto674@gmail.com

II. REPORT ORGANIZATION

As part of the USA-MTA Civ. No. 3:21-01087-DRD Stipulation and Preliminary Injunction Order, MTA shall prepare and submit monthly reports regarding the performance of its obligations under this Order until completion of the requirements of Paragraphs 3 through 10 of this Order. Each report shall cover the period ending on the last day of each month. Each report must be sent to DOJ, EPA, and DNER on or before the 15th day of the month following the reporting period. Each monthly report shall include:

i. description of compliance with each requirement of this Order;

ii. the volume, acreage, and location of the Intermediate Cover that was applied;

iii. the volume and disposition of leachate and leachate-contaminated stormwater collected;

iv. results of any sampling analysis performed; and

v. Notification of any noncompliance with this Order, including a statement describing the noncompliance and its underlying causes, proposed measures, and an implementation schedule to correct the noncompliance.

The monthly report is divided into four sections.

Section 1 summarizes the order requirements and the compliance status for each requirement. *Please note that Task IDs are not related to the Order assigned paragraphs.*

Section 2 will include detailed information or supporting documentation regarding the compliance status of each requirement needing a comprehensive description or status details.

Section 3 is a list of weekly inspections performed, and

Section 4 is the projection of next month's activities.

Section 5 includes all the attachments to the report.

III. Section 1: SUMMARY

Municipality of Toa Alta Civ. No. 3:21-01087-DRD		
Reporting Period:		October 01 to October 31, 2023
Reporting Number:		14
Reporting Official:		Nivia Ayala, PE/TerraTek
Reporting Date:		11/30/2023
	Description of Compliance with Each Requirement of the Order	
ID	Requirement	Compliance Status
2	Access	In-Compliance
3	Daily Cover	In Compliance
4	Cessation of Waste Disposal	In-Compliance
5	Posting of Signs	In Compliance
6	Intermediate Cover	In-Compliance Intermediate Cover activities for the initial 5.4 cuerdas started on August 29, 2023, with the areas identified by the surveyor. i. As of October 31, 2023, 2098 cubic meters had been applied as intermediate cover at the facility; the following area (Top Deck) for intermediate cover was cleaned, vegetation will be removed, and stormwater channels will be improved. The contractor is still working on the vegetation removal without exposing disposed waste.
7	Maintenance of Cover	In-Compliance
8	Slope Stability	In compliance with agreed short-term controls, safety barrier fencing, and H&S program.
9	Leachate Management	
9a	Leachate Management Plan	A formal Leachate Management Plan was submitted with the Preliminary Closure Plan on October 31, 2023.

9b	Management of Leachate Collected from Landfill	A new permit renewal application was submitted to PRASA on July 31, 2023. We are awaiting the approval of the application.
10	Stormwater Management	
10a	Short Term Controls	In- Compliance
10 b	Survey of Leachate Seeps	In-Compliance
10c	Stormwater Management Plan	In-Compliance
10d	Discharges of Stormwater Not from Pond	N/A
10e	Discharge/Disposal of Pond Liquid	N/A
Additional Requirements		
The volume, acreage, and location of the Intermediate Cover that was applied.		The next area (Top Deck) for intermediate cover was cleaned, vegetation removed, and stormwater channels improved. The contractor is still working on the vegetation removal without exposing disposed waste.
The volume and disposition of leachate-contaminated stormwater collected.		None
Results Of Any Sampling Analysis Performed		None
Notification Of Noncompliance		None

IV. SECTION 2: DETAIL INFORMATION OR SUPPORTING DOCUMENTATION OF EACH REQUIREMENT IN NEED OF COMPREHENSIVE DESCRIPTION OR STATUS DETAILS

A. COMPLETED REQUIREMENTS

Access:

Access is granted to the United States and the Commonwealth of Puerto Rico and their employees, representatives, and contractors to conduct the necessary inspections and studies, including reviewing the applicable record to evaluate existing conditions, following the agreed terms in the Stipulation.

Daily Cover:

Daily Cover at the facility was completed on April 30, 2022. Daily Cover covered all areas of exposed waste.

Cessation of Waste Disposal:

The cessation of waste disposal at the facility was completed by March 30, 2022. However, as agreed in the Stipulation, the temporary storage of construction and demolition (C&D) waste, bulk household waste (durable goods such as mattresses, furniture, and appliances), or yard waste (vegetation waste generated by land maintenance) for final disposal at a different landfill is active and been performed daily.

Posting of Signs:

A sign with a size of four feet by five feet was installed at the landfill entrance. See the attached pictures.

Safety Barrier Fencing

Completed on April 28, 2023.

B. Supporting documentation of each requirement in need of comprehensive description or status details

1. ID 6: Intermediate Cover

The following is a chronological order of the Municipality performed steps to negotiate and acquire the funds to perform this task:

<u>Rural Development:</u>

1. On May 18, 2020, the Municipality submitted a Notice of Intent to Rural Development requesting the award of funds under the Disaster Mitigation Assistance Grant for the Landfill.
2. On September 4, 2020, the Municipality amended its request to include the landfill closure, post-closure activities, and expansion.
3. On August 16, 2021, the Municipality received a Rural Development email confirming that all the documents for the appropriate Disaster Mitigation Assistance Grant for the Landfill were completed.
4. On August 22, 2022, the Municipality held a Public Hearing about the requested grant funds.

5. USDA Rural Grant Program, MTA submitted a final Environmental Assessment to: Quiles, Danna - RD, San Juan, PR <danna.quiles@usda.gov>; Cabrera, Jose - RD, San Juan, PR <Jose.Cabrera@usda.gov>; Davila, Sandimary - RD, San Juan, PR <Sandimary.Davila@usda.gov>; Gonzalez, Melvin - RD, SAN JUAN, PR <Melvin.Gonzalez@usda.gov>. The document was submitted on September 30, 2022.
6. As of today, the Rural Development process is still ongoing but has not yet been completed.

Department of Natural and Environmental Resources (DNER)

1. A letter dated January 26, 2023, was directed to the MTA Mayor approving $1.3M for planning and design of the closure activities. No disbursement has been received at this moment.
2. The Municipality designated $3 Million of their ARPA funds to commence the execution of the required Intermediate Cover tasks.
3. The $1.3M was reimbursed for planning and design in February 2023.
4. The MTA commenced in January 2023 an RFQ process for a Landfill Contractor to implement the Intermediate. Unfortunately, no contractor submitted a proposal for the RFQ.
5. Thus, a new formal drawing was developed to identify the specific project specifications to issue an RFP purpose that would allow more flexibility for contractors to participate. The MTA prepared a new RFP that was published in May 2023.
6. The MTA had two contractors participate in the RFP process, and it is evaluating the proposals to issue the final determination that would allow the commencement of the work during August 2023.
7. The RFP was awarded to LC Group on August 16, 2023.

1a. ID 6: Intermediate Cover

The tasks of applying intermediate cover started on August 29, 2023.

i. As of October 31, 2023, 2098 cubic meters had been applied as intermediate cover at the facility.

V. SECTION 3: WEEKLY INSPECTIONS PERFORMED DURING THE REPORTING PERIOD

Inspections were performed by TerraTek Engineering Group personnel on the following days:

October 6, 2023

October 13, 2023

October 20, 2023, and

October 27, 2023

VI. SECTION 4: PROJECTION OF NEXT MONTH'S ACTIVITIES

November 3, 2023 Weekly Inspection	Continue with the Intermediate Cover Activities. Follow-up PRASA regarding Discharge Permit Application.
November 10, 2023 Weekly Inspection	Follow up DNER for Closure Plan Evaluation and Approval Vector Control Measures Placement
November 17, 2023 Weekly Inspection	Submit the project status report to the OGP (Puerto Rico's Office of Management and Budget).
November 24, 2023 Weekly Inspection	

These dates are subject to change.

VII. Section 4: Attachments

Attachment 1: Weekly Inspections

Attachment 2: Preliminary Closure Plan

ATTACHMENT 2

Friday, October 6, 2023

Approval Status	Approved
Nombre de la persona que hace la inspeccion	Christian Villalta Calderón
Email	cristhianvillalta@gmail.com
Fecha	Friday, October 6, 2023
Hora	03:40 PM
Condicion del Clima	Soleado
Esta la entrada limpia y libre de basura?	Si
Foto Entrada	

Hay Personal en la caseta de seguridad?

SI

Cuantos camiones han llegado en el dia?

8

Fecha de la ultima verificacion del sistema de manejo de lixiviados Celda Sur?

Friday, October 6, 2023

Horas de operacion de la planta electrica

8

Datos de eventos de lluvia

No hay datos de lluvia registrados. La instalación no cuenta con pluviometro.

Estan las areas verdes limpias y se ha realizado mantenimiento?

SI

Incluir Foto

Estan los diques limpios y sus valvulas cerradas con candado?	SI
Condicion de Cubierta Talud Norte	Excelentes condiciones
Incluir foto	

Condicion Operacion Recibo de Escombros

Necesita Limpieza

Tomar foto

Equipos Operando

Al momento de la inspección no hay equipos operando.

Condicion de medidas de control de erosion y sedimentacion	Buena
Se pueden notar brotes de lixiviado?	NO
Condicion de los caminos internos	Excelentes condiciones
Condicion de areas de desvio de materiales	Area completamente limpia.
Signature	

Approval Activity History

Actor	Actions	Date
N Nivia Ayala nayala@terratekpr.com	Approve	Friday, October 13, 2023

Actor	Actions	Date
Notification	Email sent. (Your request has been approved.) cristhianvillalta@gmail.com	Friday, October 13, 2023

Friday, October 13, 2023

Approval Status	Approved
Nombre de la persona que hace la inspeccion	Christian Villalta Calderón
Email	cristhianvillalta@gmail.com
Fecha	Friday, October 13, 2023
Hora	03:29 PM
Condicion del Clima	Soleado
Esta la entrada limpia y libre de basura?	Si
Foto Entrada	

Hay Personal en la caseta de seguridad?

SI

Cuantos camiones han llegado en el dia?

10

Fecha de la ultima verificacion del sistema de manejo de lixiviados Celda Sur?

Friday, October 13, 2023

Horas de operacion de la planta electrica

8

Datos de eventos de lluvia

No hay datos registrados de lluvia.

Estan las areas verdes limpias y se ha realizado mantenimiento?

SI

Incluir Foto

Estan los diques limpios y sus valvulas cerradas con candado?	SI
Condicion de Cubierta Talud Norte	Excelentes condiciones
Incluir foto	

Condicion Operacion Recibo de Escombros

Necesita Limpieza

Tomar foto

Equipos Operando

No hay equipos operando al momento de la inspección.

Condicion de medidas de control de erosion y sedimentacion	Buena
Se pueden notar brotes de lixiviado?	NO
Condicion de los caminos internos	Excelentes condiciones
Condicion de areas de desvio de materiales	Area completamente limpia.
Signature	

Approval Activity History

Actor	Actions	Date
N Nivia Ayala nayala@terratekpr.com	Approve	Tuesday, November 28, 2023

Actor	Actions	Date
Notification	Email sent. (Your request has been approved.) cristhianvillalta@gmail.com	Tuesday, November 28, 2023

Friday, October 20, 2023

Approval Status	Approved
Nombre de la persona que hace la inspeccion	Christian Villalta Calderón
Email	cristhianvillalta@gmail.com
Fecha	Friday, October 20, 2023
Hora	12:38 PM
Condicion del Clima	Soleado
Esta la entrada limpia y libre de basura?	Si
Foto Entrada	

Hay Personal en la caseta de seguridad?

SI

Cuantos camiones han llegado en el dia?

6

Fecha de la ultima verificacion del sistema de manejo de lixiviados Celda Sur?

Friday, October 20, 2023

Horas de operacion de la planta electrica

8

Datos de eventos de lluvia

No hay datos registrados de lluvia. No se cuenta con pluviometro en las instalaciones del landfill

Estan las areas verdes limpias y se ha realizado mantenimiento?

SI

Incluir Foto

Estan los diques limpios y sus valvulas cerradas con candado?

SI

Condicion de Cubierta Talud Norte

Excelentes condiciones

Incluir foto

Condicion Operacion Recibo de Escombros

Necesita Limpieza

Tomar foto

Equipos Operando

Ninguno al momento de la inspección.

Condicion de medidas de control de erosion y sedimentacion	Buena
Se pueden notar brotes de lixiviado?	NO
Condicion de los caminos internos	Excelentes condiciones
Condicion de areas de desvio de materiales	Area completamente limpia.
Signature	

Approval Activity History

Actor	Actions	Date
N Nivia Ayala nayala@terratekpr.com	Approve	Monday, October 23, 2023

Actor	Actions	Date
Notification	Email sent. (Your request has been approved.) cristhianvillalta@gmail.com	Monday, October 23, 2023

Friday, October 27, 2023

Approval Status	Approved
Nombre de la persona que hace la inspeccion	Christian Villalta Calderón
Email	cristhianvillalta@gmail.com
Fecha	Friday, October 27, 2023
Hora	03:57 PM
Condicion del Clima	Lloviendo
Esta la entrada limpia y libre de basura?	Si

Foto Entrada

Hay Personal en la caseta de seguridad?

SI

Cuantos camiones han llegado en el dia?

6

Fecha de la ultima verificacion del sistema de manejo de lixiviados Celda Sur?

Friday, October 27, 2023

Horas de operacion de la planta electrica

8

Datos de eventos de lluvia

No hay datos disponibles.

Estan las areas verdes limpias y se ha realizado mantenimiento?

SI

Incluir Foto

Estan los diques limpios y sus valvulas cerradas con candado?	SI
Condicion de Cubierta Talud Norte	Excelentes condiciones
Incluir foto	

Condicion Operacion Recibo de Escombros

Necesita Limpieza

Tomar foto

Equipos Operando

Ninguno al momento de la inspeccion.

Condicion de medidas de control de erosion y sedimentacion	Buena
Se pueden notar brotes de lixiviado?	NO
Condicion de los caminos internos	Excelentes condiciones
Condicion de areas de desvio de materiales	Esta area esta completamente limpia.
Signature	

Approval Activity History

Actor	Actions	Date
N Nivia Ayala nayala@terratekpr.com	Approve	Tuesday, November 28, 2023

Actor	Actions	Date
Notification	Email sent. (Your request has been approved.) cristhianvillalta@gmail.com	Tuesday, November 28, 2023

ATTACHMENT 2

Toa Alta Municipal Landfill

PRELIMINARY CLOSURE PLAN OCTOBER 2023

N. Ayala
TERRATEK EG | P.O. BOX 367445 SAN JUAN, PR 00936 | 787-946-3690 | WWW.TERRATEKPR.COM

EXECUTIVE SUMMARY

The purpose of this Preliminary Closure Plan is to provide preliminary drawings and supporting documents to present a new Closure Plan strategy for the Toa Alta Municipal Landfill, as per the requirements of 40 CFR Part 258.60 and 258.61 and to comply with Puerto Rico Environmental Regulations Rule 138 of the Regulation for Non-Hazardous Solid Waste Landfills. This landfill is subject to a Stipulation and Preliminary Injunction Order with the United States Department of Justice Civ. No. 3:21-01087-DRD.

The Municipality of Toa Alta reached an agreement with the Puerto Rico Department of Natural and Environmental Resources to submit a Preliminary Design to initiate the process of submitting Final Construction Drawings for the final closure of the Landfill.

The design is presented in phases, in such a way that the Municipality can develop all closure requirements in manageable portions.

The key design elements to achieve compliance are:

A proposed Final Cover system utilizing three (3) different landfill covers;

1. Approximately 13.0 acres along the northern slopes are proposed to be capped with the ClosureTurf® system patented by Watershed Geo of Alpharetta, Georgia.
2. Approximately 12.1 acres along the south and east are proposed as evapotranspiration (ET) landfill cover as described in the February 2022 US EPA Guidance Document: Design, Implementation, and Approval of Evapotranspiration Covers in Puerto Rico.
3. Approximately 5.0 acres along the west and northwest are proposed to preserve existing vegetation designed with leachate/stormwater management controls.

- to prevent infiltration of surface water, thereby minimizing future leachate production and minimizing erosion and sedimentation from the cap;
- to minimize fugitive emissions of methane and enhance landfill gas capture;
- to minimize long-term cap maintenance.

BACKGROUND

The Toa Alta Municipal Solid Waste Landfill is situated at State Road PR-165, km 8.4, Contorno Ward, Toa Alta. According to the historical records for the Site waste deposition began in at least early 1970s. The Site accepted waste from the neighboring municipalities of Bayamon, Comerio, Corozal and Naranjito. The Site consists of approximately 30.3 acres unlined cell and a 4.4 acre lined cell, referred as the South Cell. The complete site covers approximately 18 hectares (44.47 acres) and the total waste footprint was calculated as 12.26 hectares (30.3 acres). After February 25, 2021, the waste acceptance was limited to 12,500 cubic yards per month. Since April 1, 2022, the Landfill ceased disposing of waste. However, there is a temporary storage of construction and demolition (C&D) waste, bulk household waste (durable goods such as mattresses, furniture, and appliances), or yard waste (vegetation waste generated by land maintenance) in up to four roll-off containers at the Landfill prior to its shipment for final disposal at a different landfill.

Figure 1 Site Location

Figure 2 Existing Conditions

This Reports is organized as follows:

Section 1:	Toa Alta Preliminary Engineering Report
Section 2:	Toa Alta Preliminary Engineering Calculations
Section 3:	Toa Alta Preliminary Closure Design Drawings
Section 4:	Toa Alta Preliminary CQA Plan

Reference documents used for this report:

- *Hydrologic/Hydraulic Preliminary Report December 2022 Prepared by Caribe Environmental Services.*
- *US EPA Guidance Document: Design, Implementation, and Approval of Evapotranspiration Covers in Puerto Rico.*
- *Preliminary Closureturf® Veneer Stability Analysis*
- *Preliminary Surface Water Management Systems Analysis (Closureturf® Hydrology And Hydraulic Analysis)*
- *Preliminary Final Cover (Closureturf®) System Infiltration Analysis*
- *Initial Leachate Management Plan Toa Alta Municipal Solid Waste Landfill, October 2022*
- *Stormwater management Plan Update, March 2023*
- *Toa Alta Municipal Landfill Stormwater Management Plan, July 2023*
- *Case 3:21-cv-01087 Docket #23 Declaration Hartuan Jame Law, 2021-07-15*

ENGINEERING REVISION DOCUMENT FOR TOA ALTA PRELIMINARY CLOSURE PLAN OCTOBER 2023

ASSUMPTIONS AND PROCEDURES CHECKED BY:
Signature: _____ PE
Printed Name: Nivia Ayala, PE
Affiliation: TerraTek Engineering Group, PSC
Title: General Manager
Date: 10/31/2023

COMPUTATIONS CHECKED BY:
Signature: Jerry R Blanton
Printed Name: Robbie Blanton, PE
Affiliation: Barge Design Solutions
Title: Solid Waste Lead
Date: 10/31/2023

COMPUTATIONS BY:
Signature: _____ PE
Printed Name: Samuel Sin, PE
Affiliation: Barge Design Solutions
Title: Civil Engineer
Date: 10/31/2023

APPROVED BY:
Signature: _____
Printed Name: Nivia Ayala, PE
Affiliation: TerraTek Engineering Group, PSC
Title: General Manager
Date: 10/31/2023

Approval Notes:

[1]This preliminary closure design (drawings and associated preliminary documents and calculations) shall not be considered final design and shall not be used for construction. The purpose of the preliminary closure design is to meet requirements of the U.S. district court for the district of Puerto Rico, stipulation and preliminary injunction order, civ. No. 3:21-01087-drd and to provide a basis for final design and construction documents for final closure of Toa Alta landfill. The preliminary final closure grades presented herein are based on assumed subsurface conditions, existing topographic survey, and general literature regarding the geologic conditions. Final design may require drilling, laboratory testing, and other means of determining site specific subsurface conditions for use in geotechnical global stability calculations for proposed final closure grades to meet required factors of safety for static and seismic conditions.

[2]During final design for areas of closureturf, detailed calculations, design, and layout will be provided for the proposed active horizontal gas collector/leachate management features, the proposed surficial passive gas vent system, proposed flare station, and possible alternate passive gas management (solar spark vent flares).

[3]Details shown herein are preliminary for purposes of describing design features and anticipated dimensions that will be confirmed during final design. Preliminary design details shall not be used for construction.

SECTION 1

Toa Alta Preliminary Engineering Report

PRELIMINARY

ENGINEERING REPORT

Municipality of Toa Alta, Puerto Rico

Preliminary Landfill Closure Design

Prepared For:

TerraTek Engineering Group, PSC

122 C. Isabel Andreu de Aguilar

San Juan, PR 00918

October 2023

PREPARED BY

BARGE

6525 The Corners Parkway, Suite 450
Peachtree Corners, GA 30092
BARGE # 3831800

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 Purpose of the Engineering Report

This Operations Manual has been prepared for TerraTek Engineering Group PSC on behalf of the Municipality of Toa Alta (MTA) Landfill to support the Preliminary Final Closure Design for the Toa Alta Landfill located south of the city of Toa Alta along PR 165.

THIS PRELIMINARY CLOSURE DESIGN (DRAWINGS AND ASSOCIATED PRELIMINARY DOCUMENTS AND CALCULATIONS) SHALL NOT BE CONSIDERED FINAL DESIGN AND SHALL NOT BE USED FOR CONSTRUCTION. THE PURPOSE OF THE PRELIMINARY CLOSURE DESIGN IS TO MEET REQUIREMENTS OF THE U.S. DISTRICT COURT FOR THE DISTRICT OF PUERTO RICO, STIPULATION AND PRELIMINARY INJUNCTION ORDER, CIV. NO. 3:21-01087-DRD AND TO PROVIDE A BASIS FOR FINAL DESIGN AND CONSTRUCTION DOCUMENTS FOR FINAL CLOSURE OF TOA ALTA LANDFILL.

1.2 Site Status

Barge Design Solutions, Inc. of Peachtree Corners, Georgia, (BARGE) was retained by TerraTek Engineering Group PSC in August 2023 to provide engineering services for a Preliminary Final Closure Design for the Toa Alta Landfill. Below is a review of BARGE's understanding of the current status of the landfill:

- According to MTA records, the landfill began operation in 1966. Two main waste cells were constructed and filled: the unlined northwest (original) cell, built over a karst depression, which reached capacity in August 2007; and a lined southeast (new) cell that reached capacity in 2016. Operation continued until 2022.
- Under a signed Stipulation and Preliminary Injunction Order (Order) Civ. No. 3:21-01087-DRD, MTA was required to cease disposal of waste by April 1, 2022.
- The Order required a number of required activities with timelines/deadlines: Access, Daily Cover, Cessation of Waste Disposal, Posting of Signs, Intermediate Cover, Maintenance of Cover, Slope Stability, Leachate Management, Stormwater Management, Approval of Plans, Good Engineering Practices, Reporting, Community Involvement, and Notices.
- The Order included a Declaration of Hartuan James Law (HJ Law) regarding risk of slope instability. The HJ Law document examined four critical cross sections and provided analysis and results for a static and seismic stability evaluation.

1.3 Preliminary Final Closure Design Elements

BARGE has prepared a Preliminary Final Closure Design with the following key elements:

- Approximately 13.0 acres along the northern slopes are proposed to be capped with the ClosureTurf® system patented by Watershed Geo of Alpharetta, Georgia. Used successfully in the U.S. since 2009, and now installed internationally, ClosureTurf® comprises a synthetic engineered turf manufactured by Shaw Industries of Dalton, Georgia overlays either: Agru America (of Georgetown, South Carolina) MicroSpike® textured high-density polyethylene (HDPE) MicroSpike™ geomembrane liner on flatter areas, or Agru America Super Gripnet® structured geomembrane liner on the slopes. A nominal ½-inch sand infill is applied to the synthetic turf.

- Beneath ClosureTurf®, three key elements are proposed:

    - A leachate collection toe drain that will convey leachate to an HDPE leachate pump station, whereby leachate will then be pumped to a storage tank on site via either: 1) leachate force main Alternate 1 that will convey leachate along the lower access road to the north and east to a centralized leachate tank/LFG blower/flare facility, or 2) leachate force main Alternate 2 that will convey leachate to the west to a leachate tank that is accessed by tanker truck on one-way lower access road and one-way exit from site through a gate.
    - An active horizontal landfill gas (LFG) collection/leachate management system consisting of trenches from bottom of slope to top of slope, dug through intermediate cover and containing perforated HDPE pipe within crushed stone. This system will allow leachate to drain into the leachate collection toe drain and HDPE leachate pump station.
    - a surficial passive LFG venting system with patented vents to mitigate landfill gas buildup during construction of the ClosureTurf® system.

- Approximately 12.1 acres along the south and east are proposed as evapotranspiration (ET) landfill cover as described in the February 2022 US EPA *Guidance Document: Design, Implementation, and Approval of Evapotranspiration Covers in Puerto Rico*.

- Approximately 5.0 acres along the west and northwest are proposed to preserve existing vegetation designed with leachate/stormwater management controls.

- The active horizontal LFG collection/leachate management system will have a series of horizontal gas collector wellheads that will be under vacuum from a blower system at the centralized leachate tank/LFG blower/flare facility, and convey collected LFG either to the centralized LFG blower/flare facility.

- Should the active horizontal LFG collection/leachate management system not produce required volume/quality of gas to sustain LFG combustion at the centralized LFG blower/flare, an Alternate passive LFG system will be utilized with

passive gas solar-spark vent flares located at the horizontal gas collector points wellheads.

1.4 ClosureTurf® Description

The proposed ClosureTurf® system detailed in Figure 1.1 is placed directly on top of a prepared subgrade (Intermediate Cover) and is comprised of the following components from bottom to top:

- 50-mil AGRU America, Inc. Super Gripnet® Structured Linear Low-Density Polyethylene (LLDPE) or High- Density Polyethylene (HDPE) Geomembrane (on slopes) or 40-mil AGRU America, Inc. MicroSpike® LLDPE Textured Geomembrane (on top deck areas)

- Drainage Layer which is integrated into the Super Gripnet® Structured Geomembrane (on slopes)

- Engineered Synthetic Turf (comprised of polyethylene fibers tufted through a double layer of woven polypropylene geotextiles manufactured for high UV and heat resistance); and

- Infill of ASTM C-33 or similar sand, or HydroBinder™ depending upon the hydraulic forces present in the area of application.

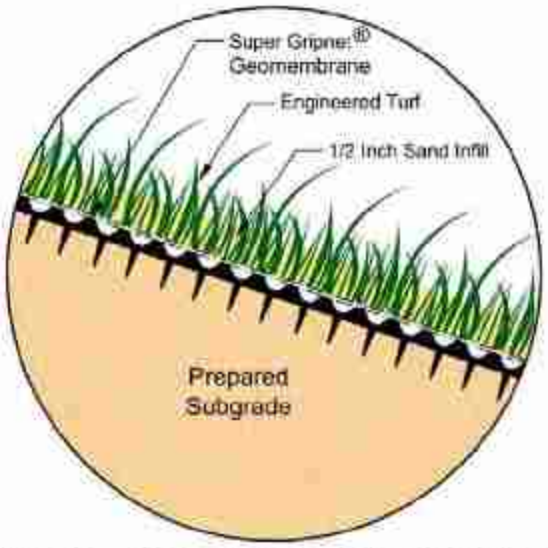

Figure 1.1 – Cross Section of ClosureTurf® System

1.5 Preliminary ET Cover Description

The proposed ET cover will consist of a thickened soil layer on top of or inclusive of Intermediate Cover that meets the textural soil classifications in Figure 1.2, and can support native vegetation (grasses, shrubs and trees.)

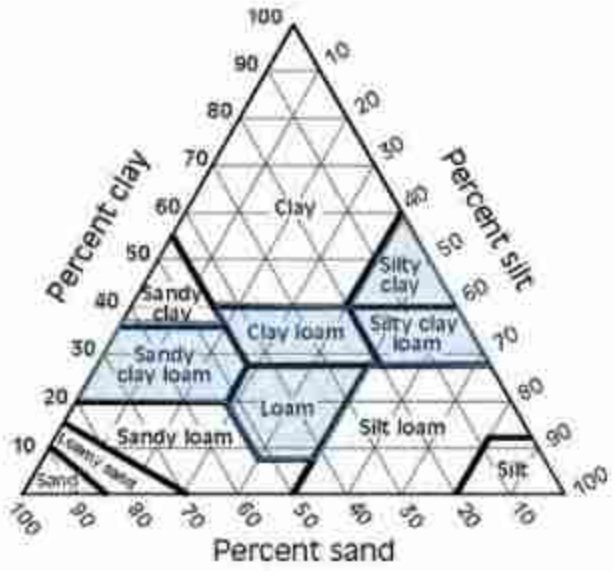

Figure 1.2 – Grain Size Distributions for USDA Textural Soil Classifications Acceptable for ET Covers in Puerto Rico (Shaded)
Source: USDA, n.d., from February 2022 US EPA *Guidance Document. Design, Implementation, and Approval of Evapotranspiration Covers in Puerto Rico.*

- Earthen cover placed over waste material to reduce water percolation into the underlying waste by using the water storage capacity of soils and the water removal capabilities of vegetation
- Allowable for use as a final landfill cover under US and Puerto Rico regulations when designed to be equivalent to conventional, compacted clay covers
- Straight-forward to design and review using the *Guidance Document*
- Ecologically self-sustainable when properly designed, built carefully, and planted with locally appropriate vegetation
- Low-cost when compared to conventional, compacted clay clovers

1.6 Environmental Benefits of the Proposed Cover Types

Environmental Benefits for the ClosureTurf® Area

- Approximately 13.0 acres along the northern slopes and "top deck" area are proposed to receive a ClosureTurf® final cover system designed to control stormwater, eliminate or drastically reduce rainwater infiltration and leachate production, and allow for the control of landfill gas (either through active collection and flaring, or through passive venting with solar spark flares)
- Provides visually aesthetic synthetic turf
- Reduces imported soil for closure resulting in direct reduction of vehicular traffic on locals roads, reduction of noise, reduction of fugitive dust
- Eliminates vegetative maintenance (mowing, fertilizing) and emissions associated with maintenance equipment
- Eliminates fugitive dust
- Improves stormwater quality
- Provides disease vector control
- Enhances global stability (flattening of existing slope to 2:4H:1V)

Environmental Benefits for the Evapotranspiration (ET) Cover Area

- Approximately 12.1 acres along the southern slopes and "top deck" area are proposed to receive ET landfill cover as described in the February 2022 US EPA *Guidance Document: Design, Implementation, and Approval of Evapotranspiration Covers in Puerto Rico*
- Allows for use of 40 CFR Part §258.60b closure criteria final cover alternative in lieu of a prescribed clay cover
- Lower long-term maintenance and improved final vegetative results compared to clay cover
- Allows for use of native trees, shrubs and grasses
- Decreases stormwater runoff and improves stormwater quality
- Provides disease vector control
- Reduces landfill gas emissions thorough increased rates of methane biological oxidation (as a result of thicker soil layer compared to prescribed clay covers; Abichou et al;, 2015)

Environmental Benefits for the Natural Area (Shown on Preliminary Closure Drawings as "Preserved Existing Vegetation with Leachate/Stormwater Management:"

- Approximately 5.0 acres along the west and northwest are proposed to preserve existing vegetation with leachate/stormwater management controls designed to provide for irrigation sufficient to support and sustain existing flora in, around, and downstream from the Landfill.
- Mature vegetation preservation on areas that have grown on top of the final daily cover can be equally protective as a designed cover.
- A seepage inventory demonstrated that the west area of the landfill does not represent an active source of leachate outflows.
- This 5.0-acre area will allow the sustainable preservation of the existing mature vegetation and provides required stormwater run-on to maintain existing conditions to effluents of Quebrada Arenas.

SECTION 2

Toa Alta Preliminary Engineering Calculations

PRELIMINARY CLOSURE DESIGN

PRELIMINARY

CLOSURETURF® CALCULATIONS

Municipality of Toa Alta, Puerto Rico

Preliminary Landfill Closure Design

Prepared For:

TerraTek Engineering Group, PSC

122 C. Isabel Andreu de Aguilar

San Juan, PR 00918

October 2023

PREPARED BY

BARGE

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Preliminary Calculations

Preliminary calculations noted below are provided and attached for the preliminary proposed ClosureTurf® areas shown on the Preliminary Closure Drawings for purposes of determining feasibility.

PRELIMINARY CLOSURETURF® VENEER STABILITY ANALYSIS

PRELIMINARY SURFACE WATER MANAGEMENT SYSTEMS ANALYSIS (CLOSURETURF® HYDROLOGY AND HYDRAULIC ANALYSIS)

PRELIMINARY FINAL COVER (CLOSURETURF®) SYSTEM INFILTRATION ANALYSIS

During final design for areas of ClosureTurf®, detailed calculations, design, and layout will be provided for the proposed active horizontal gas collector/leachate management features, the proposed surficial passive gas vent system, proposed flare station, and possible alternate passive gas management (solar spark vent flares).

Stormwater and leachate management features in the ET cover area will be determined during final design to promote environmental protection and promote slope stability until establishment of proposed et cover vegetation.

Stormwater and leachate management features in the area of preserved existing vegetation will be determined during final design to minimize disturbance of existing vegetation while promoting environmental protection.

This preliminary closure design (drawings and associated preliminary documents and calculations) shall not be considered final design and shall not be used for construction. The purpose of the preliminary closure design is to meet requirements of the U.S. District Court for the District of Puerto Rico, Stipulation and Preliminary Injunction Order, Civ. No. 3:21-01087-DRD and to provide a basis for final design and construction documents for final closure of Toa Alta landfill. The preliminary final closure grades presented are based on assumed subsurface conditions, existing topographic survey, and general literature regarding the geologic conditions. Final design may require drilling, laboratory testing, and other means of determining site specific subsurface conditions for use in geotechnical global stability calculations for proposed final closure grades to meet required factors of safety for static and seismic conditions.

PRELIMINARY CLOSURETURF® VENEER SLOPE STABILITY ANALYSIS

OBJECTIVE: Evaluates the veneer stability of Watershed Geo-patented ClosureTurf® installed as a final cover system for a hypothetical landfill. The analysis presented herein is from the Watershed Geo ClosureTurf® Design Guidance Manual and based on the procedure presented in Chapter 9 of the document titled "Geotechnical and Stability Analyses for Ohio Waste Containment Facilities" (OEPA 2004) located at: https://epa.ohio.gov/static/Portals/34/document/guidance/gd_660.pdf

PROCEDURE: The purpose of this section is to present methodology for evaluating the veneer stability for the cover system. The system will be evaluated for adequate sliding resistance due to gravitational forces and seismic forces.

METHOD:

Static and Seismic Veneer Slope Stability

Slope stability of a final cover system can be evaluated based on infinite slope or finite slope methods:

1. Infinite Slope Method: This method assumes an infinitely long slope and considers driving and resisting forces acting parallel to the slip plane. It's a simplified approach often used for stability analysis.

2. Finite Slope Method: In contrast, the finite slope method considers a slope of finite length and also takes into account the toe-buttressing effect. This method provides a more comprehensive analysis of slope stability.

3. ClosureTurf System: The ClosureTurf system is subjected to static and seismic slope stability analyses. These analyses aim to determine whether the system can withstand the forces acting on it and remain stable.

4. Method Developed by Matasovic [1991]: The stability analysis for the ClosureTurf system uses the infinite slope method developed by Matasovic in 1991. This method is chosen for its simplicity and may be well-suited for the specific conditions and requirements of the project.

$$FS = \frac{\frac{a}{\gamma_c z_c \cos^2\beta} + \tan\delta\left(1 - \frac{\gamma_w (z_c - d_w)}{\gamma_c z_c}\right) - k_s \tan\beta \tan\delta}{k_s + \tan\beta}$$

where:

FS	=	factor of safety;
β	=	slope inclination angle;
δ	=	friction angle along the critical slip surface;
a	=	adhesion intercept along the critical slip surface;
z_c	=	depth of the critical slip surface measured from the top of final cover (i.e., thickness of sand infill);
γ_c	=	unit weight of sand infill;
γ_w	=	unit weight of water = 62.4 pcf;
d_w	=	depth to water surface measured from the top of final cover (i.e., $z_c - h_{avg}$); and
k_s	=	seismic coefficient.

Evaluate the hydraulic head acting on the geomembrane

The average hydraulic head acting on the geomembrane is computed using equations presented in OEPA (2004). These equations are:

$$h_{av\theta} = \frac{P\,(1 - RC)L\,(\cos\beta)}{k_d\,(Sin\,\beta)}$$

or if h_{avg} from the above calculations is greater than Td then use: havg = $T_d + T_c$

$$h_{av\theta} = \frac{k_c\,L\,(\cos\beta)}{k_d\,(Sin\,\beta)}$$

Where:

h_{avg}	=	average hydraulic head;
P	=	precipitation;
β	=	slope inclination angle;
L	=	slope length;
T_c	=	thickness of cover soil (i.e., sand infill);
RC	=	runoff coefficient (SCS Runoff Curve Number/100);
k_d	=	hydraulic conductivity of drainage layer;
T_d	=	thickness of drainage layer; and
k_c	=	hydraulic conductivity of cover soil (i.e., sand infill)

INPUT PARAMETERS AND ANALYSIS ASSUMPTIONS

Veneer stability analyses will be performed for a slope that is considered the longest and steepest of the design grades of the landfill final cover system. The following input parameters were assumed.

Slope Geometry

slope inclination angle, β = 22.62° (i.e., 2.4 horizontal to 1 vertical)
slope maximum height, H = 26 m
slope Length, L = 68 m = 6,800 cm

ClosureTurf

sand infill thickness, z_c = 0.5 in total unit
weight of sand infill, γ_c = 115 pcf
critical interface friction angle, δ = 36°
critical interface adhesion intercept, a= 0 psf
runoff curve number (CN): = 95
drainage stud height, T_d = 3.3 mm

Transmissivity, Θ = 3.86×10^{-3} m^2/sec

Precipitation, P = 3.35 in/hour (or 2.84×10^{-3} cm/sec)

Seismic Parameters

The seismic coefficient at the site = 0.05g

CALCULATIONS AND RESULTS

Calculate the hydraulic head on the geomembrane

Step 1 - Calculate the Long-term Transmissivity of the ClosureTurf® Drainage Layer

$$\theta_L = \frac{\theta}{FS_I \times FS_{Cr} \times FS_{CC} \times FS_B \times FS_S}$$

θ_L = long-term transmissivity;
θ = tested transmissivity;
FS_I = reduction factor to account for intrusion;
FS_{Cr} = reduction factor to account for creep;
FS_{CC} = reduction factor to account for chemical clogging;
FS_B = reduction factor to account for biological clogging; and
FS_S = reduction factor to account for clogging due to infiltration of fines.

The reduction factors FSs of 4.0 was considered to account for potential clogging due to infiltration of fines. The other reduction factors are not considered to be applicable to ClosureTurf and therefore, were assumed to be 1.0.

$$\theta_L = \frac{3.86 \times 10^{-3}}{1.0 \times 1.0 \times 1.0 \times 1.0 \times 4.0} = 7.09 \text{ cm}^2/\text{sec}$$

Step 2 - Convert the Transmissivity to Hydraulic Conductivity

$$K_d = \frac{\theta_L}{T_d} = \frac{7.09}{0.33} = 21.49 \text{ cm/sec}$$

Step 3 – Calculate the Average Hydraulic Head

Check if P(1-RC) > Kc

$P(1\text{-}RC) = 2.84 \times 10^{-3} \times (1 - 95/100) = 1.42 \times 10^{-4}$ cm/sec

This value is less than the permeability of the sand infill, which has a typical permeability in the order of 10^{-2} cm/sec. Therefore, the following equation is used to calculate the hydraulic head:

$$h_{avg} = \frac{P(1 - RC) \times L(\cos\beta)}{k_d(\sin\beta)} = 0.1078 \text{ cm} = 0.042 \text{ in}$$

The calculated hydraulic head is less than the thickness of the internal drainage layer (T_s), which is 0.33 cm.

Step 2 – Calculate the static and seismic FS

Depth to water surface, $d_w = z_c - h_{avg} = 0.5 - 0.042 = 0.457$ inch

Static Veneer Slope Stability

$$FS_{Static} = \frac{\frac{a}{\gamma_c z_c cos^2\beta} + \tan\delta\left(1 - \frac{\gamma_w (z_c - d_w)}{\gamma_c z_c}\right) - k_s \tan\beta \tan\delta}{k_s + \tan\beta} = 1.66$$

Seismic Veneer Slope Stability

For veneer stability analysis of ClosureTurf, the seismic coefficient on the top of the landfill should be used. Therefore, using the seismic coefficient at the site and assuming 100 ft of waste, the seismic coefficient at the final cover surface is estimated to be 0.10g.

$$FS_{Seismic} = \frac{\frac{a}{\gamma_c z_c cos^2\beta} + \tan\delta\left(1 - \frac{\gamma_w (z_c - d_w)}{\gamma_c z_c}\right) - k_s \tan\beta \tan\delta}{k_s + \tan\beta} = 1.28$$

SUMMARY AND CONCLUSIONS

The factor of safety against veneer stability was calculated for a 2.4 horizontal to 1 vertical slope. The computed factors of safety are equal to or greater than the target factors of safety of 1.5 for long-term static conditions, and 1.0 for seismic conditions.

PRELIMINARY SURFACE WATER MANAGEMENT SYSTEMS ANALYSIS

OBJECTIVE: Evaluate surface water management system to be constructed as a part of the master plan design and verify the following: (i) the redeveloped discharge rates are compatible with the predevelopment discharge rates, and (ii) surface water structures meet minimum acceptable design standards (i.e., erosion prevention and flow capacity).

PROCEDURE: Standard surface water hydrology methods will be used to estimate run-off and evaluate permanent surface water management features. The computer program "Hydraflow Hydrographs", which employs the modeling methods presented in USDA-SCA Technical Releases 20 and 55, will be used to estimate run-off for both the predevelopment and post-development conditions. Hydraflow, various technical reports, and applicable product design manuals will be used to evaluate the various permanent surface water management features.

METHOD: The surface water management system will be designed to control the runoff from the 25-year frequency, 24-hour duration storm event.

CALCULATION SUMMARY:

Pond Calculations

1. Existing North Pond

The final design condition for the landfill was used to design the pond. Pre-developed information was developed from existing conditions. In accordance with the detention requirements, post-developed flow through the study point was designed not to exceed the peak storm rate for the 25-year storms as based on the Soil Conservation Service (SCS) Hydrology for a 24-hour storm event with a Type II rainfall distribution.

Detailed calculations for curve number calculations follow for the pond. Hydraflow Hydrographs, was used to create the pre-developed hydrograph, create the post-developed hydrograph, and to route the post-developed hydrograph through the pond to create the outflow hydrograph. The output from these calculations is provided at the end of this section.

The calculations demonstrate that the routed 25-year 24-hour storm will require 12,680 cubic meters of storage at elevation 111.21 m and the routed 100-year 24-hour storm will require 18,251 cubic meters of storage at elevation 112.37 m. The existing north pond has a capacity of 32,786 cubic meters (Hydrographs pg. 6, Pond Report – Ex. North Pond) at elevation 115 m, therefore, the pond has adequate storage for the required routed flow and includes sediment storage.

2. Existing South Pond

The final design condition for the landfill was used to design the pond. Pre-developed information was developed from existing conditions. In accordance with the detention requirements, post-developed flow through the study point was designed not to exceed the peak storm rate for the 25-year storms as based on the Soil Conservation Service (SCS) Hydrology for a 24-hour storm event with a Type II rainfall distribution.

Detailed calculations for curve number calculations follow for the pond. Hydraflow Hydrographs, was used to create the pre-developed hydrograph, create the post-developed hydrograph, and to route the post-developed hydrograph through the pond to create the outflow hydrograph. The output from these calculations is provided at the end of this section.

The calculations demonstrate that the routed 25-year 24-hour storm will require 11,222 cubic meters of storage at elevation 117.56 m and the routed 100-year 24-hour storm will require 16,152 cubic meters of storage at elevation 119.29 m. The existing north pond has a capacity of 22,157 cubic meters (Hydrographs pg. 9, Pond Report – Ex. South Pond) at elevation 121 m, therefore, the pond has adequate storage for the required routed flow and includes sediment storage.

Bench Capacity

The final design condition for the landfill was used to design the benches. At the worst-case scenario, the peak flow at the bench for 25-year 24-hour storm was 15.9 cfs. The design capacity for the bench, based on the calculation from Hydraflow Express, was 169.2 cfs. Therefore, the bench has adequate capacity for the required flow. Please see the attached Hydraflow Hydrographs and Express reports.

Downchute Capacity

The final design condition for the landfill was used to design the downchutes. At the worst-case scenario, the peak flow at the downchute for 25-year 24-hour storm was 22.7 cfs. The design capacity for the downchute, based on the calculation from Hydraflow Express, was 568.2 cfs. Therefore, the downchute has adequate capacity for the required flow. Please see the attached Hydraflow Hydrographs and Express reports.

Top (V) Ditch Capacity

The final design condition for the landfill was used to design the top ditch. At the worst-case scenario, the peak flow at the top ditch for 25-year 24-hour storm was 24.17 cfs. The design capacity for the top ditch, based on the calculation from Hydraflow Express, was 140.7 cfs. Therefore, the top ditch has adequate capacity for the required flow. Please see the attached Hydraflow Hydrographs and Express reports.

Bottom Ditch Capacity

The final design condition for the landfill was used to design the bottom ditch. At the worst-case scenario, the peak flow at the bottom ditch for 25-year 24-hour storm was 81.32 cfs. The design capacity for the bottom ditch, based on the calculation from Hydraflow Express, was 857.12 cfs. Therefore, the bottom ditch has adequate capacity for the required flow. Please see the attached Hydraflow Hydrographs and Express reports.

PRELIMINARY FINAL COVER (CLOSURETURF®) SYSTEM INFILTRATION ANALYSIS

OBJECTIVE: Evaluate the rainfall infiltration through the final cover ClosureTurf® system and verify the hydraulic efficiency of the existing landfill bottom layer.

PROCEDURES: Modeling of the infiltration through the proposed cover system and waste layers will be carried out using the Visual HELP program by Schlumberger Water Services, based upon the original Hydrologic Evaluation of Landfill Performance (HELP) model, developed for the USEPA by Schroeder et.al. 1994.

ASSUMPTIONS: The assumptions of climatic and material data to be used for HELP analysis will be based on the proposed cover design and local conditions. It is anticipated that the final cover system will be extremely effective in minimizing infiltration into the waste. Typically, we would anticipate a 99% hydraulic efficiency for the proposed cover system.

CALCULATION SUMMARY: Final cover infiltration modeling for the Toa Alta Landfill was estimated using the HELP model.

The results of the HELP model was utilized to demonstrate that very little accumulated leachate will penetrate the existing landfill bottom layer after 50 years.

The following are the liner system and input parameters used in the HELP model runs.
The final cover system is **assumed to be a Closureturf synthetic cap:**

FINAL COVER SYSTEM WITH EXISTING LANDFILL BOTTOM

- The top Layer 1.1 is a fine sand layer
- Layer 1.2 is a geocomposite drainage net
- Layer 1.3 is a 50-mil Agru Super Gripnet LLDPE structured geomembrane
- Layers 1.4 to 1.15 are alternating intermediate cover and municipal solid waste layers
- Layer 1.16 is a 2-foot-thick clay layer ($2x10^{-5}$ cm/sec permeability)

INPUT PARAMETERS

- Toa Alta, Puerto Rico was used for the default climatology.
- The refuse in the model was typical solid waste.

CONCLUSIONS

The results of the HELP model for the standard base liner system indicate that only 227 cubic feet or 1,700 gallons of accumulate leachate will penetrate the existing bottom layer after 50 years.

Project : Toa Alta CT

Description

Model : HELP
An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Your title Samuel Sin

Client : Title Key contact person

Location : San Juan

10/27/2023

1. Profile. CT 50yr

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Vegetation Class	Good stand of grass	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Loamy Fine Sand	526.0507	526.0107	0.0400
Drainage Net (0.5cm)	526.0112	525.9948	0.0164
Low Density Polyethylene (LDPE)	525.9948	525.9915	0.0033
Silty Loam	525.9965	524.4965	1.5000
Municipal Waste (312 kg/cub.m)9	524.4965	499.4965	25.0000
Silty Loam7	499.4965	498.4965	1.0000
Municipal Waste (312 kg/cub.m)8	498.4965	473.4965	25.0000
Silty Loam3	473.4990	472.4990	1.0000
Municipal Waste (312 kg/cub.m)7	472.4990	447.4990	25.0000
Silty Loam2	447.4995	446.4995	1.0000
Municipal Waste (312 kg/cub.m)6	446.4995	421.4995	25.0000
Silty Loam6	421.5000	420.5000	1.0000
Municipal Waste (312 kg/cub.m)4	420.5000	395.5000	25.0000
Silty Loam1	384.9985	383.9985	1.0000
Municipal Waste (312 kg/cub.m)	384.0000	372.0000	12.0000
Silty Clay	372.0000	370.0000	2.0000

1.1. Layer. Loamy Fine Sand

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 40.0000
Bottom Slope : 40.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.457	(vol/vol)
field capacity	0.131	(vol/vol)
wilting point	0.058	(vol/vol)
sat.hydr.conductivity	1E-3	(cm/sec)
subsurface inflow	0	(mm/year)

1.2. Layer. Drainage Net (0.5cm)

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 40.0000
Bottom Slope : 40.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	10	(cm/sec)
subsurface inflow	0	(mm/year)

1.3. Layer. Low Density Polyethylene (LDPE)

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 40.0000
Bottom Slope : 40.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	4E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	4	(#/ha)
placement quality	4	(-)
geotextile transmissivity	0	(cm2/sec)

1.4. Layer. Silty Loam

Top Slope Length: 400.0000
Bottom Slope Length: 0.0000
Top Slope: 40.0000
Bottom Slope : 40.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.5. Layer. Municipal Waste (312 kg/cub.m)9

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 40.0000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.6. Layer. Silty Loam7

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.7. Layer. Municipal Waste (312 kg/cub.m)8

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.8. Layer. Silty Loam3

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.9. Layer. Municipal Waste (312 kg/cub.m)7

Top Slope Length: 400.0000
Bottom Slope Length: 400.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.10. Layer. Silty Loam2

Top Slope Length: 400.0000
Bottom Slope Length: 300.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.11. Layer. Municipal Waste (312 kg/cub.m)5

Top Slope Length: 300.0000
Bottom Slope Length: 300.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.12. Layer. Silty Loam6

Top Slope Length: 300.0000
Bottom Slope Length: 300.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.13. Layer. Municipal Waste (312 kg/cub.m)4

Top Slope Length: 300.0000
Bottom Slope Length: 300.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.14. Layer. Silty Loam1

Top Slope Length: 0.0000
Bottom Slope Length: 300.0000
Top Slope: 2.5000
Bottom Slope : 2.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.501	(vol/vol)
field capacity	0.284	(vol/vol)
wilting point	0.135	(vol/vol)
sat.hydr.conductivity	1.9E-4	(cm/sec)
subsurface inflow	0	(mm/year)

1.15. Layer. Municipal Waste (312 kg/cub.m)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.671	(vol/vol)
field capacity	0.292	(vol/vol)
wilting point	0.077	(vol/vol)
sat.hydr.conductivity	0.001	(cm/sec)
subsurface inflow	0	(mm/year)

1.16. Layer. Silty Clay

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.479	(vol/vol)
field capacity	0.371	(vol/vol)
wilting point	0.251	(vol/vol)
sat.hydr.conductivity	2.5E-5	(cm/sec)
subsurface inflow	0	(mm/year)

Annual Totals volume (ft3)

	Year-1	Year-10	Year-30	Year-50
Precipitation (ft3)	1.0716E+06	1.0170E+06	1.0864E+06	1.1385E+06
Runoff (ft3)	2.2319E+05	2.5192E+05	2.1772E+05	2.3710E+05
Lateral drainage collected from Layer 2 (ft3)	7.0772E-01	6.5839E-01	7.1875E-01	5.8244E-01
Percolation or leakance through Layer 3 (ft3)	4.2925E+02	3.9249E+02	4.2871E+02	3.7035E+02
Percolation or leakance through Layer 16 (ft3)	**4.3006E+02**	3.9376E+02	4.2728E+02	**3.6924E+02**

(continued)

	Total
Precipitation (ft3)	5.6006E+07
Runoff (ft3)	1.3101E+07
Lateral drainage collected from Layer 2 (ft3)	3.8218E+01
Percolation or leakance through Layer 3 (ft3)	2.2671E+04
Percolation or leakance through Layer 16 (ft3)	2.2670E+04

	Year-1	Year-2	Year-3	Year-4
Percolation or leakance through Layer 16 (ft3)	4.3006E+02	5.5134E+02	4.1440E+02	5.3040E+02

(continued)

	Year-5	Year-6	Year-7	Year-8
Percolation or leakance through Layer 16 (ft3)	4.2947E+02	5.1617E+02	4.4042E+02	4.1061E+02

(continued)

	Year-9	Year-10	Year-11	Year-12
Percolation or leakance through Layer 16 (ft3)	4.0870E+02	3.9376E+02	3.6778E+02	3.1093E+02

(continued)

	Year-13	Year-14	Year-15	Year-16
Percolation or leakance through Layer 16 (ft3)	6.1062E+02	4.6285E+02	4.6335E+02	5.0745E+02

(continued)

	Year-17	Year-18	Year-19	Year-20
Percolation or leakance through Layer 16 (ft3)	6.0301E+02	5.0864E+02	3.8843E+02	3.8745E+02

(continued)

	Year-21	Year-22	Year-23	Year-24
Percolation or leakance through Layer 16 (ft3)	4.4537E+02	4.8842E+02	3.2895E+02	3.4775E+02

(continued)

	Year-25	Year-26	Year-27	Year-28
Percolation or leakance through Layer 16 (ft3)	6.0339E+02	5.3047E+02	4.4005E+02	4.2524E+02

(continued)

	Year-29	Year-30	Year-31	Year-32
Percolation or leakance through Layer 16 (ft3)	3.2826E+02	4.2728E+02	4.4945E+02	6.1562E+02

(continued)

	Year-33	Year-34	Year-35	Year-36
Percolation or leakance through Layer 16 (ft3)	3.7085E+02	4.4192E+02	4.4036E+02	4.8346E+02

(continued)

	Year-37	Year-38	Year-39	Year-40
Percolation or leakance through Layer 16 (ft3)	4.2133E+02	4.5887E+02	5.0802E+02	5.2293E+02

(continued)

	Year-41	Year-42	Year-43	Year-44
Percolation or leakance through Layer 16 (ft3)	4.8161E+02	4.4128E+02	3.2408E+02	5.1910E+02

(continued)

	Year-45	Year-46	Year-47	Year-48
Percolation or leakance through Layer 16 (ft3)	5.8622E+02	3.8599E+02	3.6359E+02	5.4236E+02

(continued)

	Year-49	Year-50	Total
Percolation or leakance through Layer 16 (ft3)	4.4243E+02	3.6924E+02	2.2670E+04

Peak daily values

	Rate	Volume	Day	Year
Percolation or leakance through Layer 16	2.8967E-04	8.9376E+00	29	2

PRELIMINARY LEACHATE INTERCEPTOR COLLECTION PIPING AND STORAGE CAPACITIES

OBJECTIVE: Evaluate the capacity of the leachate interceptor collection system piping and storage tank.

PROCEDURES: The Hydrologic Evaluation of Landfill Performance (HELP) model, developed by US EPA, will be utilized along with standard principles of pipe sizing design.

ASSUMPTIONS: The following assumptions will be made in support of the leachate collection system sizing:

- leachate collection area from Preliminary Closure Design; and
- peak infiltration values will be used to assist with sizing the leachate collection pipe and storage tank.

LEACHATE COLLECTION LINE AND STORAGE CAPACITY

The HELP model run for a final condition is considered as supporting design data used for the 4-inch leachate interceptor collection pipe calculation included at the end of this section. The pertinent data from the HELP model results (following this narrative) is that the peak daily leachate volume is 8.937 cubic feet per day, or 0.0001 cubic feet per second (cfs) for the area draining to the toe drain under proposed ClosureTurf area of 8.5 acres.

COLLECTION PIPE CAPACITY

Peak daily flow from HELP: 0.0001 cfs
The 4-inch HDPE at minimum 2% slope has the following capacity:

$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$, where n = 0.012 and S = 0.02
$Q = (1.486/0.012)*0.0872*0.3011*0.1414 = 0.46$ cfs

Therefore, the 0.46 cfs capacity of the 4-inch collection line is greater than the 0.0001 cfs peak flow to the line.

LEACHATE STORAGE TANK CAPACITY

Again, HELP model runs presented previously are used to verify sizing of the leachate storage tank. Assuming the peak annual total volume from the HELP model output in year 32, the peak monthly volume can be calculated as:

(616 cubic feet) / 12 months * 7.481 gal/cubic foot = 384 gallons per month

This is very conservative as it represents a peak flow from the 8.5 acres of ClosureTurf area.

The suggested minimum tank size should have a capacity of 1,000 gallons. Therefore, the tank can provide 2.6 months of storage at peak estimated leachate flow.

PRELIMINARY LEACHATE PUMP STATION PUMPING CAPACITY

OBJECTIVE: Evaluate the pumping capacity of the leachate interceptor pump station.

PROCEDURES: Utilize calculation of total dynamic head (TDH) curve plotted on manufacturer's Pump Curve.

TOTAL DYNAMIC HEAD (TDH) ALTERNATE 1 TANK LOCATION

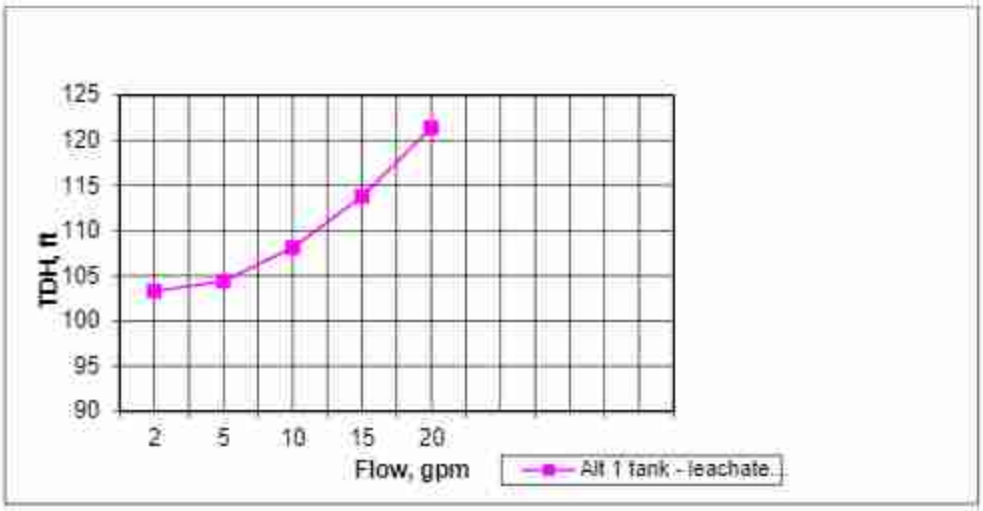
From the design plan for the **Alternate 1** tank location, assumptions are made for static head. TDH is calculated for selected flows between 2 gpm and 20 gpm assuming a pipe condition of old steel.

Top pump station at 115 m or 374 ft, assume Sump pump at 364 ft, termin at tank base 140.5 m or 457 ft, assume inlet to tank at 467 ft

1105 ft fm 2"/4", differential elevation 103 ft

FLOW, gpm	TDH, ft (2")	Total TDH, ft
2	103.3	103.3
5	104.4	104.4
10	108.1	108.1
15	113.8	113.8
20	121.4	121.4

A TDH curve is plotted:



PUMP SELECTION AND DUTY POINT – ALTERNATE 1 TANK LOCATION

Assuming the use of GunnCo P2K-25 series Sidesloper™ Leachate Pump, a the TDH curve is plotted against P2K-25 models as shown on the following page.

The suggested duty point for **Alternate 1** tank location based upon the assumptions is 15 gpm @ 112 ft TDH for a P2K 25.5 model pump.

TOTAL DYNAMIC HEAD (TDH) ALTERNATE 2 TANK LOCATION

From the design plan for the **Alternate 2** tank location, assumptions are made for static head. TDH is calculated for selected flows between 2 gpm and 20 gpm assuming a pipe condition of old steel.

Top pump station at 115 m or 374 ft, assume Sump pump at 364 ft, termin at tank base 115 m or 374 ft, assume inlet to tank at 384 ft

238 ft fm 2"/4", differential elevation 20 ft

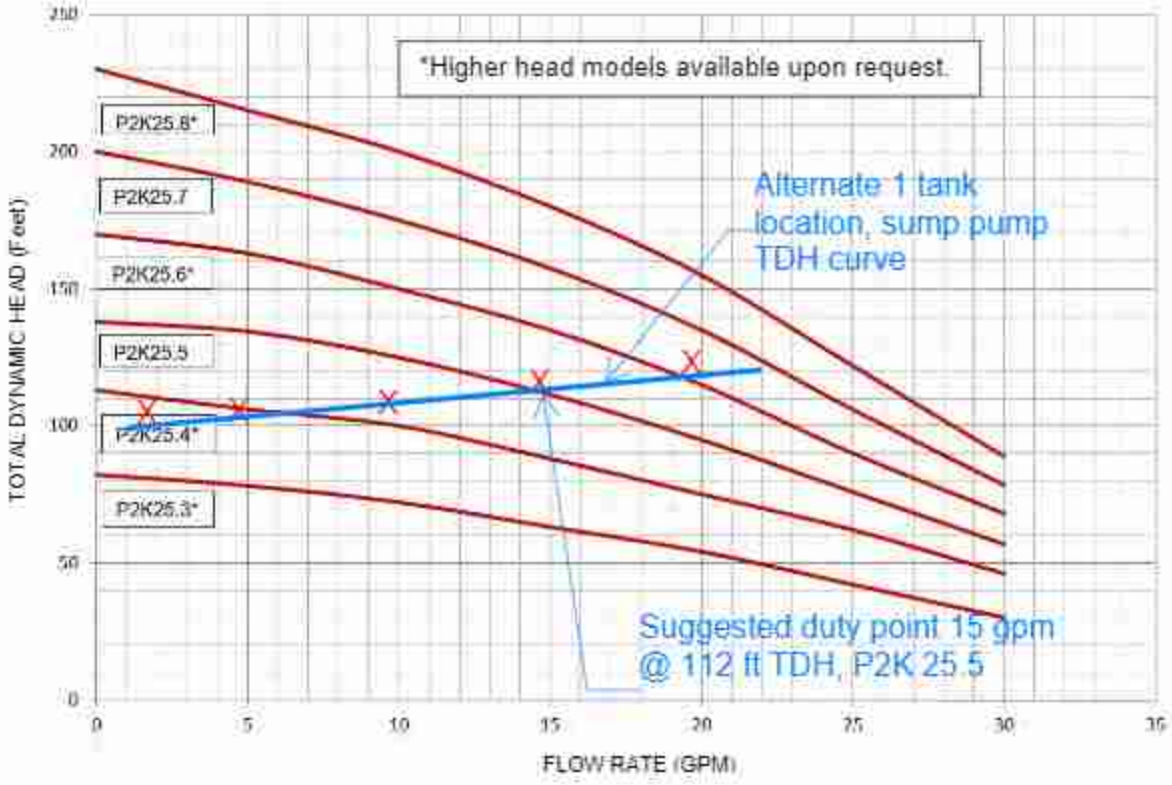
FLOW, gpm	TDH, ft (2")	Total TDH, ft
2	20	20
5	20.3	20.3
10	21.1	21.1
15	22.4	22.4
20	24	24

PUMP SELECTION AND DUTY POINT – ALTERNATE 2 TANK LOCATION

A much different pump would be needed for the **Alternate 2** tank location and would need be determined from research of different pump suppliers.

GunnCo Pump & Control Inc.

Sidesloper™ Leachate Pumping System



Model	Max. H.P.	Est. Weight**	Max. Pump Dia.	Discharge Size	Est. Length Pump & Motor***	Carrier Model
P2K25.3*	0.5	25.0 lbs.	4"	1.5"	19.4"	A4
P2K25.4*	0.75	27.0 lbs.	4"	1.5"	20.8"	A4
P2K25.5	0.75	23.4 lbs.	4"	1.5"	21.8"	A4
P2K25.6*	1.0	29.0 lbs.	4"	1.5"	23.1"	A4
P2K25.7	1.0	25.2 lbs.	4"	1.5"	24.1"	A4
P2K25.8*	1.5	30.0 lbs.	4"	1.5"	26.3"	B4

* Preferred Models.

** Estimated pump with single phase motor. Add estimate of .5 lbs. per foot for cable and discharge piping.

*** Length is based on bare pump and single phase motor. Does not include carrier or any fittings.

GunnCo pumps are provided with male cam-lock discharge fitting unless specified other. See Wheeled Carrier Dimension sheets for additional information.

Curves are based on stainless steel with Teflon® bearing and seals.

SECTION 3

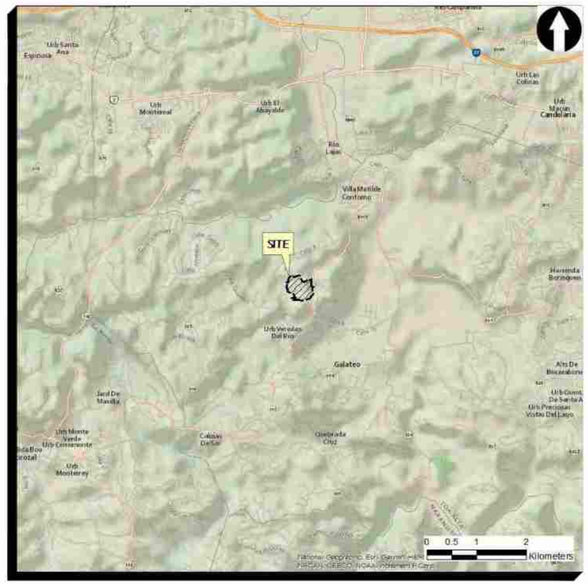
Toa Alta Preliminary Closure Design Drawings

TOA ALTA LANDFILL

TOA ALTA, PUERTO RICO

PRELIMINARY CLOSURE DESIGN

LOCATION MAP



VICINITY MAP

INDEX OF DRAWINGS

Sheet No.	Description
1	COVER SHEET
2	EXISTING SITE CONDITIONS DECEMBER 2022
3	EXISTING SITE CONDITIONS WITH DECEMBER 2022 AERIAL PHOTO
4	TOP OF INTERMEDIATE COVER PLAN
5	FINAL GRADING PLAN
5A	ALTERNATE FINAL GRADING PLAN
6	LEACHATE MANAGEMENT PLAN
7	GAS MANAGEMENT PLAN
8	LANDFILL PROFILES
9	DETAILS 1 OF 4
10	DETAILS 2 OF 4
11	DETAILS 3 OF 4
12	DETAILS 4 OF 4

PREPARED FOR:

TERRATEK ENGINEERING GROUP, PSC
P.O. BOX 367445 SAN JUAN, PR 00936
PHONE: (787) 505-6139 // FAX: (787) 946-3790

FACILITY INFORMATION:

OWNER: MUNICIPALITY OF TOA ALTA

LOCATION: 9PCP+CCJ, TOA ALTA, 00953, PUERTO RICO

CONSULTANT: NIVIA AYALA, PE, GENERAL MANAGER
(787) 505-6139
nayala@terratekpr.com

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THIS PRELIMINARY CLOSURE DESIGN (DRAWINGS AND ASSOCIATED PRELIMINARY DOCUMENTS AND CALCULATIONS) SHALL NOT BE CONSIDERED FINAL DESIGN AND SHALL NOT BE USED FOR CONSTRUCTION. THE PURPOSE OF THE PRELIMINARY CLOSURE DESIGN IS TO MEET REQUIREMENTS OF THE U.S. DISTRICT COURT FOR THE DISTRICT OF PUERTO RICO, STIPULATION AND PRELIMINARY INJUNCTION ORDER, CIV. NO. 3:21-01087-DRD AND TO PROVIDE A BASIS FOR FINAL DESIGN AND CONSTRUCTION DOCUMENTS FOR FINAL CLOSURE OF TOA ALTA LANDFILL. THE PRELIMINARY FINAL CLOSURE GRADES PRESENTED HEREIN ARE BASED ON ASSUMED SUBSURFACE CONDITIONS, EXISTING TOPOGRAPHIC SURVEY, AND GENERAL LITERATURE REGARDING THE GEOLOGIC CONDITIONS. FINAL DESIGN MAY REQUIRE DRILLING, LABORATORY TESTING, AND OTHER MEANS OF DETERMINING SITE SPECIFIC SUBSURFACE CONDITIONS FOR USE IN GEOTECHNICAL GLOBAL STABILITY CALCULATIONS FOR PROPOSED FINAL CLOSURE GRADES TO MEET REQUIRED FACTORS OF SAFETY FOR STATIC AND SEISMIC CONDITIONS.

BARGE DESIGN SOLUTIONS

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Peachtree Corners, Georgia 30092 // PHONE (678) 515-9411

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OCT 31, 2023
PROJECT No. 3831800

TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO
PRELIMINARY CLOSURE DESIGN

SHEET 1

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LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND ELEVATION (METERS)
- LIMITS OF WASTE
- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER

LIMIT OF WASTE

LINE	COURSE	DISTANCE	POINT	COORDINATES NORTHING	COORDINATES EASTING	DESCRIPTION
101-102	N 83°32'14" E	65.602	101	259350.0421	217819.9128	WOOD STAKE
102-103	S 77°21'55" E	41.589	102	259357.4263	217885.0984	WOOD STAKE
103-104	N 34°24'35" E	60.417	103	259348.3294	217925.6800	WOOD STAKE
104-105	N 23°40'59" E	90.597	104	259398.1748	217959.8222	WOOD STAKE
105-106	N 10°21'13" W	48.496	105	259481.1416	217996.2130	WOOD STAKE
106-107	N 0°4'12" E	68.584	106	259528.8484	217987.4971	WOOD STAKE
107-108	N 10°10'25" W	70.161	107	259597.4322	217987.5808	WOOD STAKE
108-109	N 71°8'54" W	75.283	108	259666.4901	217975.1882	WOOD STAKE
109-110	N 83°5'6" W	55.943	109	259690.8154	217903.9434	WOOD STAKE
110-111	N 29°26'15" E	40.113	110	259697.5507	217848.4075	WOOD STAKE
111-112	N 54°8'4" W	66.318	111	259732.4847	217868.1220	WOOD STAKE
112-113	N 73°54'14" W	100.474	112	259771.3395	217814.3781	WOOD STAKE
113-114	S 40°28'21" W	84.979	113	259799.1960	217717.8424	WOOD STAKE
114-115	S 21°12'22" W	61.199	114	259734.5513	217662.6842	WOOD STAKE
115-116	S 16°58'46" W	42.237	115	259677.4962	217640.5471	WOOD STAKE
116-117	S 45°21'54" W	37.460	116	259637.1007	217628.2127	WOOD STAKE
117-118	S 24°46'30" E	118.111	117	259610.7817	217601.5560	WOOD STAKE
118-119	S 62°41'6" E	48.717	118	259503.5417	217651.0507	WOOD STAKE
119-120	S 73°7'52" E	51.721	119	259481.1866	217694.3355	WOOD STAKE
120-121	S 25°29'43" E	74.752	120	259466.1781	217743.8307	WOOD STAKE
121-101	S 42°3'29" E	65.543	121	259398.7056	217776.0067	WOOD STAKE

NOTES

1. EXISTING TOPOGRAPHY BASED UPON PLANO TOPOGRAFICO "ASBUILT" CONDICIONES EXISTENTES, IDENTIFICATION SUMIDEROS LIXIVIADOS EXISTENTES, BY HECTOR TIRADO RODRIGUEZ, P.E., R.P.A., DATED DECEMBER 19, 2022.
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EXISTING CONDITIONS DECEMBER 2022

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

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LEGEND

- PROPERTY BOUNDARY
- 142 EXISTING GROUND ELEVATION (METERS)
- LIMITS OF WASTE
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EXISTING CONDITIONS WITH AERIAL PHOTO

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TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION

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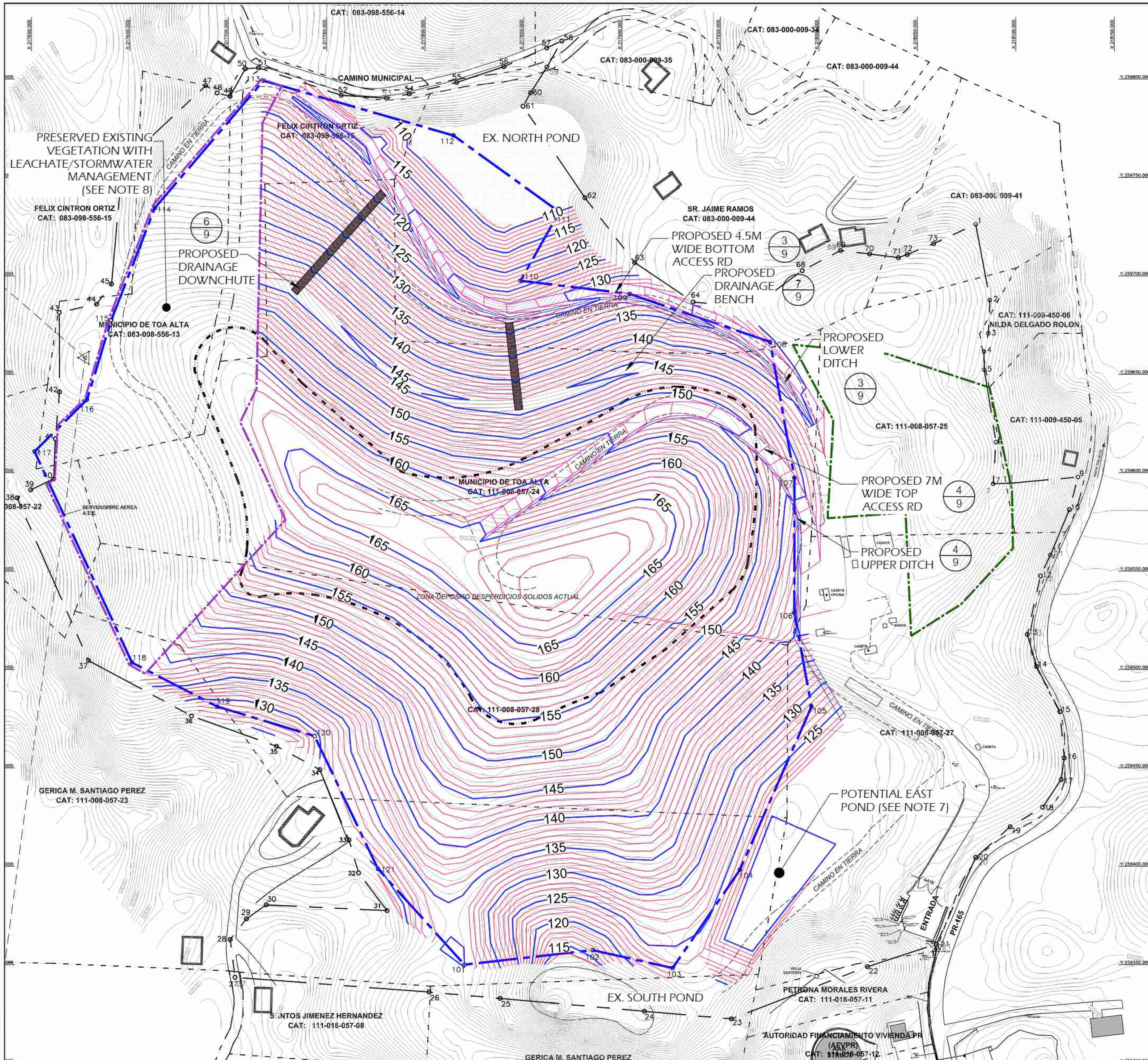

LEGEND

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- LIMITS OF WASTE
- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER
- PROPOSED TOP OF INTERMEDIATE COVER (1-METER CONTOUR)
- 160 PROPOSED TOP OF INTERMEDIATE COVER (5-METER INDEX CONTOUR)

NOTES

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5. THE LIMIT OF WASTE SHOWN ON THIS PLAN IS BASED ON A LIMIT OF WASTE STUDY PROVIDED BY TOA ALTA.
6. TOP OF INTERMEDIATE COVER GRADES SHOWN HEREIN ARE PRELIMINARY AND BASED UPON MINIMUM 12 INCHES OF SOIL THICKNESS IN PLACE AFTER CUT OR FILL REQUIRED TO MEET SUBGRADE (BOTTOM OF 12-INCH INTERMEDIATE COVER.)
7. DURING FINAL DESIGN, A POTENTIAL EAST POND MAY BE PROPOSED AS TEMPORARY EROSION CONTROL OR TO MANAGE STORM WATER FROM THE ET COVER AREA.
8. STORMWATER AND LEACHATE MANAGEMENT FEATURES IN THE AREA OF PRESERVED EXISTING VEGETATION WILL BE DETERMINED DURING FINAL DESIGN TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION WHILE PROMOTING ENVIRONMENTAL PROTECTION.

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TOP OF INTERMEDIATE COVER

PRELIMINARY CLOSURE DESIGN

TOA ALTA LANDFILL

TOA ALTA, PUERTO RICO

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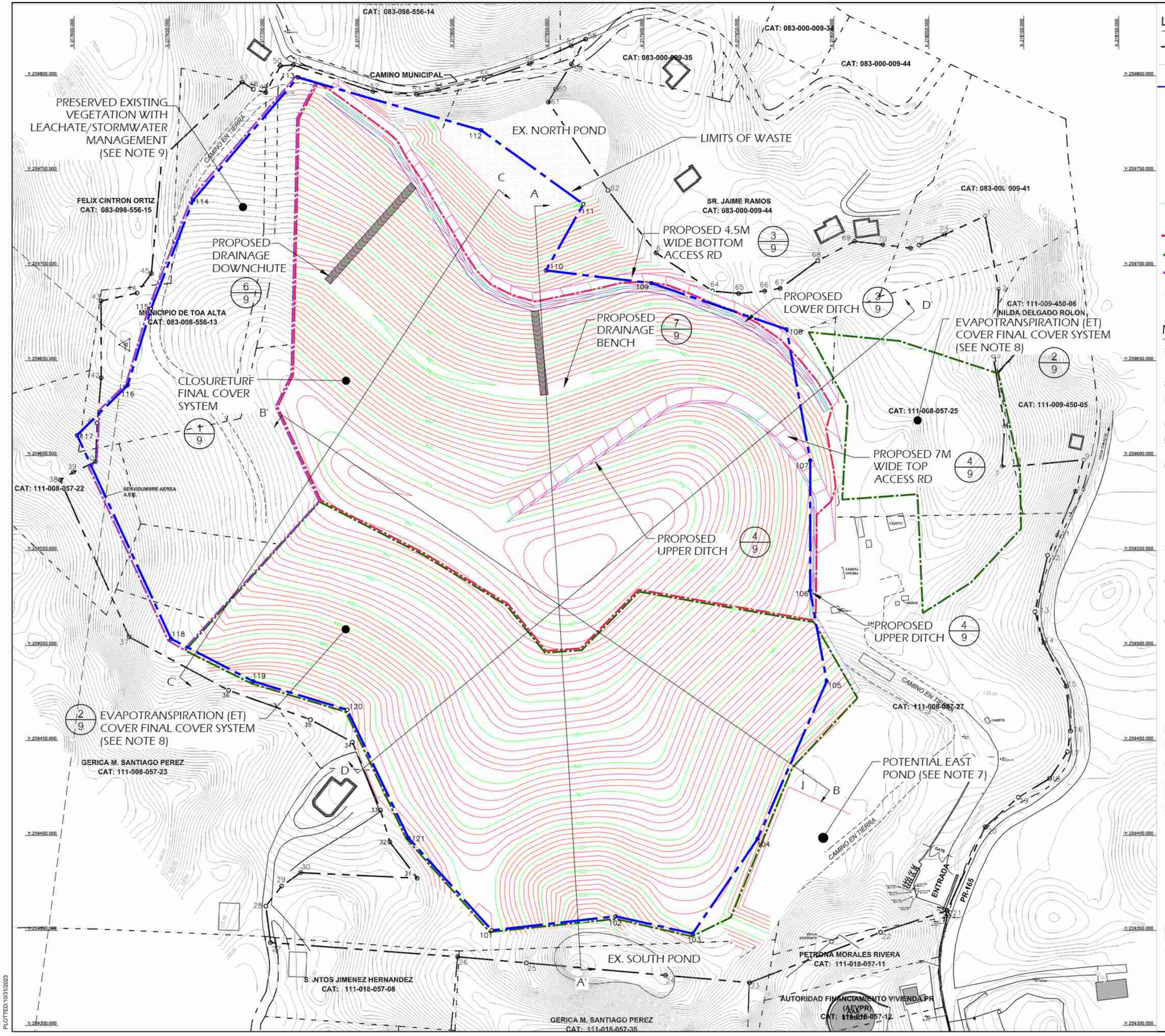

LEGEND

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- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER
- PROPOSED FINAL COVER ELEVATION (5 -METER INDEX CONTOUR)
- LIMITS OF CLOSURETURF
- LIMITS OF ET COVER
- EXISTING AREA PRESERVED
- CROSS SECTION

NOTES

1. EXISTING TOPOGRAPHY BASED UPON PLANO TOPOGRAFICO "ASBUILT" CONDICIONES EXISTENTES, IDENTIFICATION SUMIDEROS LIXIVIADOS EXISTENTES, BY HECTOR TIRADO RODRIGUEZ, P.E., R.P.A., DATED DECEMBER 19, 2022.
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3. ALL ELEVATIONS AND DISTANCES ARE IN METERS, EXCEPT THOSE THAT INDICATE THE OTHERWISE.
4. HORIZONTAL AND VERTICAL DATUM ARE NAD83.
5. THE LIMIT OF WASTE SHOWN ON THIS PLAN IS BASED ON A LIMIT OF WASTE STUDY PROVIDED BY TOA ALTA.
6. FINAL GRADES SHOWN HEREIN ARE PRELIMINARY AND REPRESENT TOP OF FINAL CLOSURE. THE PRELIMINARY FINAL CLOSURE GRADES PRESENTED HEREIN ARE BASED ON ASSUMED SUBSURFACE CONDITIONS, EXISTING TOPOGRAPHIC SURVEY, AND GENERAL LITERATURE REGARDING THE GEOLOGIC CONDITIONS. FINAL DESIGN MAY REQUIRE DRILLING, LABORATORY TESTING, AND OTHER MEANS OF DETERMINING SITE SPECIFIC SUBSURFACE CONDITIONS FOR USE IN GEOTECHNICAL GLOBAL STABILITY CALCULATIONS FOR PROPOSED FINAL CLOSURE GRADES TO MEET REQUIRED FACTORS OF SAFETY FOR STATIC AND SEISMIC CONDITIONS.
7. DURING FINAL DESIGN, A POTENTIAL EAST POND MAY BE PROPOSED AS TEMPORARY EROSION CONTROL OR TO MANAGE STORMWATER FROM THE ET COVER AREA.
8. STORMWATER AND LEACHATE MANAGEMENT FEATURES IN THE ET COVER AREA WILL BE DETERMINED DURING FINAL DESIGN TO PROMOTE ENVIRONMENTAL PROTECTION AND PROMOTE SLOPE STABILITY UNTIL ESTABLISHMENT OF PROPOSED ET COVER VEGETATION.
9. STORMWATER AND LEACHATE MANAGEMENT FEATURES IN THE AREA OF PRESERVED EXISTING VEGETATION WILL BE DETERMINED DURING FINAL DESIGN TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION WHILE PROMOTING ENVIRONMENTAL PROTECTION.

PROPOSED COVER AREAS

CLOSURETURF	13.0 AC
ET COVER	12.1 AC
PRESERVED EXISTING VEGETATION WITH LEACHATE/STORMWATER MANAGEMENT	5.0 AC

0 50 100 Meters

PRELIMINARY - NOT FOR CONSTRUCTION

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FINAL GRADING PLAN

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REV.	DR.	CHK.	DATE	REVISION INFORMATION DESCRIPTION
0	SSS	JRB	10-31-2023	PRELIMINARY DESIGN

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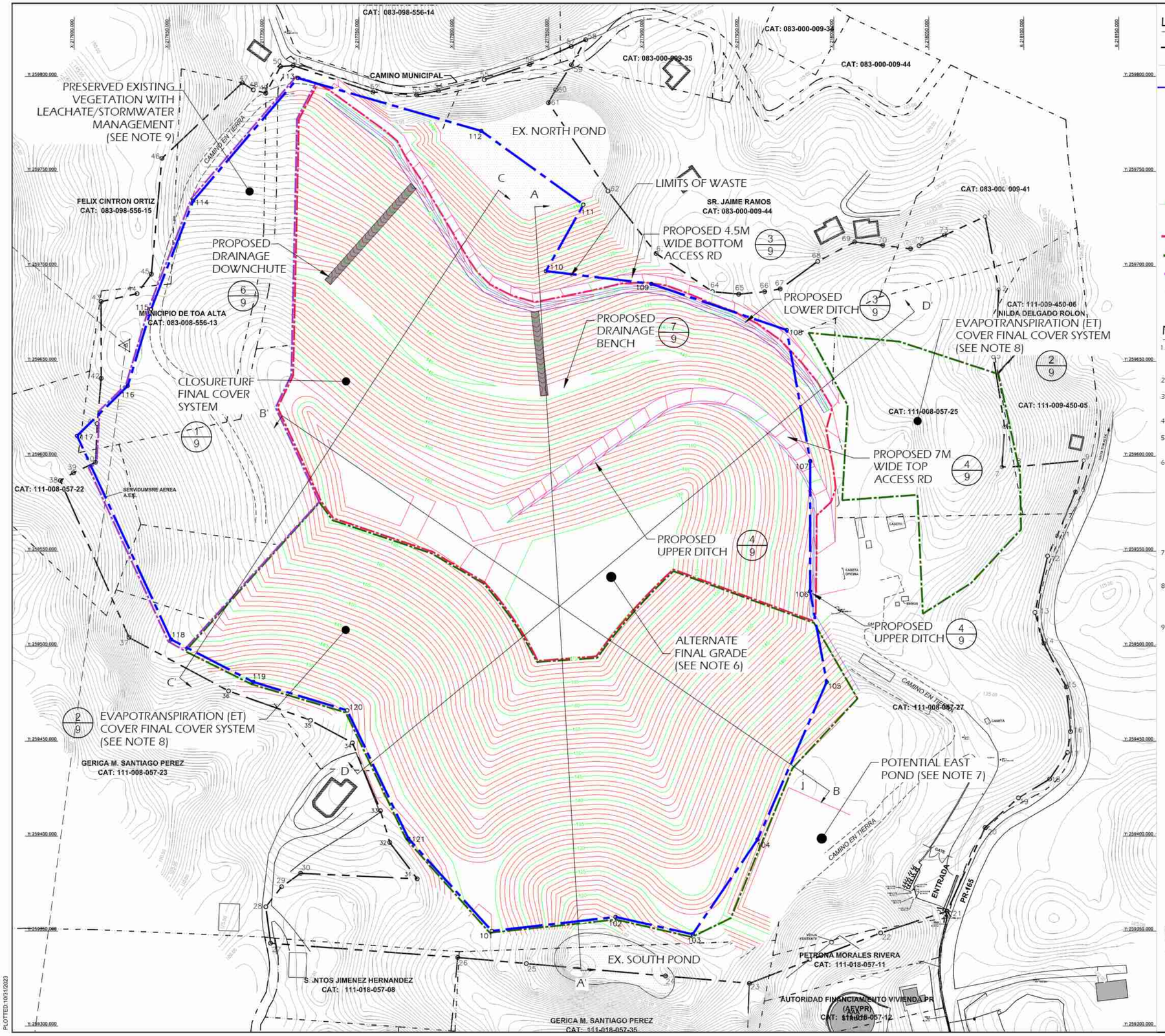

LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND ELEVATION (METERS)
- LIMITS OF WASTE
- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER
- PROPOSED FINAL COVER ELEVATION (5 -METER INDEX CONTOUR)
- LIMITS OF CLOSURETURF
- LIMITS OF ET COVER
- EXISTING AREA PRESERVED
- CROSS SECTION

NOTES

1. EXISTING TOPOGRAPHY BASED UPON PLANO TOPOGRAFICO "ASBUILT" CONDICIONES EXISTENTES, IDENTIFICATION SUMIDEROS LIXIVIADOS EXISTENTES, BY HECTOR TIRADO RODRIGUEZ, P.E., R.P.A., DATED DECEMBER 19, 2022.
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3. ALL ELEVATIONS AND DISTANCES ARE IN METERS, EXCEPT THOSE THAT INDICATE THE OTHERWISE.
4. HORIZONTAL AND VERTICAL DATUM ARE NAD83.
5. THE LIMIT OF WASTE SHOWN ON THIS PLAN IS BASED ON A LIMIT OF WASTE STUDY PROVIDED BY TOA ALTA.
6. ALTERNATE FINAL GRADES SHOWN HEREIN ARE PRELIMINARY AND REPRESENT TOP OF FINAL CLOSURE, ASSUMING THAT CONSTRUCTION/DEMOLITION WASTE CAN BE PLACED TO ACHIEVE A TOP DECK FINAL CLOSURE ELEVATION OF 170 METERS. THE PRELIMINARY ALTERNATE FINAL CLOSURE GRADES PRESENTED HEREIN ARE BASED ON ASSUMED SUBSURFACE CONDITIONS, EXISTING TOPOGRAPHIC SURVEY, AND GENERAL LITERATURE REGARDING THE GEOLOGIC CONDITIONS. FINAL DESIGN MAY REQUIRE DRILLING, LABORATORY TESTING, AND OTHER MEANS OF DETERMINING SITE SPECIFIC SUBSURFACE CONDITIONS FOR USE IN GEOTECHNICAL GLOBAL STABILITY CALCULATIONS FOR PROPOSED FINAL CLOSURE GRADES TO MEET REQUIRED FACTORS OF SAFETY FOR STATIC AND SEISMIC CONDITIONS.
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9. STORMWATER AND LEACHATE MANAGEMENT FEATURES IN THE AREA OF PRESERVED EXISTING VEGETATION WILL BE DETERMINED DURING FINAL DESIGN TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION WHILE PROMOTING ENVIRONMENTAL PROTECTION.

PROPOSED COVER AREAS

CLOSURETURF	13.0 AC
ET COVER	12.1 AC
PRESERVED EXISTING VEGETATION WITH LEACHATE/STORMWATER MANAGEMENT	5.0 AC

0 50 100 Meters

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ALTERNATE FINAL GRADING PLAN

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION

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LEACHATE TANK (ALTERNATE 2, VOLUME T.B.D.)

ONE-WAY DRIVE TANKER EXIT GATE (LEACHATE TANK ALTERNATE 2)

LEACHATE FORCEMAIN PIPE & TRENCH (ALTERNATE 2)

CAMINO MUNICIPAL

DUPLEX LEACHATE PUMP STATION

EX. NORTH POND

PRESERVED EXISTING VEGETATION WITH LEACHATE/STORMWATER MANAGEMENT (SEE NOTE 9)

CAMINO EN TIERRA

FELIX CINTRON ORTIZ
CAT: 083-098-556-15

MUNICIPIO DE TOA ALTA
CAT: 083-008-556-13

CLOSURETURF FINAL COVER SYSTEM

PROPOSED LEACHATE TOE DRAIN

CAT: 111-008-057-22

SERVIDUMBRE AEREA A.E.E.

CAT: 083-000-009-34

CAT: 083-000-009-35

CAT: 083-000-009-44

SR. JAIME RAMOS
CAT: 083-000-009-44

CAT: 083-000-009-41

LEACHATE FORCEMAIN PIPE & TRENCH (ALTERNATE 1)

CAT: 111-009-450-06
NILDA DELGADO ROLON

LEACHATE TANK (ALTERNATE 1, VOLUME T.B.D.) & FLARE STATION CONCRETE PAD

CAT: 111-008-057-25

EVAPOTRANSPIRATION (ET) COVER FINAL COVER SYSTEM (SEE NOTE 8)

EVAPOTRANSPIRATION (ET) COVER FINAL COVER SYSTEM (SEE NOTE 8)

GERICA M. SANTIAGO PEREZ
CAT: 111-008-057-23

CAT: 111-008-057-27

POTENTIAL EAST POND (SEE NOTE 7)

CAMINO EN TIERRA

EX. SOUTH POND

S .NTOS JIMENEZ HERNANDEZ
CAT: 111-018-057-08

GERICA M. SANTIAGO PEREZ
CAT: 111-018-057-35

PETRONA MORALES RIVERA
CAT: 111-018-057-11

AUTORIDAD FINANCIAMIENTO VIVIENDA PR (AFVPR)
CAT: 111-018-057-12

ENTRADA

PR-165

CASETA

CASETA OFICINA

BANOS

LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND ELEVATION (METERS)
- LIMITS OF WASTE
- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER
- PROPOSED FINAL COVER ELEVATION (5 -METER INDEX CONTOUR)
- LIMITS OF CLOSURETURF
- LIMITS OF ET COVER
- PROPOSED LEACHATE TOE DRAIN
- PROPOSED DUAL CONTAINED FORCEMAIN

NOTES

1. EXISTING TOPOGRAPHY BASED UPON PLANO TOPOGRAFICO "ASBUILT" CONDICIONES EXISTENTES, IDENTIFICATION SUMIDEROS LIXIVIADOS EXISTENTES, BY HECTOR TIRADO RODRIGUEZ, P.E., R.P.A., DATED DECEMBER 19, 2022.
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5. THE LIMIT OF WASTE SHOWN ON THIS PLAN IS BASED ON A LIMIT OF WASTE STUDY PROVIDED BY TOA ALTA.

FINAL GRADES SHOWN HEREIN ARE PRELIMINARY AND REPRESENT TOP OF FINAL CLOSURE. THE PRELIMINARY FINAL CLOSURE GRADES PRESENTED HEREIN ARE BASED ON ASSUMED SUBSURFACE CONDITIONS, EXISTING TOPOGRAPHIC SURVEY, AND GENERAL LITERATURE REGARDING THE GEOLOGIC CONDITIONS. FINAL DESIGN MAY REQUIRE DRILLING, LABORATORY TESTING, AND OTHER MEANS OF DETERMINING SITE SPECIFIC SUBSURFACE CONDITIONS FOR USE IN GEOTECHNICAL GLOBAL STABILITY CALCULATIONS FOR PROPOSED FINAL CLOSURE GRADES TO MEET REQUIRED FACTORS OF SAFETY FOR STATIC AND SEISMIC CONDITIONS.

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0 50 100 Meters

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LEACHATE MANAGEMENT PLAN

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION			
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LEGEND

- PROPERTY BOUNDARY
- EXISTING GROUND ELEVATION (METERS)
- LIMITS OF WASTE
- STRUCTURE
- TELEPHONE POST
- SANITARY
- ELECTRIC POLE
- ELECTRIC TOWER
- PROPOSED FINAL COVER ELEVATION (5 -METER INDEX CONTOUR)
- LIMITS OF CLOSURETURF
- LIMITS OF ET COVER
- LEACHATE TOE DRAIN
- DUAL CONTAINED FORCEMAIN
- PROPOSED HORIZONTAL GAS COLLECTOR
- ACTIVE GAS HEADER
- SURFICIAL PASSIVE GAS VENT SYSTEM

NOTES

1. EXISTING TOPOGRAPHY BASED UPON PLANO TOPOGRAFICO "ASBUILT" CONDICIONES EXISTENTES, IDENTIFICATION SUMIDEROS LIXIVIADOS EXISTENTES, BY HECTOR TIRADO RODRIGUEZ, P.E., R.P.A., DATED DECEMBER 19, 2022.
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10. DURING FINAL DESIGN FOR AREAS OF CLOSURETURF, DETAILED CALCULATIONS, DESIGN, AND LAYOUT WILL BE PROVIDED FOR THE PROPOSED ACTIVE HORIZONTAL GAS COLLECTOR/LEACHATE MANAGEMENT FEATURES, THE PROPOSED SURFICIAL PASSIVE GAS VENT SYSTEM, PROPOSED FLARE STATION, AND POSSIBLE ALTERNATE PASSIVE GAS MANAGEMENT (SOLAR SPARK VENT FLARES).

PRELIMINARY - NOT FOR CONSTRUCTION

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GAS MANAGEMENT PLAN

PRELIMINARY CLOSURE DESIGN TOA ALTA LANDFILL

TOA ALTA, PUERTO RICO

REVISION INFORMATION

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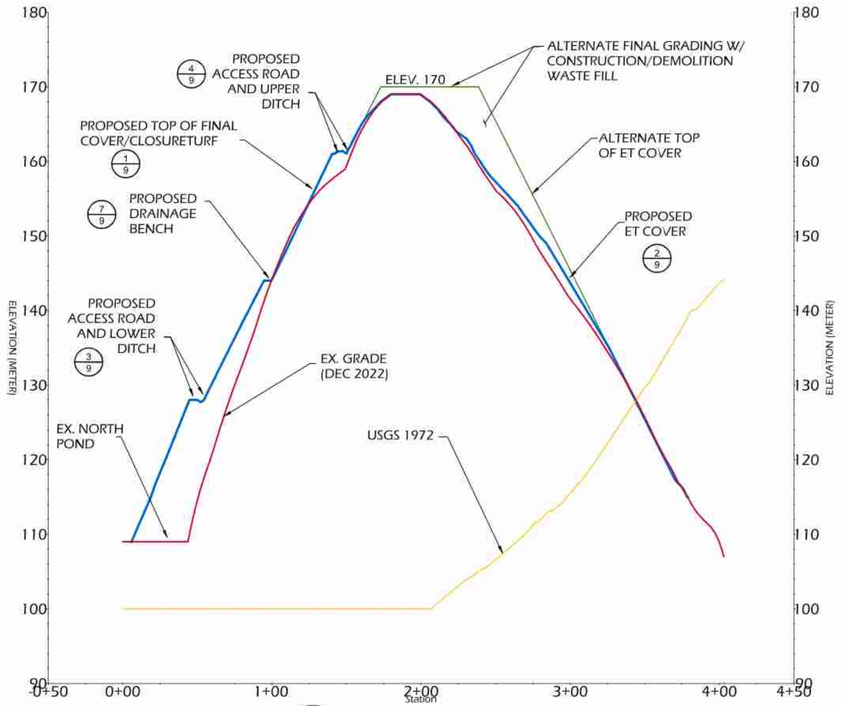
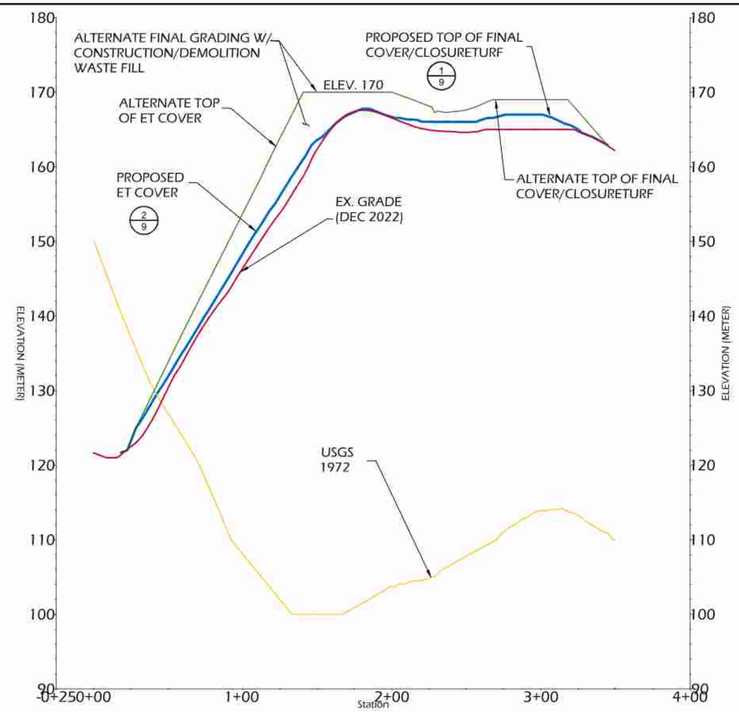
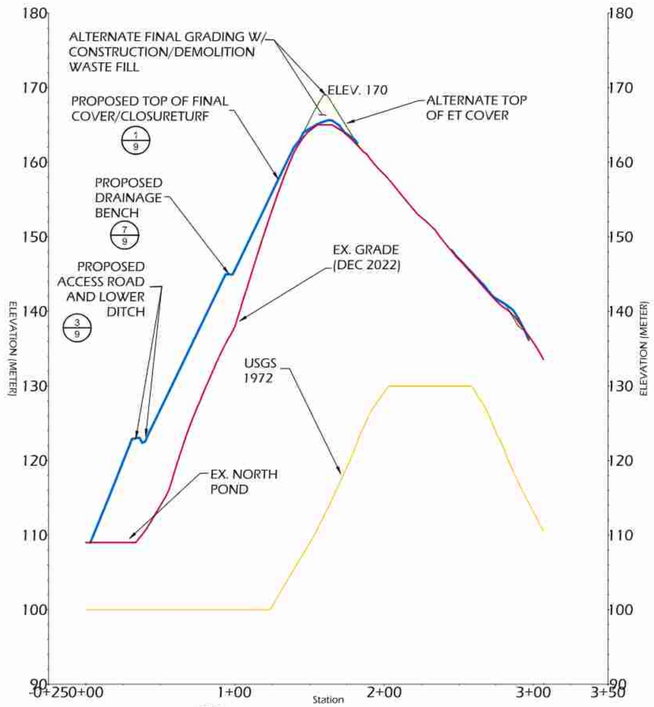


1/5 PROFILE A-A'



2/5 PROFILE B-B'
WEST TO EAST



3/5 PROFILE C-C'

NOTES

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5. THE LIMIT OF WASTE SHOWN ON THIS PLAN IS BASED ON A LIMIT OF WASTE STUDY PROVIDED BY TOA ALTA.
6. FINAL GRADES (OR ALTERNATE FINAL GRADES ASSUMING THAT CONSTRUCTION/DEMOLITION WASTE CAN BE PLACED TO ACHIEVE A TOP DECK FINAL CLOSURE ELEVATION OF 170 METERS) SHOWN HEREIN ARE PRELIMINARY AND REPRESENT TOP OF FINAL CLOSURE. THE PRELIMINARY ALTERNATE FINAL CLOSURE GRADES PRESENTED HEREIN ARE BASED ON ASSUMED SUBSURFACE CONDITIONS, EXISTING TOPOGRAPHIC SURVEY, AND GENERAL LITERATURE REGARDING THE GEOLOGIC CONDITIONS. FINAL DESIGN MAY REQUIRE DRILLING, LABORATORY TESTING, AND OTHER MEANS OF DETERMINING SITE SPECIFIC SUBSURFACE CONDITIONS FOR USE IN GEOTECHNICAL GLOBAL STABILITY CALCULATIONS FOR PROPOSED FINAL CLOSURE GRADES TO MEET REQUIRED FACTORS OF SAFETY FOR STATIC AND SEISMIC CONDITIONS.

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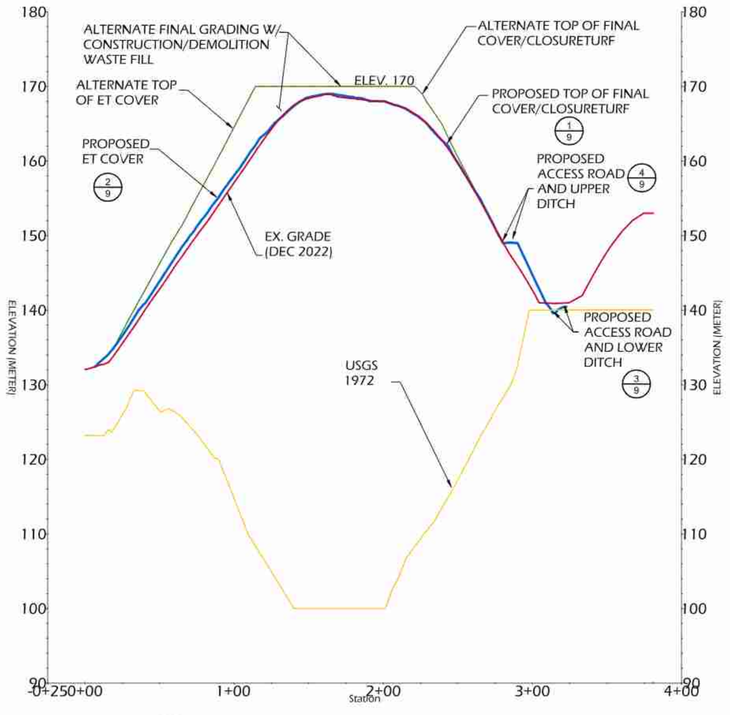

4/5 PROFILE D-D'

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LANDFILL PROFILES

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION			
REV.	DR.	CHK.	DATE	DESCRIPTION
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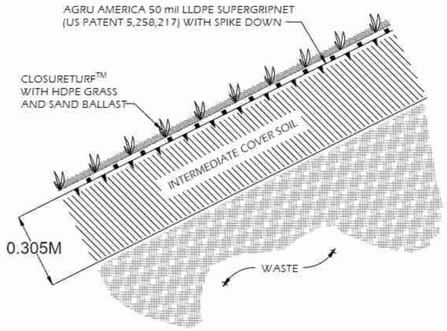
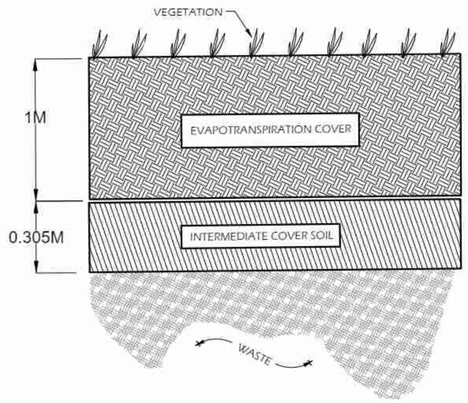
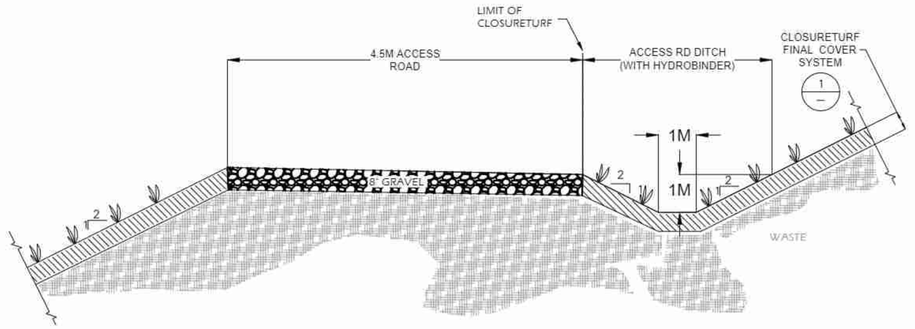


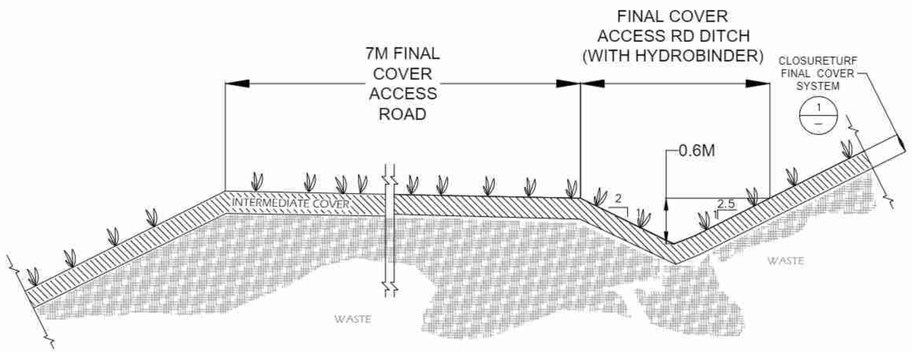
1 - CLOSURETURF FINAL COVER SYSTEM



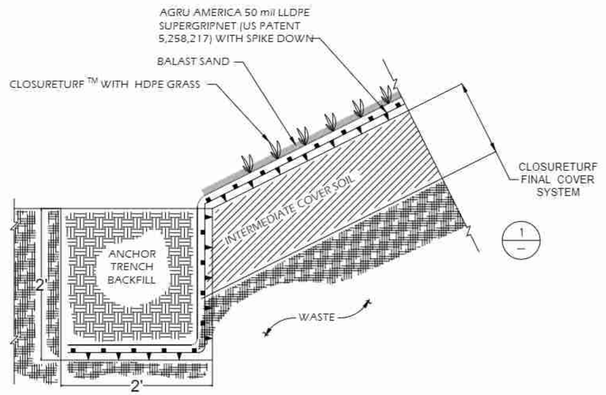
2 - EVAPOTRANSPIRATION COVER FINAL COVER SYSTEM



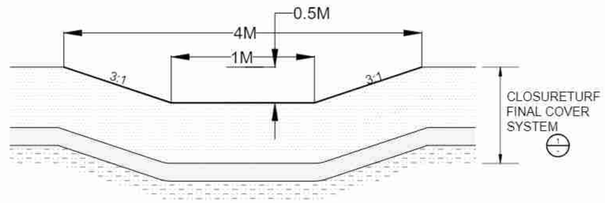
3 - BOTTOM ACCESS ROAD



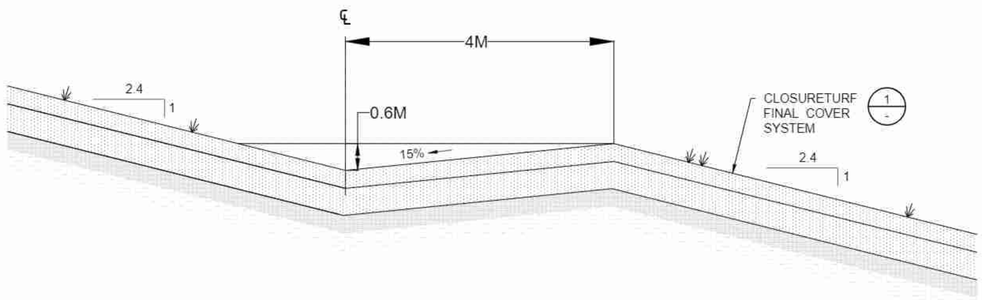
4 - CLOSURETURF TOP ACCESS ROAD



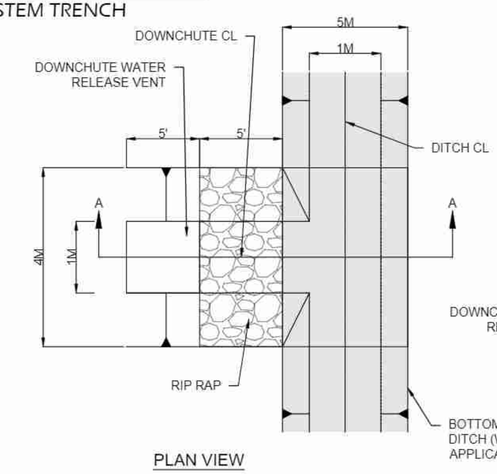
5 - CLOSURETURF FINAL COVER SYSTEM TRENCH



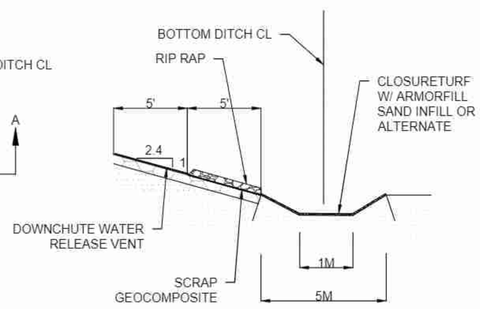
6 - DRAINAGE DOWNCHUTE



7 - DRAINAGE BENCH



PLAN VIEW



SECTION A-A

8 - DOWNCHUTE OUTLET PROTECTION

PRELIMINARY - NOT FOR CONSTRUCTION

NOTE: DETAILS SHOWN HEREIN ARE PRELIMINARY FOR PURPOSES OF DESCRIBING DESIGN FEATURES AND ANTICIPATED DIMENSIONS THAT WILL BE CONFIRMED DURING FINAL DESIGN. PRELIMINARY DESIGN DETAILS SHALL NOT BE USED FOR CONSTRUCTION.

BARGE DESIGN SOLUTIONS
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PHONE (678) 515-5411

DETAILS 1

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION

REV.	DR.	CHK.	DATE	DESCRIPTION
0	SS	JRB	10-31-2023	PRELIMINARY DESIGN

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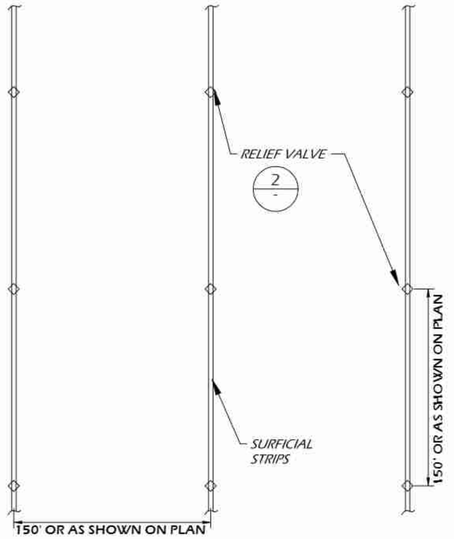
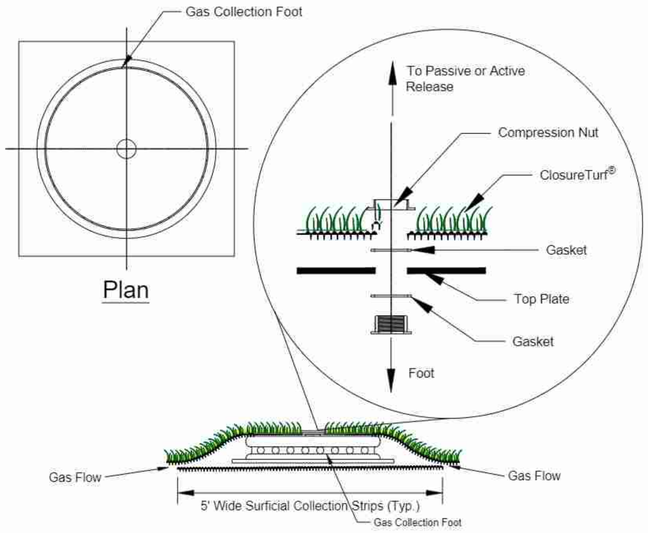
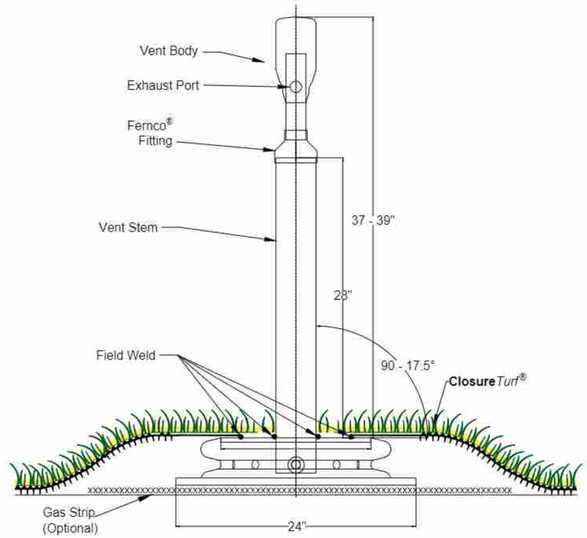


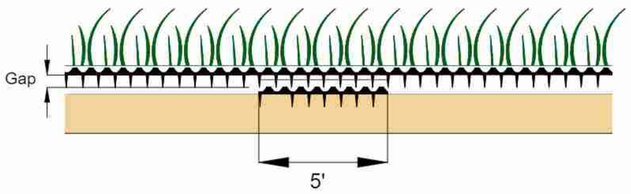
1 / 5 TYPICAL SURFICIAL PASSIVE GAS VENT SYSTEM PLAN
(SEE NOTE 2)



B / - SURFICIAL PASSIVE GAS VENT COLLECTION FOOT ELEVATION VIEW
(SEE NOTE 2)

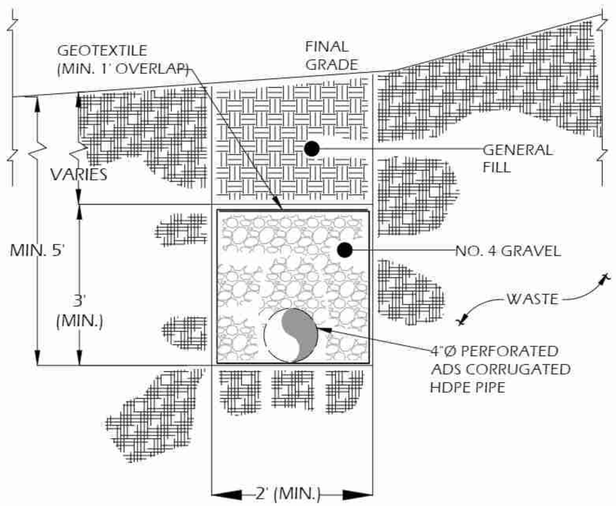


2 / - DETAIL (TYP.) RELIEF VALVE PASSIVE GAS VENT
(SEE NOTE 2)

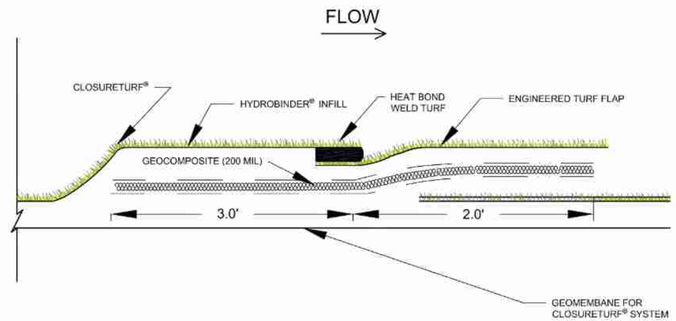


Use Super Gripnet or Single Sided Geocomposite for Strips

A / - SURFICIAL PASSIVE GAS STRIP SECTION
(SEE NOTE 2)



3 / - DETAIL (TYPICAL) LEACHATE TOE DRAIN



4 / - CLOSURETURF WATER RELEASE VENT

NOTES:
1. DETAILS SHOWN HEREIN ARE PRELIMINARY FOR PURPOSES OF DESCRIBING DESIGN FEATURES AND ANTICIPATED DIMENSIONS THAT WILL BE CONFIRMED DURING FINAL DESIGN. PRELIMINARY DESIGN DETAILS SHALL NOT BE USED FOR CONSTRUCTION.
2. DURING FINAL DESIGN FOR AREAS OF CLOSURETURF, DETAILED CALCULATIONS, DESIGN, AND LAYOUT WILL BE PROVIDED FOR THE PROPOSED ACTIVE HORIZONTAL GAS COLLECTOR/LEACHATE MANAGEMENT FEATURES, THE PROPOSED SURFICIAL PASSIVE GAS VENT SYSTEM, PROPOSED FLARE STATION, AND POSSIBLE ALTERNATE PASSIVE GAS MANAGEMENT (SOLAR SPARK VENT FLARES).

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PHONE (678) 515-5411

DETAILS 2

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION

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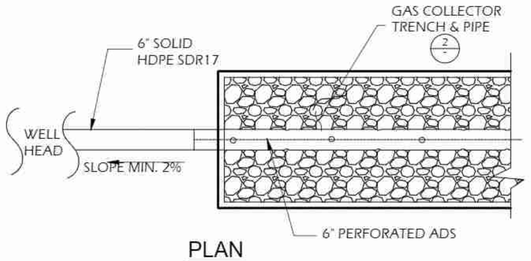
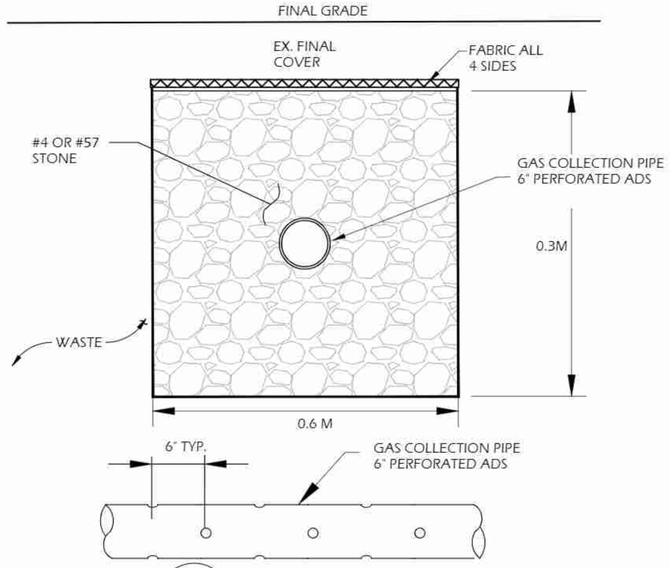
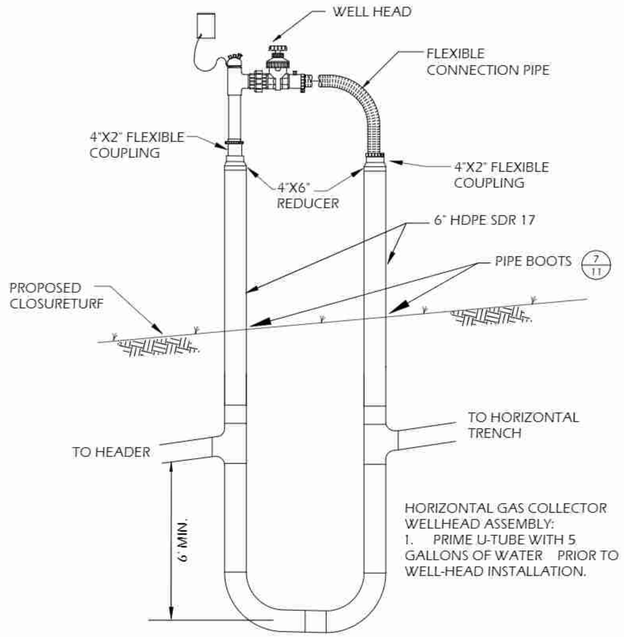


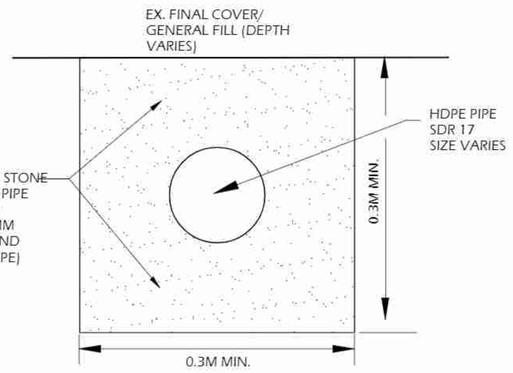
1 / - ACTIVE HORIZONTAL GAS COLLECTOR/LEACHATE MANAGEMENT
(SEE NOTE 2)



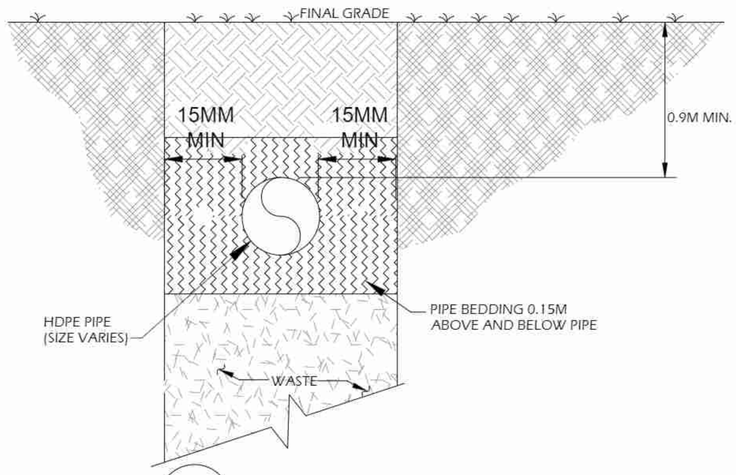
2 / - ACTIVE HORIZONTAL GAS COLLECTOR /LEACHATE MANAGEMENT TRENCH AND PIPE
(SEE NOTE 2)



3 / - ACTIVE HORIZONTAL GAS COLLECTOR CONTROL POINT
(SEE NOTE 2)

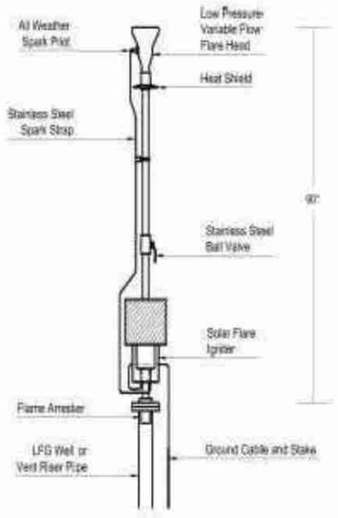


4 / - PIPE BEDDING DETAIL
(SEE NOTE 2)



5 / - TYPICAL GAS HEADER PIPE & TRENCH
(SEE NOTE 2)

TYPICAL INSTALLATION
CF-5 / CF-10



6 / - ALTERNATE PASSIVE GAS MANAGEMENT SOLAR SPARK VENT FLARES
(SEE NOTE 2)

NOTES:
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DETAILS 3

PRELIMINARY CLOSURE DESIGN
TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

REVISION INFORMATION

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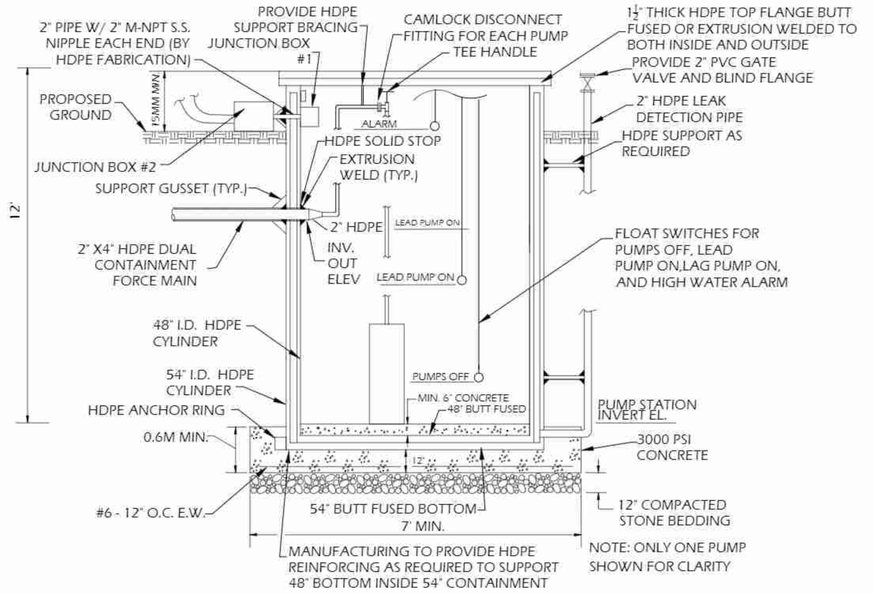
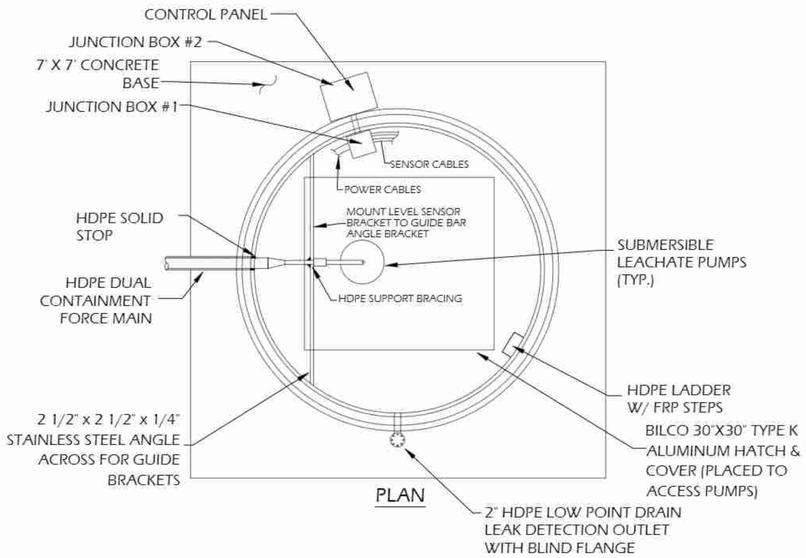


ELEVATION



PLAN

1 - DUPLEX LEACHATE PUMP STATION

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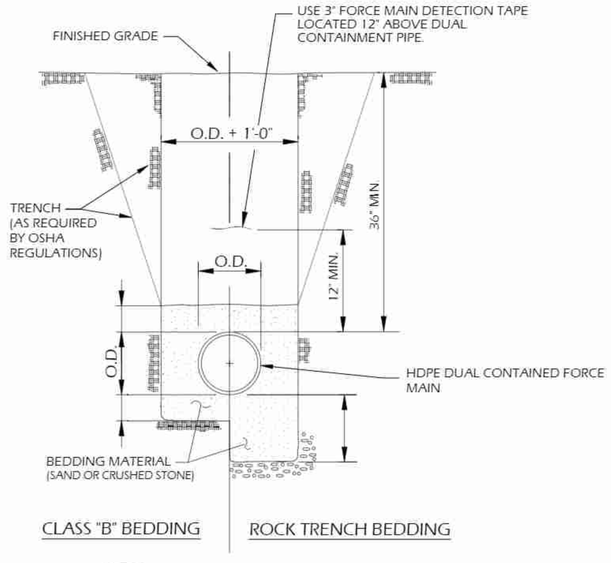
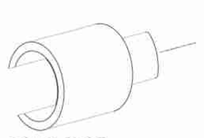


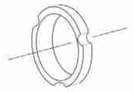
CLASS "B" BEDDING ROCK TRENCH BEDDING

2 - LEACHATE FORCEMAIN TRENCH



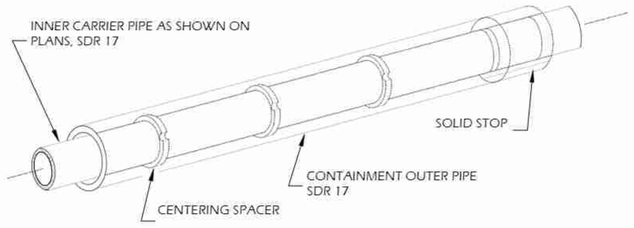
SOLID STOP

A SOLID POLYETHYLENE STOP ISOLATES A SECTION OF DOUBLE CONTAINMENT PIPE TO CONTROL EXPANSION.



CENTERING SPACER

CENTERING SPACERS KEEP THE CARRIER PIPE STRAIGHT FOR UNIFORM EXPANSION INSIDE THE CONTAINMENT PIPE. SPACING INTERVAL (O.C.) TO BE 1/4" THICK @ 4' INTERVALS. ALL SPACERS TO HAVE A MINIMUM OF 3 - 1" HOLES W/ONE HOLE LINED UP WITH THE INVERT OF PIPE.



HDPE DUAL CONTAINED PIPE SECTION

3 - LEACHATE FORCEMAIN PIPE

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DETAILS 4

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TOA ALTA LANDFILL
TOA ALTA, PUERTO RICO

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SECTION 4

Toa Alta Preliminary CQA Plan

PRELIMINARY

CONSTRUCTION QUALITY ASSURANCE PLAN

Municipality of Toa Alta, Puerto Rico

Preliminary Landfill Closure Design

Prepared For:

TERRATEK ENGINEERING GROUP, PSC

TerraTek Engineering Group, PSC

122 C. Isabel Andreu de Aguilar

San Juan, PR 00918

October 2023

PREPARED BY

BARGE DESIGN SOLUTIONS

6525 The Corners Parkway, Suite 450
Peachtree Corners, GA 30092
BARGE # 3831800

TABLE OF CONTENTS

TABLES

1.0 INTRODUCTION

1.1 OVERVIEW

This Construction Quality Assurance (CQA) Plan defines the Roles and Responsibilities of the entities involved in quality control (QC) and quality assurance (QA) activities during Final Closure of the Municipality of Toa Alta (MTA) Landfill (referred to as the "Project" in the remainder of this document).

CQA is applicable to all natural and geosynthetic components that might normally be used in the construction and closure of waste containment facilities, e.g., in liner systems, fluid collection and removal systems, and cover systems. In addition, it also encompasses the ancillary construction activities during construction, e.g., drainage features, access roads, and temporary dewatering facilities. Moreover, this guidance document also describes the minimum requirements for documentation and certification for the Project.

THIS PRELIMINARY CLOSURE DESIGN (DRAWINGS AND ASSOCIATED PRELIMINARY DOCUMENTS AND CALCULATIONS) SHALL NOT BE CONSIDERED FINAL DESIGN AND SHALL NOT BE USED FOR CONSTRUCTION. THE PURPOSE OF THE PRELIMINARY CLOSURE DESIGN IS TO MEET REQUIREMENTS OF THE U.S. DISTRICT COURT FOR THE DISTRICT OF PUERTO RICO, STIPULATION AND PRELIMINARY INJUNCTION ORDER, CIV. NO. 3:21-01087-DRD AND TO PROVIDE A BASIS FOR FINAL DESIGN AND CONSTRUCTION DOCUMENTS FOR FINAL CLOSURE OF TOA ALTA LANDFILL.

1.2 SCOPE

CQA services will be provided by a consulting engineering firm, reporting to the Owner, specializing in the inspection and testing of soils and geosynthetics. The scope of the CQA Plan includes:

- defining the qualifications and responsibilities of the CQA Consultant overseeing the construction activities;
- establishing procedures for construction documentation; and
- establishing procedures for providing final documentation for the verification of the overall construction conforming to the Construction Drawings, Technical Specifications, approved design changes, and other relevant design documents (collectively referred to as "Construction Documents" in the remainder of this document).

2.0 CQA PLAN DEFINITIONS

2.1 CONSTRUCTION QUALITY ASSURANCE AND CONSTRUCTION QUALITY CONTROL

In the context of this document, construction quality assurance and construction quality control are defined as follows:

2.1.1 Construction Quality Assurance (CQA) – A planned and systematic pattern of actions taken by an organization to verify that construction materials and/or services achieve compliance with technical, contractual, and regulatory requirements. This generally involves observation, review of submitted test results by others, and conducting independent tests to verify conformity of the various components of the Project with the requirements of the Construction Documents.

2.1.2 Manufacturer Quality Control/Construction Quality Control (MQC/CQC) - A planned system of actions taken by the Contractor, Manufacturers, or Installers to monitor, check, and control the quality of their own work (verify that they are supplying materials and providing the workmanship as required by the Construction Documents). Sometimes the CQC services may be performed "in-house", and other times CQC services are subcontracted to an outside consultant hired by the Contractor. MQC refers to QC functions performed by manufacturers, and CQC refers to QC functions performed by construction contractors and installers.

2.2 CONFORMANCE TESTING AND PERFORMANCE TESTING

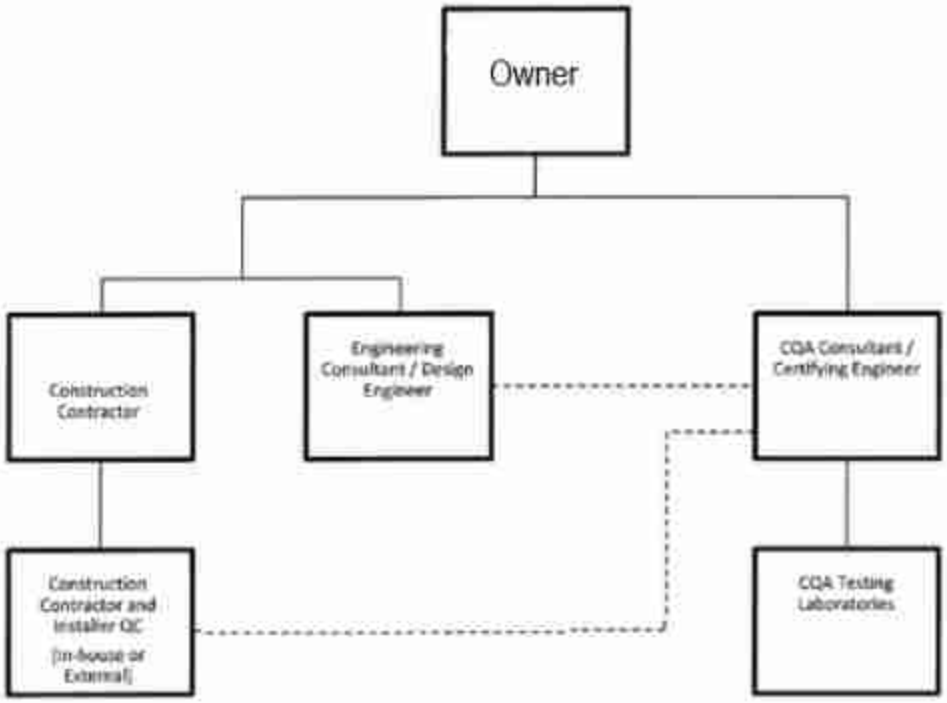
In the context of this document, conformance testing and performance testing are defined as follows:

2.2.1 Conformance Testing – Testing performed to evaluate whether a construction material (e.g., soil, aggregate, or geosynthetic) to be used on the Project possesses properties and characteristics that are in conformance with the specified parameters. By definition, conformance testing is conducted before a material is installed.

2.2.2 Performance Testing – Testing performed on a completed work product to evaluate whether the construction material (e.g., soil, aggregate, or geosynthetic) as- constructed/installed possesses properties and characteristics that are in conformance with the specified performance parameters and work product acceptance criteria.

3.0 PERSONNEL

3.1 GENERAL CQA ORGANIZATION CHART



3.2 CQA CONSULTANT

3.2.1 Definition

The CQA Consultant is the party retained by the Owner responsible for performing CQA activities as described in this CQA Plan. The qualifications and responsibilities of the CQA Consultant are described below. Resumes and qualifications including experience with projects of similar type, size, and complexity will be provided to the Owner for their review and approval.

3.2.2 Qualifications

The CQA Consultant will:

- have specialized experience in the design of geo-environmental infrastructure involving earthwork, waste materials management, geosynthetics and piping installations, project-site water management, revegetation, containment (lining) systems, and final cover system design, and CQA of these components;
- possess the equipment, personnel, and licenses necessary to conduct the monitoring and testing required by the CQA Plan and the Construction Documents;
- be experienced in the review of Contractor submittals for conformance with the Project requirements and in the resolution of non-conformances; and
- be experienced in the preparation and/or review of CQA documentation including CQA plans, field documentation, field testing procedures, laboratory testing procedures, technical specifications, technical drawings, and CQA certification reports.

The CQA Consultant organization will be led by the CQA Certifying Engineer, who will be a Professional Engineer registered to practice in the Commonwealth of Puerto Rico. The CQA Site Manager will be the on-site representative of the CQA Consultant and will have experience in construction activities required for the Project.

3.2.3 Responsibilities

The CQA Consultant will be responsible for:

- reviewing the Construction Documents prior to the start of the construction;
- monitoring the compliance of construction materials and manufactured products (e.g., geosynthetics) delivered to the site with the MQC submittals and conformance requirements and/or shop drawings previously reviewed and approved by the Design Engineer;
- monitoring and documenting that the Contractor's construction methods and workmanship are performed in accordance with the Construction Documents;
- performing on-site field and/or laboratory QA verification testing;

- maintaining calibration certificates of field-testing equipment in the CQA Consultant's on-site project file;
- reviewing field and laboratory MQC test results in a timely manner so as to not impede or delay construction activities; and
- promptly notifying the Owner of any nonconformances of the Contractor's work with any requirements of the Project, including those requirements related to the prompt delivery of MQC results to the CQA consultant.

The specific duties of the individual CQA personnel are discussed in the following subsections.

3.2.3.1 CQA Certifying Engineer

The CQA Certifying Engineer:

- He/she must be a Puerto Rico Licensed Professional Engineer
- reviews the Construction Documents;
- attends scheduled meetings related to Project construction quality activities;
- administers the CQA program (i.e., assigns and manages all on-site CQA personnel, reviews all field reports, provides engineering review of all CQA-related activities);
- provides quality control of CQA documentation;
- reviews and documents changes to the design during construction; and
- prepares and seals the final CQA Certification Report.

3.2.3.2 CQA Site Manager

The CQA Site Manager:

- serves as the on-site representative of the CQA Consultant;
- familiarizes all CQA field technicians with the site, Construction Documents, and the CQA requirements;
- manages the daily activities of the CQA field technicians;
- attends regularly scheduled CQA-related meetings on-site;

- reviews the ongoing preparation of the construction record drawings;
- reviews test results, certifications, and documentation provided by the Contractor, Geosynthetics Manufacturer, and Installer and makes appropriate recommendations;
- reviews the CQA field technicians' daily notes and logs;
- prepares a daily report for the Project;
- oversees the collection and shipping of laboratory test samples;
- reviews the results of field and laboratory testing and makes appropriate recommendations;
- reports any unresolved deviations from the CQA Plan and Construction Documents to the Owner and CQA Certifying Engineer;
- assists with the preparation of the final CQA Certification Report;
- reviews the Geosynthetics MQC documentation; and
- performs duties of CQA field technicians, as needed.

3.2.3.3 CQA Field Technicians

CQA field technicians:

- monitor material stockpiles for any deterioration of materials;
- monitor surface-water drainage in the areas of soil and geosynthetic material stockpiles;
- monitor and test earthwork placement and compaction operations;
- monitor the unloading, storage, and on-site handling of the geosynthetics;
- monitor geosynthetic material deployment and installation operations;
- monitor geosynthetic repair operations;

- assist with the collection and shipping of laboratory test samples;
- document any on-site activities that could result in damage to the soils or geosynthetic components of the construction and report them as soon as practical to the CQA Site Manager;
- prepare notes and logs; and
- report problems to the CQA Site Manager.

3.3 CQA EARTHWORK LABORATORY

3.3.1 Definition

The CQA Earthwork Testing Laboratory (CQA Earthwork Laboratory) is a party of the CQA Consultant and will be responsible for conducting CQA geotechnical laboratory testing in accordance with standards referenced in the Construction Documents and this CQA Plan. The testing results generated by the CQA Earthwork Laboratory will be used by the CQA Consultant to verify compliance of the earthwork with the Construction Documents and this CQA Plan.

3.3.2 Qualifications

The CQA Earthwork Laboratory will be experienced in testing of soils using methods in accordance with American Society of Testing and Materials (ASTM) and other applicable soil test standards and holding appropriate and current industry certification(s)/accreditation(s). The CQA Earthwork Laboratory will be capable of providing test results within a maximum of seven (7) working days of receipt of samples, except for those tests that require longer to perform, and will maintain that capability throughout the duration of the earthwork construction.

Prior to construction, the CQA Earthwork Laboratory will be required to submit their qualifications and QA/QC procedures to the CQA Consultant and the Owner for review and comment.

3.4 CQA GEOSYNTHETICS LABORATORY

3.4.1 Definition

The CQA Geosynthetics Testing Laboratory is a party of the CQA Consultant and will be responsible for conducting tests on samples of geosynthetic materials used in the construction in accordance with standards referenced in the Construction Documents and this CQA Plan. The testing results generated by the CQA Geosynthetics Laboratory will be used by the CQA Consultant to verify compliance of the geosynthetic materials with the Construction Documents and this CQA Plan.

3.4.2 Qualifications

The CQA Geosynthetics Laboratory will be currently accredited by the Geosynthetic Institute (GSI) under their Geosynthetic Accreditation Institute- Laboratory Accreditation Program (GAI-LAP), be approved by the Certifying CQA Engineer and the Owner and have experience in testing geosynthetics to be used for the Project. The CQA Geosynthetics Laboratory will be familiar with ASTM and other applicable geosynthetic test standards. The CQA Geosynthetics Laboratory will be capable of providing destructive test results for geomembrane field seams within 24 hours of receipt of samples and will maintain that capability throughout the duration of geosynthetic material installation.

Prior to construction, the CQA Geosynthetics Laboratory will be required to submit their qualifications and QA/QC procedures to the CQA Consultant and the Owner for review and comment.

3.5 DESIGN ENGINEER

The Design Engineer is the engineer-of-record under whose direction the design of the Project was prepared. The Design Engineer will be a Professional Engineer registered in the Commonwealth of Puerto Rico. The Design Engineer will be responsible for:

- approving all design and specification changes and making design clarifications that may be required during construction;
- assisting the Construction Manager in reviewing and approving the Contractor's shop drawings and submittals, as necessary;

- periodically visiting the site during construction and attending the project coordination meetings, as required, to verify conformance with the Construction Documents and this CQA Plan; and

- discussing and interpreting all elements of the design and having the authority to recommend changes or modifications to the Construction Documents for approval by the Owner and the Puerto Rico Department of Natural and Environmental Resources (DNER), as required.

The CQA Consultant and Design Engineer may be from the same organization.

3.6 SURVEYOR

The Surveyor is the party acceptable to the Owner and retained by the Contractor who will be responsible for performing surveying activities and issuing survey products in accordance with the Construction Documents and for signing and sealing the construction survey record drawings. The Surveyor will be a Commonwealth of Puerto Rico licensed Professional Land Surveyor, with personnel experienced in the provision of surveying services and their detailed documentation. The Owner may also retain a third-party surveyor, having similar qualifications, to perform verification surveys.

3.7 CONSTRUCTION MANAGER

The Project Construction Manager (PCM), hereafter referred to as simply the Construction Manager, is an individual, appointed by the Owner, who will serve as the owner's representative and who will be responsible for overall management of the construction Project. The Construction Manager will give direction to the Contractor. The CQA Consultant will provide the Construction Manager with notifications, reports, and monitoring logs as requested.

3.8 CONTRACTOR

The term "Contractor" refers to the General Contractor (i.e., the Prime Contractor) who is retained by the Owner to closure construction. In general, the Contractor will be responsible for furnishing and installing materials in accordance with the Construction Documents (unless certain items may be procured and/or installed under separate contracts with or on behalf of the Owner). In this role, the Contractor will be responsible for earthwork activities, installation of lined cells and their leachate management systems, installation of the final cover system, and constructing associated surface water management features and other related site work. The Contractor may subcontract with various parties to conduct certain portions of the Project (e.g., geosynthetic Installer(s)). The Owner will select a Contractor qualified for this Project through experience constructing projects involving similar work elements, and with personnel and equipment availability as needed to execute a project of this magnitude.

As set forth in the Construction Documents, the Contractor will prepare various Work Plans for approval by the Owner. During construction, the Contractor will work with the Owner/Construction Manager to develop an approved schedule, execute the work according to that schedule, and communicate the timing of key milestones/activities with appropriate project parties (e.g., CQA Consultant). Note that the preceding description of the Contractor's roles and responsibilities is only a general summary and does not represent the comprehensive scope of work required by the Construction Documents. In the event of any discrepancies, the Construction Documents will govern.

3.9 *GEOSYNTHETICS MANUFACTURERS AND INSTALLERS*

Geosynthetics are manufactured materials. The Manufacturers who will supply geosynthetic materials for this Project (either procured by the Contractor or procured by the Owner, as established for the scope of work set forth in the Closure Construction Contract) are responsible for the manufacture/fabrication of such materials and for quality control during manufacture/fabrication. The minimum Manufacturer qualifications for the various geosynthetic materials of the Project are set forth in the Construction Documents.

The geosynthetic Manufacturers must implement an MQC program. MQC refers to actions taken at their manufacturing facility (i.e., prior to shipment to the jobsite) to control the quality of their products and to monitor/verify that the materials and workmanship of the geosynthetics meet the Project requirements as set forth herein and in the Construction Documents. The MQC program will be conducted by MQC personnel who are stationed at the manufacturing facility (i.e., employed or contracted by the Manufacturer), and overseen by an MQC manager.

Manufactured geosynthetics products are placed and installed in the field by an Installer, who will be subcontracted by the Contractor. The minimum geosynthetics Installer qualifications for the various geosynthetic materials of the Project are set forth in the Construction Documents.

4.0 DOCUMENTATION

4.1 OVERVIEW

The CQA Consultant will prepare and retain necessary documentation related to the CQA monitoring and testing activities performed, including review and evaluation of all daily reports. The CQA Site Manager will provide these records to the Construction Manager as requested. The CQA Site Manager will also maintain a complete file of the Construction Documents, CQA Plan, Contractor's QC Plan(s), Work Plans, checklists, test procedures, daily field reports, QC and QA data sheets and logs, and other pertinent design, construction, and CQA documentation at the site.

4.2 DAILY RECORD KEEPING

The CQA Consultant's daily reporting procedures will include: (i) daily field report; (ii) monitoring logs; (iii) photographs; (iv) testing data sheets, and (v) when appropriate, non- conformance and corrective measures reports.

4.2.1 Daily Field Reports

The CQA Consultant's daily field reports will include the following information as applicable:

- date, project name, location, and other pertinent project identifiers;
- weather conditions;
- equipment and personnel on site (including the CQA personnel);
- summary on meetings held and their results;
- a list of off-site materials received, including a list of all QC and QA documentation received;
- process description(s) and location(s) of construction activities underway during the time frame of the report;
- descriptions and specific locations of areas of work being tested and/or observed and documented;
- descriptions, maps, or sketches of locations where tests and samples were taken;
- a narrative summary of field test results;

- decisions made regarding acceptance of work and/or corrective actions to be taken in instances of substandard testing results; and
- reference to data sheets and non-conformance reports used to substantiate the non-conformances described above.

4.2.2 Monitoring Logs and Test Data Sheets

The CQA Consultant will record monitoring observations and test results on appropriate monitoring logs and test data sheets, respectively. The CQA Consultant will use the monitoring logs and test data sheets to track completeness of the required CQA activities.

The CQA Consultant's monitoring logs and test data sheets will include the following information as applicable:

- project specific information such as project name, location, and other pertinent project identifiers;
- the date the CQA activity was performed;
- a unique identifying sheet number for cross-referencing and document control;
- description or title of the CQA activity, along with the location and type of activity or location from which the sample was obtained;
- recorded observation or test data;
- results of the CQA activity and comparison with specification requirements (pass/fail); and
- the initials or signature of personnel involved in CQA inspection activity.

The CQA Consultant will maintain separate monitoring logs to track and catalog all QC information received from the CQC Consultant and to document conformance or nonconformance of the information with the requirements of the Construction Documents. The CQA Consultant may also maintain a log of periodic photographic documentation obtained as a pictorial record of construction.

4.2.3 Non-Conformance and Corrective Measures Reporting

A non-conformance is defined herein as material or workmanship that does not meet the specified requirement(s) contained in the Construction Documents.

The CQA Consultant will prepare non-conformance and corrective measures reports as needed and will cross-reference the reports to specific daily field reports, monitoring logs, or test data sheets where the non-conformance was identified. The reports will include the following information, as applicable:

- a unique identifying sheet number for cross-referencing and document control;
- detailed description of the problem;
- location of the problem;
- probable cause;
- how and when the problem was located;
- estimation of how long problem has existed;
- suggested corrective measures;
- documentation of corrections (referenced to test data sheets);
- suggested methods to prevent similar problems; and
- signature of the appropriate CQA field technicians and the CQA Site Manager.

The CQA Consultant will inform the Construction Manager in writing of any significant recurring non-conformance with the Construction Documents or CQA Plan. It will be the responsibility of the Construction Manager to direct the Contractor to make appropriate changes in materials or procedures to correct the non-conformance. The CQA Consultant will document the corrective actions taken to mitigate non-conformances.

4.3 CQA CERTIFICATION REPORT

At the completion of major construction phases, but no less frequent than on an annual basis, the CQA Consultant will provide the Owner with a CQA Certification Report pertaining to a particular construction phase or the construction achieved in the previous year, for submittal to PRDNER. This report will acknowledge that: (i) the work has been performed in compliance with the Construction Documents and this CQA Plan; (ii) physical sampling and testing has been conducted with appropriate standards and at pre-defined frequencies; (iii) the Contractor's CQC and Manufacturer's MQC documentation is in conformance with the submittal

requirements and Technical Specifications, (iv) the test results met the minimum requirements defined in the Construction Documents and this CQA Plan; and (v) the phase or the activities of the previous year were constructed in accordance with PRDNER Permit and approved permit documents.

At a minimum, the CQA Certification Report will include:

- summary of CQA activities;
- daily field reports;
- monitoring logs;
- QC and QA test data sheets (summary sheets/tabulations) including sample locations;
- QC and QA certifications and laboratory test results;
- non-conformance and corrective measures reports;
- documentation of design clarifications or revisions; and
- a summary statement indicating compliance with the Construction Documents and any approved changes, signed and sealed by the CQA Certifying Engineer.

The record drawings produced by the Surveyor will also be included as part of the CQA Certification Report. Required record drawings and their contents are set forth in the Technical Specifications, along with related Surveyor qualification requirements. In general, the record drawings will include scaled drawings depicting the locations and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.) and geomembrane panel layout drawings.

5.0 EARTHWORK

5.1 INTRODUCTION

CQA monitoring and testing will be performed during earthwork construction. CQC monitoring and testing may be performed during earthwork construction at the option of the Contractor. This earthwork may include: (i) general earthwork for preparation of subgrade and installation of soil for foundation improvement areas, dikes, channels, roads, ponds, ditches, etc.; (ii) installation of granular materials such as sand, gravel, base aggregate, and riprap; (iii) installation of soil components of liner systems; and (iv) installation of soil components of final cover systems. Minimum acceptance criteria to be used for evaluation of acceptability of the various earthwork components are identified in the Construction Documents.

5.2 AS-BUILT SURVEYS

Prior to the placement of successive soil or geosynthetic layers, the CQA Consultant will review as-built surveys that indicate compliance of the preceding layer thickness, limits, and grades with the Construction Documents.

5.3 FOUNDATION IMPROVEMENTS

If required at a particular site, the CQA Consultant will visually observe and document the Contractor's foundation improvement activities. The CQA Consultant will monitor and document that the foundation improvements are implemented to conform with the requirements of the Construction Documents, including:

- proof-rolling over the entire bottom of excavation area;
- identification and characterization of cover-collapse features and soft spots;
- remediation of cover-collapse features as appropriate for the size and extent of the feature;
- excavation and backfilling around rock pinnacles or removal of the pinnacles; and
- ground improvement of soft areas.

It will be the responsibility of the CQA Consultant to delineate any areas of non-conformance and observe their mitigation to verify that acceptable conditions are achieved. Upon completion and approval/acceptance of the above activities, placement and compaction of soil fill will commence, and the construction will be monitored, tested, and documented as set forth in the remainder of this section.

5.4 SUBGRADE

During construction, the CQA Consultant will monitor and document subgrade preparation to confirm that a firm and smooth surface free of vegetation and other deleterious materials is achieved. Material to be placed to achieve design grades will be monitored and conformance-tested by the CQA Consultant to verify that the material complies with the Construction Documents. Material placed to achieve design grades will be monitored and performance-tested by the CQA Consultant to verify that fill placement, grading, and compaction complies with the Construction Documents.

It will be the responsibility of the CQA Consultant to delineate any areas of non-conformance and observe their mitigation to verify that acceptable results are achieved.

5.5 CONFORMANCE OBSERVATIONS AND TESTING

5.5.1 Conformance Observations

The CQA Consultant will observe the earthwork components to verify they are uniform and conform to the requirements of the Construction Documents. For soil materials obtained from on-site sources, visual inspections will be performed by the CQA Consultant prior to the materials being used. If soil materials are obtained from off-site borrow sources, visual inspection may be performed by the CQA Consultant at the source location. Borrow area inspections may also be utilized by the CQA Consultant to verify that only suitable soil materials are transported to the site.

The CQA Consultant will confirm that granular materials (i.e., sand, gravel, base aggregate, and riprap) are certified by the Contractor's supplier to meet the requirements of the material type shown on the Construction Documents and are free of deleterious materials. All materials failing to comply with conformance standards will be rejected for use at the site.

Initial on-site evaluation of various soil types by CQA personnel during construction will be largely by visual and manual methods; therefore, the CQA personnel will be experienced with visual and manual soil classification procedures.

5.5.2 Conformance Test Methods and Frequencies

Conformance testing to evaluate the suitability of soil and granular materials during construction will be performed by the CQA Consultant in accordance with current ASTM or other applicable test procedures. The specified methods and minimum frequencies are indicated in Tables 1 and

2 presented in this document for each material type. The CQA Consultant may also conduct additional

conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

5.6 CONSTRUCTION MONITORING

During installation of the earthwork components, the CQA Consultant will observe and document the earthwork components to verify they are installed in accordance with the requirements of the Construction Documents and the CQA Plan. The CQA Consultant will also evaluate the procedures, methods, and equipment used by the Contractor to install the earthwork components. This will include visual observation and documentation of the Contractor's earthwork activities for the following:

- changes in soil consistency;
- thickness of lifts as loosely placed and compacted;
- soil conditioning prior to placement including general observations regarding moisture distribution, clod size, etc.;
- condition of final surfaces;
- placement methods which may damage or cause displacement or wrinkling of geosynthetics;
- the action of the compaction and heavy hauling equipment on the construction surface (sheepsfoot penetration, pumping, cracking, rutting, etc.);
- the number of passes used to compact each lift, and
- desiccation cracks or the presence of ponded water.

5.7 PERFORMANCE TESTING

Performance tests that are used to evaluate the suitability of in-place constructed soil and granular components will be performed by the CQA Consultant in accordance with current ASTM or other applicable test procedures and at the minimum frequencies indicated in the tables presented in this document for each material type. The CQA Consultant may also conduct additional performance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

5.8 DEFICIENCIES

If a deficiency (i.e., non-conformance of the materials or workmanship with the requirements of the Construction Documents) is discovered in the earthwork

construction, the CQA Consultant will assess the extent and nature of the deficiency by performing additional tests, observations, review of records, or other means that the CQA Consultant deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA Consultant will define the limits and nature of the defect.

If the deficiency cannot be resolved by the Contractor immediately or as soon as practical after identification, the CQA Site Manager will schedule appropriate re-tests for after the work deficiency is corrected.

The CQA Consultant will verify that:

- the Contractor has corrected all noted deficiencies before any additional work can be performed in the area of the deficiency; and
- if a specified criterion cannot be met because of site-specific reasons or unusual weather conditions hindering the work, the Contractor will submit suggested solutions or alternatives to the Design Engineer and Construction Manager for review.

5.9 DOCUMENTATION

CQA monitoring and testing will be documented by the CQA Consultant on forms specifically designed for this purpose. Reports and forms will be submitted to the Construction Manager.

6.0 GEOMEMBRANE

6.1 INTRODUCTION

The Construction Quality Assurance (CQA) Consultant will perform conformance and destructive seam testing, review the Manufacturer Quality Control (MQC) documentation and test results, and monitor the installation of geomembranes to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met. These procedures will be followed during installation of the geomembrane components for base liner systems and for cover systems (including the geomembrane component of closure systems with engineered turf).

6.2 MANUFACTURING PLANT VISIT

At the request of the Owner, the CQA Consultant or the Owner's Representative will visit the plant of the geomembrane Manufacturer to verify that manufacturing quality control procedures are in conformance with the Construction Documents. If possible, such a visit will be performed prior to or during the manufacturing of the geomembrane rolls for the Project.

During the project-specific manufacturing plant visit, the CQA Consultant or Owner's Representative will:

- verify that the measurements of properties by the Manufacturer are properly documented and test methods used are acceptable;
- spot-inspect the rolls and verify that they are free of holes, blisters, or any sign of contamination by foreign matter;
- review packaging and transportation procedures to verify that these procedures are not damaging the geomembrane;
- verify that all rolls are properly labeled; and
- verify that extrusion rods and/or beads manufactured for the field seaming of the geomembrane are derived from the same base resin type as the geomembrane.

Upon completion of the manufacturing plant visit, a report describing the findings and observations will be completed by the CQA Consultant or Owner's Representative and be included as an attachment to the final CQA Certification Report.

6.3 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geomembrane on the Project site. Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected in the rolled material. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe or non-repairable flaws that may compromise geomembrane quality; and
- rolls that include minor and repairable flaws that do not compromise geomembrane quality.

The CQA Consultant will also monitor that equipment used to handle the geomembrane on site is adequate and does not pose any risk of damage to the geomembrane during handling.

6.4 MANUFACTURER QC (MQC) TESTING AND CONFORMANCE (CQA) TESTING

6.4.1 Geomembrane MQC Testing Requirements

The geomembrane Manufacturer will perform QC testing on the geomembrane materials and rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies as presented in Table 3.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met.

6.4.2 Geomembrane Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, geomembrane CQA testing to evaluate the conformance of the geomembrane with the requirements of the Construction Documents and the CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Table 3.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

6.4.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the geomembrane. Any non- conformance of the material properties with the requirements of the Construction Documents will be reported to the Contractor and Construction Manager.

6.4.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be retested. If the retest fails or if the option to retest is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, which have been determined by correlation with the Manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing should continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geomembrane conformance failures.

6.5 ANCHOR TRENCH

The CQA Consultant will monitor, verify, and document that the anchor trench has been constructed as shown in the Construction Documents and meets the minimum requirements of the CQA Plan as described below. To confirm conformance with the Construction Documents, the CQA Consultant will:

- monitor that the anchor trench is constructed with a slightly rounded corner where the geosynthetics enter the trench and is backfilled as soon as possible after all geosynthetics are installed;
- perform in-place moisture/density testing of the compacted anchor trench backfill as required by the Construction Documents;
- observe that geosynthetic materials in the anchor trench are temporarily anchored with sand bags or other suitable methods if the trench will remain open after the installation of geosynthetics;

- monitor that no loose soils are left to underlie the geosynthetics in the anchor trench and all temporary ballast (i.e., sandbags) and deleterious materials are removed from the anchor trench prior to backfilling; and

- monitor that backfilling of the anchor trench is performed using extreme care when the geomembrane is in its most contracted state to minimize wrinkling and stress concentrations.

6.6 GEOMEMBRANE PLACEMENT

6.6.1 CQA Consultant Responsibility During Placement

The CQA Consultant will monitor, verify, and document that geomembrane placement is conducted in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.6.2 Field Panel Identification

A field panel is a piece of geomembrane larger than approximately 10 square feet (ft^2) that is to be seamed in the field, (i.e., a field panel is a roll or a portion of roll to be seamed in the field). The CQA Consultant will verify that each field panel is given an "identification code" (number or letter-number) that will:

- be selected as simple and logical as possible;

- be substantially consistent with the as-built layout plan; and

- allow tracing of the Manufacturer's roll numbers to the field panel identification code.

The CQA Consultant will verify documentation showing the correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all CQA records.

6.6.3 Field Panel Placement

The CQA Consultant will monitor that field panels are installed substantially at the location indicated in the Installer's layout plan, as approved or modified. The CQA Consultant will record the field panel identification

code, Manufacturer's roll number, location, date of installation, time of installation, and dimensions of each field panel.

The CQA Consultant will monitor that geomembrane placement does not proceed:

- at an ambient temperature below 40°F or above 104°F unless authorized by the Design Engineer, or

- during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

The CQA Consultant will monitor that the above conditions are fulfilled and that the supporting soil has not been damaged by adverse weather conditions. The CQA Consultant will monitor geomembrane deployment for conformance with the Construction Documents, including that:

- the geomembrane is deployed under acceptable temperature and weather conditions;

- any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;

- the prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement;

- any geosynthetic elements immediately underlying the geomembrane are clean and free of foreign objects or debris;

- all personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting subbase;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

- adequate temporary loading and/or anchoring (e.g., sand bags, tires),

not likely to damage the geomembrane, has been placed to prevent uplift by wind; and

- direct contact with the geomembrane is minimized (i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected).

The CQA Consultant will observe the geomembrane panels, after placement and prior to seaming, for damage. The CQA Consultant will advise the Construction Manager of any panels, or portions of panels, that should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the

CQA Consultant. CQA for geomembrane repairs will be in accordance with Section 6.8.

6.7 FIELD PANEL SEAMING

6.7.1 CQA Consultant Responsibility During Seaming

The CQA Consultant will monitor, verify, and document that geomembrane panel layout and field panel seaming is conducted in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.7.2 Panel Layout

The CQA Consultant will review the panel layout drawing previously submitted to the Construction Manager by the Installer and verify that

- seams are generally oriented parallel to the line of maximum slope (i.e., oriented along, not across, the slope);
- the number of seams is minimized in corners and odd-shaped geometric locations;
- a seam numbering system is used that is compatible with the field panel identification numbering system and is agreed upon by the CQA Consultant and the Installer prior to any seaming; and
- the panel layout is consistent with accepted state of practice.

6.7.3 Seaming Equipment and Products

The CQA Consultant will verify that only extrusion welding and fusion welding are used for field seaming. The CQA Consultant will document that any alternate process proposed by the Installer is reviewed and approved by the Design Engineer and Construction Manager.

The CQA Consultant will verify that no geomembrane seaming is performed unless the CQA Consultant is on site. The CQA Consultant will monitor the general seaming procedure used as follows:

- the Installer uses of seaming equipment specifically recommended by the Geosynthetics Manufacturer by make and model and marked with an identification number;
- the Installer uses a firm substrate such as a flat board, a conveyor belt, or similar hard surface directly under the seam overlap, if required, to achieve proper support;
- the Installer cuts fishmouths or wrinkles at the seam overlaps along the ridge of the wrinkle in order to achieve a flat overlap;
- the Installer cuts fishmouths or wrinkles and patches any portion, where the overlap is inadequate, with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions;
- the Installer/Contractor provides adequate illumination if seaming operations are carried out at night, and
- the Installer extends seaming to the outside edge of panels to be placed in the anchor trench.

6.7.3.1 Fusion Process

The CQA Consultant will monitor ambient temperatures, geomembrane surface temperatures, apparatus speed, and apparatus temperatures at appropriate intervals. The CQA Consultant will also monitor that:

- the fusion-welding apparatus is an automated, self-propelled device;
- the fusion-welding apparatus is equipped with gauges giving the applicable temperatures and welding speed;

- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;
- equipment used for seaming will not damage the geomembrane;
- the seaming zone is dry and clean;
- there is sufficient overlap between panels;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- for cross seams, the edge of the cross seam is cut or ground to a smooth incline (top and bottom) prior to welding;
- an insulating material is placed beneath the hot welding apparatus after usage; and
- a movable protective layer is used, as necessary, directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

6.7.3.2 Extrusion Process

The CQA Consultant will verify that the extrudate is comprised of the same resin as the geomembrane sheeting. The CQA Consultant will monitor extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals to document that they conform to the Construction Documents.

The CQA Consultant will also monitor that:

- the extrusion-welding apparatus is equipped with gauges giving the temperature in the apparatus and at the nozzle;
- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;
- equipment used for seaming is not likely to damage the geomembrane;

- the seaming zone is dry and clean;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane; and
- an insulating material is placed beneath the hot welding apparatus after usage.

6.7.4 Seam Preparation

To confirm conformance with the Construction Documents, the CQA Consultant will monitor that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- seams are overlapped in accordance with the requirements of the Construction Documents;
- if seam overlap grinding is required, the process is completed according to the Geosynthetics Manufacturer's instructions or the Construction Documents, whichever is the more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
- the grind depth is constructed in accordance with the requirements of the Construction Documents;
- grinding marks do not appear beyond the extrudate after it is placed; and
- seams are aligned with the fewest possible number of wrinkles and fishmouths.

6.7.5 Weather Conditions for Seaming

The CQA Consultant will monitor that the weather conditions for seaming are within the acceptable range, as follows:

- the ambient temperature is not below 40°F or above 104°F, unless authorized by the Design Engineer;

- geomembrane is preheated by either sun or hot air device between ambient temperatures of 40°F and 50°F prior to performing seaming; and

- geomembrane seam areas are dry and protected from rain and wind.

The CQA Consultant will verify and document that methods used by the Installer for seaming at ambient temperatures below 40°F or above 104°F will produce seams that are entirely equivalent to seams produced at ambient temperatures between 40°F and 104°F and will protect the overall quality of the geomembrane. The CQA Consultant will monitor that seaming conducted during abnormal weather conditions is performed in accordance with the methods approved by the Design Engineer.

6.7.6 Overlapping and Temporary Bonding

The CQA Consultant will monitor that:

- the panels of geomembrane have a finished overlap of a minimum of 4 inches for both extrusion and fusion welding but in any event sufficient overlap is provided to allow peel tests to be performed on the seam;

- no solvent or adhesive is used; and

- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane and specifically that the temperature of hot air at the nozzle of any spot-welding apparatus is controlled such that the geomembrane is not damaged.

6.7.7 Trial Seams

The CQA Consultant will verify that the Installer performs trial seam tests in accordance with the Construction Documents. The CQA Consultant will observe and document the Installer's trial seam testing procedures. The trial seam samples will be assigned an identification number and marked accordingly by the CQA Consultant. Each sample will be marked with the date, time, machine temperature(s) and setting(s), number of seaming unit, and name of seaming technician. Trial seam samples will be maintained until destructive seam testing of the applicable seams are tested and pass.

6.7.8 Nondestructive Seam Continuity Testing

The CQA Consultant will monitor that the Installer nondestructively tests all field seams over their full length using a vacuum test unit or air pressure test (for double fusion seams only). The CQA Consultant will monitor that the Installer performs spark testing if the seam cannot be tested using the vacuum or air pressure test methods. The purpose of nondestructive tests is to check the continuity of seams. The CQA Consultant will monitor that the Installer performs continuity testing as the seaming work progresses, not at the completion of all field seaming. The CQA Consultant will:

- monitor nondestructive testing;
- document the results of the nondestructive testing; and
- inform the Contractor and Construction Manager of any non-conformance.

The CQA Consultant will monitor that the Installer performs any required seam repairs in accordance with the Construction Documents. The CQA Consultant will:

- observe the repair procedures;
- observe the re-testing procedures; and
- document the results.

The CQA Consultant will record the seam number, date of observation, dimensions and/or descriptive location of the seam length tested, name of person performing the test, and outcome of the test.

6.7.9 Destructive Testing and CQA Performance Testing Requirements

The CQA Consultant will monitor the Installer performing destructive seam field testing during the geomembrane installation. The purpose of this testing is to evaluate seam strength. The CQA Consultant will monitor that the Installer performs destructive seam testing as the seaming work progresses, not at the completion of all field seaming.

The CQA Consultant will also conduct laboratory destructive seam testing as required by this CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies presented in Table 4.

The CQA Consultant will review the destructive seam test results to verify that the requirements of the Construction Documents and this CQA Plan are met. The CQA Consultant may conduct additional destructive seam testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

6.7.9.1 Location and Frequency

The CQA Consultant will select all destructive seam test sample locations. Sample locations will be established as follows.

- Destructive testing will be performed at a minimum frequency of one test location per 500 feet of seam length. This minimum frequency is to be determined as an average taken throughout the entire installation. This minimum frequency may be increased for seams made outside the normal ambient temperature range of 40°F to 104°F.

- Test locations will be determined during seaming at the CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Installer will not be informed in advance of the locations where the seam samples will be taken.

6.7.9.2 Sampling Procedures

Destructive seam testing will be performed by the CQA Geosynthetics Laboratory as seaming progresses in order to obtain test results prior to the geomembrane being covered by overlying materials. The CQA Consultant will:

- observe sample cutting;

- assign a number to each sample, and mark it accordingly; and

- record sample location on geomembrane panel layout drawing.

The CQA Consultant will monitor that the Installer performs repairs to all holes in the geomembrane resulting from destructive seam test sampling in accordance with repair procedures described in the Construction Documents. In addition, the CQA Consultant will monitor that the Installer performs non-destructive testing as described in this Section to ensure the continuity of the new seams.

6.7.9.3 Size of Samples

The CQA Consultant will monitor that at a given sampling location, two types of samples (field test samples and laboratory test samples) are taken:

- First, a minimum of two field samples or test strips are taken for field testing. Each of these test strips are approximately 1 inch wide by 12 inches long, with the seam centered parallel to the width. The distance between these two specimens is approximately 42 inches. If both specimens pass the field test described in this Section, a second full laboratory destructive sample is taken for testing by the CQA Geosynthetics Laboratory.

- The full destructive sample is located between the two field test strips. The sample is approximately 12 inches wide by 42 inches long with the seam centered lengthwise. The sample is cut into three parts and distributed as follows:

  - one approximately 12 inches by 12 inches portion to the Installer;

  - one approximately 12 inches by 12 inches portion to the Construction Manager for archive storage; and

  - one approximately 12 inches by 18 inches portion for CQA Geosynthetics Laboratory testing.

6.7.9.4 Field Testing

The CQA Consultant will monitor that the test strips are tested in the field for peel adhesion using a gauged tensiometer by the Installer. In addition to meeting the strength requirements outlined in the Construction Documents, the CQA Consultant will monitor that all specimens exhibit a film tear bond and do not fail in the weld. If any field test sample fails to meet these requirements, the destructive sample has failed.

The CQA Consultant will witness all field tests and mark all samples and portions with their number. The CQA Consultant will also log the date, number of seaming unit, seaming technician identification, destructive sampling, and pass or fail description.

6.7.9.5 Geosynthetics Laboratory Testing

Destructive test samples will be tested by the CQA Geosynthetics Laboratory. Testing will include "Bonded Seam Strength" and "Peel Adhesion". At least five specimens will be tested for each test method (i.e., five for peel and five for shear). Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear, etc.). Both the inside and outside tracks of the double track fusion seams will be tested for peel adhesion. A passing test will meet the minimum required values in the Construction Documents.

The Geosynthetics Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available and report the results to the Construction Manager.

6.7.9.6 Procedures for Destructive Test Failure

The CQA Consultant will monitor that the following procedures apply whenever a sample fails a destructive test, whether that test was conducted in the field or by the CQA Geosynthetics Laboratory. The CQA Consultant will monitor that the Installer follows one of the two options below:

- The Installer can reconstruct the seam (e.g., remove the old seam and re-seam) between any two passed destructive test locations or between points judged by the CQA Consultant to represent

  conditions of the failed seam (e.g., a tie-in seam or a seam made by the apparatus and/or operator used in the failing seam); or

- The Installer can trace the welding path to an intermediate location a minimum of 10 feet from the point of the failed test in each direction and take a small sample for additional field testing in accordance with the destructive test procedure at each location. If these additional isolation samples pass the field test, then full laboratory samples are taken at both locations. If these laboratory samples meet the specified strength criteria, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed or repaired.

The CQA Consultant will monitor that all failed seams are bound by two locations from which samples passing laboratory destructive tests have been taken or the entire seam is reconstructed and re-tested. In cases exceeding 150 feet of reconstructed seam, a sample will be taken from the reconstructed portion of the seam and must pass destructive testing. The CQA Consultant will observe that any repairs are made in accordance with Section 6.8. The CQA Consultant will document all actions taken in conjunction with destructive test failures.

6.8 DEFECTS AND REPAIRS

6.8.1 CQA Consultant Responsibility for Monitoring Defects and Repairs

The CQA Consultant will monitor, verify, and document that geomembrane defects are addressed and repairs are made in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.8.2 Identification

All seams and non-seam areas of the geomembrane will be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The CQA Consultant will request that the Contractor broom or wash the geomembrane surface if the amount of dust or mud inhibits examination.

6.8.3 Repair Procedures

The CQA Consultant will monitor that any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test is repaired by the Installer in accordance with the Construction Documents. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure, materials, and equipment will be agreed upon between the Installer and CQA Consultant.

In addition, the following conditions will be monitored by the CQA Consultant:

- surfaces of the geomembrane which are to be repaired are abraded no more than one hour prior to the repair;

- all surfaces are clean and dry at the time of the repair;
- patches or caps extend at least 6 inches beyond the edge of the defect, and all corners of patches are rounded with a radius of at least 3 inches; and
- the geomembrane below large caps is appropriately cut to avoid water or gas collection between the two sheets.

6.8.4 Verification of Repairs

Each repair will be numbered and logged by the CQA Consultant. The CQA Consultant will monitor that each repair is non-destructively tested by the Installer using approved methods. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Consultant. The CQA Consultant will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

6.9 GEOMEMBRANE ACCEPTANCE

In accordance with the Construction Documents, the Contractor retains all responsibility for the geosynthetics until acceptance by the Construction Manager. The terms and conditions for liner and cover system geomembranes acceptance are described in the Construction Documents.

6.10 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

The procedures outlined in this section are intended to allow the CQA Consultant to verify that the installation of materials in contact with the geomembrane do not cause damage to it.

6.10.1 Soils

The CQA Consultant will monitor that the Contractor conforms with the requirements of the Construction Documents and takes all necessary precautions to verify that the geomembrane is not damaged during its installation, during the installation of other components of the liner and the final cover systems, or by other construction activities. The CQA Consultant will monitor the following:

- placement of soil materials above the geomembrane and that soils are not placed at an ambient temperature below 40°F or above 104°F

unless otherwise approved by the Design Engineer and Construction Manager;

- overlying soil and aggregate/riprap materials are not placed above the geomembrane until a cushion layer(s) is in place;
- material placement operations above the geomembrane are performed by the Contractor in a manner that does not damage the geomembrane and that minimizes wrinkles in the geomembrane;
- equipment used for placing materials above the geomembrane are not driven directly on the geomembrane or other geosynthetic layers;
- a minimum material thickness of 1 foot is maintained between a low ground pressure (LGP - having a maximum ground pressure of 5 pounds per square inch [psi]) track-mounted dozer and the geomembrane;
- a minimum material thickness of 3 feet is maintained between rubber-tired or non-low ground pressure tracked vehicles and the geomembrane during construction activities; and
- material thickness above the geomembrane is greater than 3 feet in heavily trafficked areas such as access ramps.

6.10.2 Appurtenances

The CQA Consultant will monitor that:

- installation of the geomembrane in appurtenant areas and connection of geomembrane to appurtenances (e.g., concrete pads or concrete embedment strips at geomembrane termination) are made in accordance with the Construction Documents;
- extreme care is given by the Installer when seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and
- the geomembrane is not visibly damaged when making connections to appurtenances.

6.11 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geomembrane on the Project site. Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected in the rolled material. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe or non-repairable flaws that may compromise geomembrane quality; and
- rolls that include minor and repairable flaws that do not compromise geomembrane quality.

The CQA Consultant will also monitor that equipment used to handle the geomembrane on site is adequate and does not pose any risk of damage to the geomembrane during handling.

6.12 MANUFACTURER QC (MQC) TESTING AND CONFORMANCE (CQA) TESTING

6.12.1 Geomembrane MQC Testing Requirements

The geomembrane Manufacturer will perform QC testing on the geomembrane materials and rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies as presented in Table 3.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met.

6.12.2 Geomembrane Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, geomembrane CQA testing to evaluate the conformance of the geomembrane with the requirements of the Construction Documents and the CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Table 3.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

6.12.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the geomembrane. Any non- conformance of the material properties with the requirements of the Construction Documents will be reported to the Contractor and Construction Manager.

6.12.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be retested. If the retest fails or if the option to retest is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls, which have been determined by correlation with the Manufacturer's roll number, to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing should continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geomembrane conformance failures.

6.13 ANCHOR TRENCH

The CQA Consultant will monitor, verify, and document that the anchor trench has been constructed as shown in the Construction Documents and meets the minimum requirements of the CQA Plan as described below. To confirm conformance with the Construction Documents, the CQA Consultant will:

- monitor that the anchor trench is constructed with a slightly rounded corner where the geosynthetics enter the trench and is backfilled as soon as possible after all geosynthetics are installed;
- perform in-place moisture/density testing of the compacted anchor trench backfill as required by the Construction Documents;
- observe that geosynthetic materials in the anchor trench are temporarily anchored with sand bags or other suitable methods if the trench will remain open after the installation of geosynthetics;

- monitor that no loose soils are left to underlie the geosynthetics in the anchor trench and all temporary ballast (i.e., sandbags) and deleterious materials are removed from the anchor trench prior to backfilling; and
- monitor that backfilling of the anchor trench is performed using extreme care when the geomembrane is in its most contracted state to minimize wrinkling and stress concentrations.

6.14 GEOMEMBRANE PLACEMENT

6.14.1 CQA Consultant Responsibility During Placement

The CQA Consultant will monitor, verify, and document that geomembrane placement is conducted in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.14.2 Field Panel Identification

A field panel is a piece of geomembrane larger than approximately 10 square feet (ft^2) that is to be seamed in the field, (i.e., a field panel is a roll or a portion of roll to be seamed in the field). The CQA Consultant will verify that each field panel is given an "identification code" (number or letter-number) that will:

- be selected as simple and logical as possible;
- be substantially consistent with the as-built layout plan; and
- allow tracing of the Manufacturer's roll numbers to the field panel identification code.

The CQA Consultant will verify documentation showing the correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code will be used for all CQA records.

6.14.3 Field Panel Placement

The CQA Consultant will monitor that field panels are installed substantially at the location indicated in the Installer's layout plan, as approved or modified. The CQA Consultant will record the field panel identification code, Manufacturer's roll number, location, date of installation, time of installation, and dimensions of each field panel.

The CQA Consultant will monitor that geomembrane placement does not proceed:

- at an ambient temperature below 40°F or above 104°F unless authorized by the Design Engineer; or

- during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

The CQA Consultant will monitor that the above conditions are fulfilled and that the supporting soil has not been damaged by adverse weather conditions. The CQA Consultant will monitor geomembrane deployment for conformance with the Construction Documents, including that:

- the geomembrane is deployed under acceptable temperature and weather conditions;

- any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means;

- the prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement;

- any geosynthetic elements immediately underlying the geomembrane are clean and free of foreign objects or debris;

- all personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane;

- the method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting subbase;

- the method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);

- adequate temporary loading and/or anchoring (e.g., sand bags, tires),

not likely to damage the geomembrane, has been placed to prevent uplift by wind; and

- direct contact with the geomembrane is minimized (i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected).

The CQA Consultant will observe the geomembrane panels, after placement and prior to seaming, for damage. The CQA Consultant will advise the Construction Manager of any panels, or portions of panels, that should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the

CQA Consultant. CQA for geomembrane repairs will be in accordance with Section 6.8.

6.15 FIELD PANEL SEAMING

6.15.1 CQA Consultant Responsibility During Seaming

The CQA Consultant will monitor, verify, and document that geomembrane panel layout and field panel seaming is conducted in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.15.2 Panel Layout

The CQA Consultant will review the panel layout drawing previously submitted to the Construction Manager by the Installer and verify that:

- seams are generally oriented parallel to the line of maximum slope (i.e., oriented along, not across, the slope);
- the number of seams is minimized in corners and odd-shaped geometric locations;
- a seam numbering system is used that is compatible with the field panel identification numbering system and is agreed upon by the CQA Consultant and the Installer prior to any seaming; and

- the panel layout is consistent with accepted state of practice.

6.15.3 Seaming Equipment and Products

The CQA Consultant will verify that only extrusion welding and fusion welding are used for field seaming. The CQA Consultant will document that any alternate process proposed by the Installer is reviewed and approved by the Design Engineer and Construction Manager.

The CQA Consultant will verify that no geomembrane seaming is performed unless the CQA Consultant is on site. The CQA Consultant will monitor the general seaming procedure used as follows:

- the Installer uses of seaming equipment specifically recommended by the Geosynthetics Manufacturer by make and model and marked with an identification number;
- the Installer uses a firm substrate such as a flat board, a conveyor belt, or similar hard surface directly under the seam overlap, if required, to achieve proper support;
- the Installer cuts fishmouths or wrinkles at the seam overlaps along the ridge of the wrinkle in order to achieve a flat overlap;
- the Installer cuts fishmouths or wrinkles and patches any portion, where the overlap is inadequate, with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions;
- the Installer/Contractor provides adequate illumination if seaming operations are carried out at night, and
- the Installer extends seaming to the outside edge of panels to be placed in the anchor trench.

6.15.3.1 Fusion Process

The CQA Consultant will monitor ambient temperatures, geomembrane surface temperatures, apparatus speed, and apparatus temperatures at appropriate intervals. The CQA Consultant will also monitor that:

- the fusion-welding apparatus is an automated, self-propelled device;

- the fusion-welding apparatus is equipped with gauges giving the applicable temperatures and welding speed;
- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;
- equipment used for seaming will not damage the geomembrane;
- the seaming zone is dry and clean;
- there is sufficient overlap between panels;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
- for cross seams, the edge of the cross seam is cut or ground to a smooth incline (top and bottom) prior to welding;
- an insulating material is placed beneath the hot welding apparatus after usage; and
- a movable protective layer is used, as necessary, directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

6.15.3.2 Extrusion Process

The CQA Consultant will verify that the extrudate is comprised of the same resin as the geomembrane sheeting. The CQA Consultant will monitor extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals to document that they conform to the Construction Documents.

The CQA Consultant will also monitor that:

- the extrusion-welding apparatus is equipped with gauges giving the temperature in the apparatus and at the nozzle;
- the number of spare operable seaming apparatus agreed by the Construction Manager are maintained on site;

- equipment used for seaming is not likely to damage the geomembrane;
- the seaming zone is dry and clean;
- the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel;
- the electric generator is placed on a smooth base such that no damage occurs to the geomembrane; and
- an insulating material is placed beneath the hot welding apparatus after usage.

6.15.4 Seam Preparation

To confirm conformance with the Construction Documents, the CQA Consultant will monitor that:

- prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- seams are overlapped in accordance with the requirements of the Construction Documents;
- if seam overlap grinding is required, the process is completed according to the Geosynthetics Manufacturer's instructions or the Construction Documents, whichever is the more stringent, prior to the seaming operation, and in a way that does not damage the geomembrane;
- the grind depth is constructed in accordance with the requirements of the Construction Documents;
- grinding marks do not appear beyond the extrudate after it is placed; and
- seams are aligned with the fewest possible number of wrinkles and fishmouths.

6.15.5 Weather Conditions for Seaming

The CQA Consultant will monitor that the weather conditions for seaming are within the acceptable range, as follows:

- the ambient temperature is not below 40°F or above 104°F, unless authorized by the Design Engineer;
- geomembrane is preheated by either sun or hot air device between ambient temperatures of 40°F and 50°F prior to performing seaming; and
- geomembrane seam areas are dry and protected from rain and wind.

The CQA Consultant will verify and document that methods used by the Installer for seaming at ambient temperatures below 40°F or above 104°F will produce seams that are entirely equivalent to seams produced at ambient temperatures between 40°F and 104°F and will protect the overall quality of the geomembrane. The CQA Consultant will monitor that seaming conducted during abnormal weather conditions is performed in accordance with the methods approved by the Design Engineer.

6.15.6 Overlapping and Temporary Bonding

The CQA Consultant will monitor that:

- the panels of geomembrane have a finished overlap of a minimum of 4 inches for both extrusion and fusion welding but in any event sufficient overlap is provided to allow peel tests to be performed on the seam;
- no solvent or adhesive is used; and
- the procedure used to temporarily bond adjacent panels together does not damage the geomembrane and specifically that the temperature of hot air at the nozzle of any spot-welding apparatus is controlled such that the geomembrane is not damaged.

6.15.7 Trial Seams

The CQA Consultant will verify that the Installer performs trial seam tests in accordance with the Construction Documents. The CQA Consultant will observe and document the Installer's trial seam testing procedures. The

trial seam samples will be assigned an identification number and marked accordingly by the CQA Consultant. Each sample will be marked with the date, time, machine temperature(s) and setting(s), number of seaming unit, and name of seaming technician. Trial seam samples will be maintained until destructive seam testing of the applicable seams are tested and pass.

6.15.8 Nondestructive Seam Continuity Testing

The CQA Consultant will monitor that the Installer nondestructively tests all field seams over their full length using a vacuum test unit or air pressure test (for double fusion seams only). The CQA Consultant will monitor that the Installer performs spark testing if the seam cannot be tested using the vacuum or air pressure test methods. The purpose of nondestructive tests is to check the continuity of seams. The CQA Consultant will monitor that the Installer performs continuity testing as the seaming work progresses, not at the completion of all field seaming. The CQA Consultant will:

- monitor nondestructive testing;
- document the results of the nondestructive testing; and
- inform the Contractor and Construction Manager of any non-conformance.

The CQA Consultant will monitor that the Installer performs any required seam repairs in accordance with the Construction Documents. The CQA Consultant will:

- observe the repair procedures;
- observe the re-testing procedures; and
- document the results.

The CQA Consultant will record the seam number, date of observation, dimensions and/or descriptive location of the seam length tested, name of person performing the test, and outcome of the test.

6.15.9 Destructive Testing and CQA Performance Testing Requirements

The CQA Consultant will monitor the Installer performing destructive seam field testing during the geomembrane installation. The purpose of this

testing is to evaluate seam strength. The CQA Consultant will monitor that the Installer performs destructive seam testing as the seaming work progresses, not at the completion of all field seaming.

The CQA Consultant will also conduct laboratory destructive seam testing as required by this CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies presented in Table 4.

The CQA Consultant will review the destructive seam test results to verify that the requirements of the Construction Documents and this CQA Plan are met. The CQA Consultant may conduct additional destructive seam testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

6.15.9.1 Location and Frequency

The CQA Consultant will select all destructive seam test sample locations. Sample locations will be established as follows.

- Destructive testing will be performed at a minimum frequency of one test location per 500 feet of seam length. This minimum frequency is to be determined as an average taken throughout the entire installation. This minimum frequency may be increased for seams made outside the normal ambient temperature range of 40°F to 104°F.

- Test locations will be determined during seaming at the CQA Consultant's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Installer will not be informed in advance of the locations where the seam samples will be taken.

6.15.9.2 Sampling Procedures

Destructive seam testing will be performed by the CQA Geosynthetics Laboratory as seaming progresses in order to obtain test results prior to the geomembrane being covered by overlying materials. The CQA Consultant will:

- observe sample cutting;

- assign a number to each sample, and mark it accordingly; and

- record sample location on geomembrane panel layout drawing.

The CQA Consultant will monitor that the Installer performs repairs to all holes in the geomembrane resulting from destructive seam test sampling in accordance with repair procedures described in the Construction Documents. In addition, the CQA Consultant will monitor that the Installer performs non-destructive testing as described in this Section to ensure the continuity of the new seams.

6.15.9.3 Size of Samples

The CQA Consultant will monitor that at a given sampling location, two types of samples (field test samples and laboratory test samples) are taken:

- First, a minimum of two field samples or test strips are taken for field testing. Each of these test strips are approximately 1 inch wide by 12 inches long, with the seam centered parallel to the width. The distance between these two specimens is approximately 42 inches. If both specimens pass the field test described in this Section, a second full laboratory destructive sample is taken for testing by the CQA Geosynthetics Laboratory.

- The full destructive sample is located between the two field test strips. The sample is approximately 12 inches wide by 42 inches long with the seam centered lengthwise. The sample is cut into three parts and distributed as follows:

  - one approximately 12 inches by 12 inches portion to the Installer;

  - one approximately 12 inches by 12 inches portion to the Construction Manager for archive storage; and

  - one approximately 12 inches by 18 inches portion for CQA Geosynthetics Laboratory testing.

6.15.9.4 Field Testing

The CQA Consultant will monitor that the test strips are tested in the field for peel adhesion using a gauged tensiometer by the Installer. In addition to meeting the strength requirements outlined in the Construction Documents, the CQA Consultant will monitor that all specimens exhibit a film tear bond and do not fail in the weld. If any field test sample fails to meet these requirements, the destructive sample has failed.

The CQA Consultant will witness all field tests and mark all samples and portions with their number. The CQA Consultant will also log the date, number of seaming unit, seaming technician identification, destructive sampling, and pass or fail description.

6.15.9.5 Geosynthetics Laboratory Testing

Destructive test samples will be tested by the CQA Geosynthetics Laboratory. Testing will include "Bonded Seam Strength" and "Peel Adhesion". At least five specimens will be tested for each test method (i.e., five for peel and five for shear). Specimens will be selected alternately by test from the samples (i.e., peel, shear, peel, shear, etc.). Both the inside and outside tracks of the double track fusion seams will be tested for peel adhesion. A passing test will meet the minimum required values in the Construction Documents.

The Geosynthetics Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available and report the results to the Construction Manager.

6.15.9.6 Procedures for Destructive Test Failure

The CQA Consultant will monitor that the following procedures apply whenever a sample fails a destructive test, whether that test was conducted in the field or by the CQA Geosynthetics Laboratory. The CQA Consultant will monitor that the Installer follows one of the two options below:

- The Installer can reconstruct the seam (e.g., remove the old seam and re-seam) between any two passed destructive test locations or between points judged by the CQA Consultant to represent

conditions of the failed seam (e.g., a tie-in seam or a seam made by the apparatus and/or operator used in the failing seam); or

- The Installer can trace the welding path to an intermediate location a minimum of 10 feet from the point of the failed test in each direction and take a small sample for additional field testing in accordance with the destructive test procedure at each location. If these additional isolation samples pass the field test, then full laboratory samples are taken at both locations. If these laboratory samples meet the specified strength criteria, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam should be reconstructed or repaired.

The CQA Consultant will monitor that all failed seams are bound by two locations from which samples passing laboratory destructive tests have been taken or the entire seam is reconstructed and re-tested. In cases exceeding 150 feet of reconstructed seam, a sample will be taken from the reconstructed portion of the seam and must pass destructive testing. The CQA Consultant will observe that any repairs are made in accordance with Section 6.8. The CQA Consultant will document all actions taken in conjunction with destructive test failures.

6.16 DEFECTS AND REPAIRS

6.16.1 CQA Consultant Responsibility for Monitoring Defects and Repairs

The CQA Consultant will monitor, verify, and document that geomembrane defects are addressed and repairs are made in accordance with the Construction Documents and that CQA activities are performed as described in the subsections below.

6.16.2 Identification

All seams and non-seam areas of the geomembrane will be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane will be clean at the time of examination. The CQA Consultant will request that the Contractor broom or wash the geomembrane surface if the amount of dust or mud inhibits examination.

6.16.3 Repair Procedures

The CQA Consultant will monitor that any portion of the geomembrane exhibiting a flaw or failing a destructive or nondestructive test is repaired by the Installer in accordance with the Construction Documents. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure, materials, and equipment will be agreed upon between the Installer and CQA Consultant.

In addition, the following conditions will be monitored by the CQA Consultant:

- surfaces of the geomembrane which are to be repaired are abraded no more than one hour prior to the repair;
- all surfaces are clean and dry at the time of the repair;
- patches or caps extend at least 6 inches beyond the edge of the defect, and all corners of patches are rounded with a radius of at least 3 inches; and
- the geomembrane below large caps is appropriately cut to avoid water or gas collection between the two sheets.

6.16.4 Verification of Repairs

Each repair will be numbered and logged by the CQA Consultant. The CQA Consultant will monitor that each repair is non-destructively tested by the Installer using approved methods. Repairs which pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the CQA Consultant. The CQA Consultant will observe all non-destructive testing of repairs and will record the number of each repair, date, and test outcome.

6.17 GEOMEMBRANE ACCEPTANCE

In accordance with the Construction Documents, the Contractor retains all responsibility for the geosynthetics until acceptance by the Construction Manager. The terms and conditions for liner and cover system geomembranes acceptance are described in the Construction Documents.

6.18 MATERIALS IN CONTACT WITH THE GEOMEMBRANE

The procedures outlined in this section are intended to allow the CQA Consultant to verify that the installation of materials in contact with the geomembrane do not cause damage to it.

6.18.1 Soils

The CQA Consultant will monitor that the Contractor conforms with the requirements of the Construction Documents and takes all necessary precautions to verify that the geomembrane is not damaged during its installation, during the installation of other components of the liner and the final cover systems, or by other construction activities. The CQA Consultant will monitor the following:

- placement of soil materials above the geomembrane and that soils are not placed at an ambient temperature below 40°F or above 104°F unless otherwise approved by the Design Engineer and Construction Manager;
- overlying soil and aggregate/riprap materials are not placed above the geomembrane until a cushion layer(s) is in place;
- material placement operations above the geomembrane are performed by the Contractor in a manner that does not damage the geomembrane and that minimizes wrinkles in the geomembrane;
- equipment used for placing materials above the geomembrane are not driven directly on the geomembrane or other geosynthetic layers;
- a minimum material thickness of 1 foot is maintained between a low ground pressure (LGP - having a maximum ground pressure of 5 pounds per square inch [psi]) track-mounted dozer and the geomembrane;
- a minimum material thickness of 3 feet is maintained between rubber-tired or non-low ground pressure tracked vehicles and the geomembrane during construction activities; and
- material thickness above the geomembrane is greater than 3 feet in heavily trafficked areas such as access ramps.

6.18.2 Appurtenances

The CQA Consultant will monitor that:

- installation of the geomembrane in appurtenant areas and connection of geomembrane to appurtenances (e.g., concrete pads or concrete embedment strips at geomembrane termination) are made in accordance with the Construction Documents;

- extreme care is given by the Installer when seaming around appurtenances since neither non-destructive nor destructive testing may be feasible in these areas; and

- the geomembrane is not visibly damaged when making connections to appurtenances.

7 GEOTEXTILES

7.1 INTRODUCTION

The CQA Consultant will perform conformance testing, review the MQC documentation, and monitor the installation of the geotextile layers to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met.

7.2 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the geotextile on the Project site. The CQA Consultant will verify that the geotextile is protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

The CQA Consultant will monitor that transportation, handling, and storage of geotextile conforms with the Construction Documents, including:

- handling of the geotextile rolls is performed in a competent manner such that damage does not occur to the geotextile or to its protective wrapping;
- geotextile rolls are not stacked upon one another to the extent that deformation of the core occurs or to the point where accessibility can cause damage in handling;
- geotextile rolls are stacked in such a way that access for conformance sampling is possible;
- protective wrappings are removed less than one hour prior to unrolling the geotextile;
- after unrolling, a geotextile is not exposed to ultraviolet light for more than 30 calendar days;
- outdoor storage of geotextile rolls does not exceed the Manufacturer's recommendations or longer than six months, whichever is less;
- for storage periods longer than six months, a temporary enclosure is placed over the rolls, or they are moved to an enclosed facility; and
- the location of temporary field storage is not in areas where water can accumulate, and the rolls are elevated off the ground to prevent contact with ponded water.

- Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without

- unrolling the materials unless defects or damages are found or suspected. The CQA Consultant will indicate to the Construction Manager

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe flaws; and

- rolls that include minor repairable flaws that do not compromise geotextile functionality.

The CQA Consultant will also monitor that equipment used to handle the geotextiles on site is adequate and does not pose any risk of damage to the geotextiles during handling.

7.3 MANUFACTURER QC (MQC) TESTING AND CONFORMANCE (CQA) TESTING

7.3.1 Geotextile MQC Testing Requirements

The geotextile Manufacturer will perform QC testing on the geotextile materials and rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum MQC frequencies as presented in Table 5.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met.

7.3.2 Geotextile Conformance Testing Requirements

The CQA Consultant will coordinate, and the CQA Geosynthetics Laboratory will perform, geotextile conformance testing to evaluate the conformance of the geotextile with the requirements of the Construction Documents and the CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Table 5, corresponding to each geotextile material type that will be used.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or the CQA Certifying Engineer.

7.3.3 Test Results

All MQC and conformance test results will be reviewed, accepted, and

reported by the CQA Consultant before deployment of geotextiles. Any non-conformance of the material properties with the requirements of the Construction Documents will be reported to the Contractor and Construction Manager.

7.3.4 Test Failure

In the case of failing test results, the Contractor may request that another sample from the failing roll be re-tested. If the re-test fails or if the option to re-test is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant. These isolation samples will be taken from rolls that have been determined by correlation with the Manufacturer's roll number to have been manufactured prior to and after the failing roll. This method for choosing isolation rolls for testing will continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with geotextile conformance failures.

7.4 PLACEMENT

The CQA Consultant will monitor, verify, and document that geotextile placement is conducted in accordance with the Construction Documents and that CQA activities are performed as described below.

The CQA Consultant will monitor the placement of all geotextiles to verify that they are not damaged in any way and the following requirements of the Construction Documents are met:

- on slopes, the geotextiles are securely anchored in the anchor trench and then deployed down the slope in such a manner as to continually keep the geotextile in tension;
- in the presence of wind, all geotextiles are weighted with sandbags or equivalent; such sandbags are installed during placement and will remain until replaced with earth cover material;
- trimming of the geotextiles is performed using only an upward cutting hook blade and special care is given to protect other materials from damage which could be caused by the cutting of the geotextiles;
- the Installer is taking necessary precautions to prevent damage to underlying layers during placement of the geotextile;

- during placement of geotextiles, care is given not to entrap stones, excessive dust, or moisture that could generate clogging of drains or filters; and

- a visual examination of the geotextile is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, (e.g., stones, sharp objects, small tools, sandbags, etc.) are present.

7.5 *SEAMS AND OVERLAPS*

The CQA Consultant will monitor, verify, and document that geotextile seams and overlaps are in accordance with the Construction Documents and that CQA activities are performed as described below.

The CQA Consultant will monitor that the following requirements of the Construction Documents are met:

- all geotextiles are continuously sewn (i.e., no spot sewing);

- geotextiles are overlapped 6 inches prior to seaming;

- no horizontal seams are constructed on side slopes that are steeper than 10 horizontal to 1 vertical (i.e., seams to be aligned along, not across the slope), except as part of a patch;

- sewing uses polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile; and

- seams are sewn using a single row Stich Type 401 two-thread chain stitch.

7.6 *REPAIRS*

The CQA Consultant will monitor, verify, and document that geotextile repairs are made in accordance with the Construction Documents and that CQA activities are performed as described below.

The CQA Consultant will monitor that any holes or tears in the geotextile are repaired as follows:

- For slopes steeper than 10 horizontal:1 vertical, a patch made from the same geotextile is double seamed into place (with each seam 1/4 inches to 3/4 inches apart and no closer than 1 inch from any edge) with a minimum 12-inch overlap. Should any tear exceed 50 percent of the width of the roll, that roll is removed from the slope and replaced.

- For slopes milder than 10 horizontal:1 vertical, a patch made from the same geotextile is sewn in place with a minimum of 12-inch overlap in all directions away from the repair area.

The CQA Consultant will observe that care is given to remove any soil or other material which may have penetrated the torn geotextile and all repairs and verify that any non- conformance with the above requirements is corrected.

7.7 *PLACEMENT OF SOILS OR GRANULAR MATERIALS*

The CQA Consultant will monitor, verify, and document that placement of soils or granular materials on top of geotextiles is conducted in accordance with the Construction Documents and that CQA activities are performed as described below.

The CQA Consultant will monitor that the Contractor's placement of soil or granular materials on top of the geotextile is in conformance with the Construction Documents, including:

- that no damage occurs to the geotextile;
- that no shifting of the geotextile from its intended position occurs and underlying materials are not exposed or damaged;
- that excess tensile stress does not occur in the geotextile;
- that equipment does not drive directly on the geotextile; and
- the Contractor uses only LGP equipment on layers less than 3-feet thick above the geomembrane and geotextile separator or cushion layer.

The CQA Consultant will monitor that covering of the geotextile with overlying layers is completed within 30 days of installation to prevent UV degradation and, on side slopes, soil and granular layers are placed over the geotextile from the bottom of the slope upward.

8 ENGINEERED TURF

8.1 INTRODUCTION

The CQA Consultant will perform conformance testing, review the MQC documentation and testing results, and monitor the installation of engineered turf to verify that the Manufacturer's specifications and the requirements of the Construction Documents and the CQA Plan are met. The installation of the engineered turf will also include the installation of overlaying ballast material (i.e., sand infill, cementitious binder, and/or armored fill).

8.2 MANUFACTURING PLANT VISIT

At the request of the Owner, the CQA Consultant or the Owner's Representative will visit the plant of the engineered turf Manufacturer to verify that manufacturing quality control procedures are in conformance with the Construction Documents. If possible, such a visit will be performed prior to or during the manufacturing of the engineered turf rolls for the Project.

During the project-specific manufacturing plant visit, the CQA Consultant or Owner's Representative will:

- verify that the measurements of properties by the Manufacturer are properly documented and test methods used are acceptable;
- spot-inspect the rolls and verify that they are free of holes, blisters, or any sign of contamination by foreign matter;
- review packaging and transportation procedures to verify that these procedures are not damaging the engineered turf; and
- verify that all rolls are properly labeled.

Upon completion of the manufacturing plant visit, a report describing the findings and observations will be completed by the CQA Consultant or Owner's Representative and be included as an attachment to the final CQA Certification Report.

8.3 TRANSPORTATION, HANDLING, AND STORAGE

The CQA Consultant will monitor the transportation, handling, and storage of the engineered turf on the Project site. The CQA Consultant will verify that the engineered turf is protected from precipitation or other inundation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

The CQA Consultant will monitor that transportation, handling, and storage of engineered turf conforms with the Construction Documents, including:

- handling of the engineered turf rolls is performed in a competent manner such that damage does not occur to the engineered turf or to its protective wrapping;
- engineered turf rolls are not stacked upon one another to the extent that deformation of the core occurs or to the point where accessibility can cause damage in handling; and
- engineered turf rolls are stacked in such a way that access for conformance sampling is possible.

Upon delivery at the site, the Contractor, Installer, and CQA Consultant will conduct an inspection of the rolls for defects and damage. This inspection will be conducted without unrolling the materials unless defects or damages are found or suspected in the rolled material. The CQA Consultant will indicate to the Construction Manager:

- rolls, or portions thereof, that will be rejected and removed from the site because they have severe or non-repairable flaws that may compromise engineered turf quality; and
- rolls that include minor and repairable flaws that do not compromise engineered turf quality.

8.4 MANUFACTURER QC (MQC) TESTING AND CONFORMANCE (CQA) TESTING

8.4.1 Engineered Turf MQC Testing Requirements

The engineered turf Manufacturer will perform QC testing on the engineered turf materials and rolls that will be used on this Project in accordance with the current versions of the ASTM and other applicable test procedures, and at the minimum MQC frequencies as presented in Table 6.

The CQA Consultant will review the MQC certifications and test results to verify that the Manufacturer's specifications and the requirements of the Construction Documents and this CQA Plan are met.

8.4.2 Sand Infill Material Pre-Construction Testing Requirements

The sand infill supplier/manufacturer will perform the geotechnical pre-

construction QC testing on a representative sample of the sand infill that will be used on this Project as required by the Construction Documents. The CQA Consultant will review the QC certifications and test results to verify that the requirements of the Construction Documents are met.

8.4.3 Engineered Turf Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Geosynthetics Laboratory) will perform, engineered turf CQA testing to evaluate the conformance of the engineered turf with the requirements of the Construction Documents and the CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Table 6.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

8.4.4 Sand Infill Material Conformance CQA Testing Requirements

The CQA Consultant will coordinate, and a qualified laboratory (i.e., the CQA Soils Laboratory) will perform, sand infill CQA testing to evaluate the conformance of the sand material with the requirements of the Construction Documents and the CQA Plan. The testing will be performed in accordance with the current versions of the ASTM and other applicable test procedures and at the minimum frequencies indicated in Table 6.

The CQA Consultant may conduct additional conformance testing if deemed necessary by the Owner and/or CQA Certifying Engineer.

8.4.5 Test Results

All MQC and conformance test results will be reviewed, accepted, and reported by the CQA Consultant before deployment of the engineered turf and placement of sand infill. Any non-conformance of the material properties with the requirements of the Construction Documents will be reported to the Contractor and Construction Manager.

8.4.6 Test Failure

All materials failing to comply with conformance standards will be rejected for use at the site. In the case of failing test results of engineered turf, the Contractor may request that another sample from the failing roll be retested. If the retest fails or if the option to retest is not exercised, then two isolation conformance samples will be obtained by the CQA Consultant.

These isolation samples will be taken from rolls, which have been determined by correlation with the manufacturer's roll number, to have been manufactured prior to and after the

failing roll. This method for choosing isolation rolls for testing should continue until passing tests are achieved. All rolls that fall numerically between the passing roll numbers will be rejected. In the case of failing test results of sand infill, the sand represented by the failing test will be rejected. If requested by the sand supplier and approved by the Owner, the CQA Consultant may conduct additional conformance testing of subdivided portions of sand infill to isolate the failing material.

The CQA Consultant will verify that the Contractor has replaced all rejected rolls. The CQA Consultant will document all actions taken in conjunction with engineered turf and/or sand infill conformance failures.

8.5 PLACEMENT

The CQA Consultant will monitor, verify, and document that engineered turf placement is conducted in accordance with the Construction Documents, the engineered turf and underlying geomembrane are not damaged in any way, and that the following conditions are met:

- on slopes, the engineered turf is securely anchored in the anchor trench and then deployed down the slope in such a manner as to continually keep the engineered turf in tension;
- the engineered turf is laid substantially smooth;
- panels are deployed from the top of the slope in a way that the engineered turf filaments are pointing upslope after deployment is complete;
- in the presence of wind, the engineered turf is weighted with sandbags or equivalent and that sandbags will remain until replaced with ballast material;
- trimming of the engineered turf is performed using only an upward cutting hook blade and special care is given to protect other materials from damage which could be caused by the cutting of the engineered turf;
- the Installer is taking necessary precautions with the use of equipment to prevent damage to underlying layers during placement of the engineered turf;
- care is given not to entrap stones, or excessive dust, and

- a visual examination of the engineered turf is carried out over the entire surface, after installation, to verify that no potentially harmful foreign objects, (e.g., stones, sharp objects, small tools, sandbags, etc.) are present.

8.6 FIELD SEAMING

8.6.1 Trial Seams (Fusion Seams)

The CQA Consultant will monitor, verify, and document that fusion trial seaming of the engineered turf is conducted in accordance with the Construction Documents and the following requirements are met:

- fusion trial seams are conducted at daily start-up, immediately after any break, anytime the welding machine is turned off for more than 30 minutes, and no less than after five hours of seaming;
- fusion trial weld samples must be a minimum of 3 feet long and 12 inches wide, with the seam centered lengthwise; and
- fusion trial weld samples must comply with "VISUAL PASSING CRITERIA", which is when a manual peel/pull test is performed and approximately 75% of the top turf panel tufts transfer to the bottom turf panel.

8.6.2 Production Seaming (Fusion Seams)

The CQA Consultant will monitor, verify, and document that fusion field seaming is conducted in accordance with the Construction Documents and the following requirements are met:

- the fusion seaming device is a Manufacturer-approved device;
- there is a seam overlap of at least the amount recommended by the Manufacturer;
- prior to starting the production fusion seaming, trial seams are performed in accordance to Section 8.6.1;
- mechanical or hot knife trimming and cutting devices are utilized for salvage trimming; and
- defects are repaired in accordance to Section 8.7.

8.6.3 Production Seaming (Sewn Seam)

The CQA Consultant will monitor, verify, and document that field seaming is conducted in accordance with the Construction Documents and the following requirements are met:

- a single stitch prayer type seam is constructed using a Manufacturer-approved sewing machine;
- the thread is Polyester or an equivalent polymer approved by the Manufacturer; and
- sewing occurs between the 1st and 2nd row of tufts from the edge.

8.7 DEFECTS AND REPAIRS

The CQA Consultant will monitor, verify, and document that engineered turf defects are addressed and repairs are made in accordance with the Construction Documents and that the following requirements are met:

- repairs are completed by using a heat-bonded seam;
- all tie-in seams along flatter slopes (i.e. 15% or less) with lengths greater than 25 feet use an approved heat bonded seam so a consistent pressure is achieved throughout the seam; and
- a hand-held heat gun with a pressure wheel is used in smaller/concentrated areas.

The Installer may also demonstrate techniques and practices for the Manufacturer's approval. A field demonstration and approval by the Owner is required before incorporating any alternative technique.

8.8 EQUIPMENT ON THE ENGINEERED TURF

The procedures outlined in this section are intended to allow the CQA Consultant to verify that the installation of materials in contact with the engineered turf do not cause damage to it. The CQA Consultant will monitor, verify, and document that the following requirements are met:

- on slopes equal to or exceeding 15 percent, no equipment on the engineered- turf until the sand infill is in-place;

- on slopes less than 15 percent, small single-operator rubber-tired all-terrain vehicles (ATVs) are allowed to drive on the engineered-turf prior to sand infill placement if the tire pressure is less than 5 psi; and

- once the full specified sand infill thickness is in-place, rubber-tired passenger cars or light-to-medium-duty pickup trucks are allowed to drive on the completed engineered-turf provided their tire pressures are less than 35 psi.

8.9 INFILL PLACEMENT

The CQA Consultant will monitor, verify, and document that the infill placement (sand infill, cementitious binder, or armored fill polymer emulsion, where specified) is conducted in accordance with the Construction Documents and that the following requirements are met:

- only infill of an approved type and from an approved source is utilized (i.e., infill material that has undergone the required pre-construction QC testing and submittals, and CQA conformance testing as applicable), and the infill material remains consistent;

- infill is placed uniformly to the required thickness (and within allowable tolerances);

- installation is only performed by a Manufacturer-approved Installer;

- the infill is worked into the engineered turf between the synthetic yarn blades in a manner such that the tufts are in an upright position;

- equipment used to place the infill meets the vehicle type and ground pressure requirements outlined previously, and/or blowers are used to spread and place the infill;

- infill placement does not occur during inclement weather or when there is snow/ice on the engineered turf;

- where cementitious binder is to be installed:

    - it is only installed at locations specified in the Construction Documents and only while the binder is in a dry state;

    - the required cementitious binder thickness is achieved, with tufts free and upright, prior to the start of hydration;

    - hydration occurs on the same day that the cementitious binder is placed;

    - the cementitious binder is hydrated thoroughly, through the full thickness, and without causing excessive runoff;

- where armored fill polymer emulsion is to be applied to sand infill:

    - the emulsion is only applied at locations specified in the Construction Documents;
    - the required water-to-emulsion mix ratio is achieved;
    - the emulsion is verified to have fully penetrated and saturated the sand; and
    - foot traffic is avoided for 48 hours after application, and vehicle traffic is prohibited for 7 days after application.

SOILS TESTING TABLES

TABLE 1

CQC/CQA ACTIVITIES/TESTS FOR FILL

ITEM		REQUIRED ACTIVITY/TEST	MINIMUM CQC FREQUENCY	MINIMUM CQA FREQUENCY
Fill	Conformance Testing[1]	Visual Observation	Note 3	As required (continuous during placement)
		Particle Size Analysis ASTM C136	Note 3	1 per source or visual change in material type & 1 per 5,000 yd^3
		Atterberg Limits ASTM D4318	Note 3	1 per source or visual change in material type & 1 per 5,000 yd^3
		Soil Classification ASTM D2488	Note 3	1 per source or visual change in material type & 1 per 5,000 yd^3
		Moisture Content ASTM D2216	Note 3	1 per source or visual change in material type & 1 per 5,000 yd^3
		Standard Proctor ASTM D698	Note 3	1 per source or visual change in material type & 1 per 20,000 yd^3
		Triaxial Testing (Remolded) ASTM D4767	Note 3	1 per source
Fill	Performance Testing[2]	Visual Observation	Note 3	Continuous
		Lift Depth Check	Note 3	As required
		Nuclear Densometer In-place Density and Moisture Content ASTM D6938	Note 3	1 per 10,000 sf per 6-inch lift or 1 test per 200 lf per lift for linear features
		Moisture Content ASTM D2216	Note 3	1 per 10 nuclear densometer tests
		Sand Cone Density or Drive Tube Sample ASTM D1556 or ASTM D2937	Note 3	1 per 25 nuclear densometer tests

Notes:

lf – linear feet; sf – square feet; yd^3 – cubic yards

1) Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2) Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3) The Contractor and the Contractor's CQC Consultant may conduct conformance and performance tests to ensure Technical Specifications are met. The CQA test results will pass or fail the final product.
4) Target values for the required activities/tests will be provided in the Construction Documents (Technical Specifications).

TABLE 2

CQC/CQA ACTIVITIES/TESTS FOR FINAL COVER SYSTEM SOIL COMPONENTS

ITEM	REQUIRED ACTIVITY/TEST	MINIMUM CQC FREQUENCY	MINIMUM CQA FREQUENCY
Vegetative Cover Layer (Final Cover System) Conformance Testing[1]	Visual Observation	Note 4	As required
	Sieve Analysis ASTM C136	Note 4	1 per source or visual change in material type & 1 per 10,000 yd^3
	Atterberg Limits ASTM D4318	Note 4	1 per source or visual change in material type & 1 per 10,000 yd^3
	Soil Classification ASTM D2487	Note 4	1 per source or visual change in material type & 1 per 10,000 yd^3
Vegetative Cover Layer (Final Cover System) Performance Testing[2]	Visual Observation	Note 4	As required
	Lift Depth Check	Note 4	As required

Notes:

yd^3 – cubic yards

1) Conformance testing is performed on borrow sources prior to placement of material to verify the minimum required values are met and the material remains consistent.
2) Performance testing is performed on materials after placement is complete to verify that the lift or layer meets design requirements.
3) Testing of hydraulic conductivity of protective cover soils may be required on a site-specific basis.
4) The Contractor and the Contractor's CQC Consultant may conduct conformance and performance tests to ensure Technical Specifications are met. The CQA test results will pass or fail the final product.
5) Target values for the required activities/tests will be provided in the Construction Documents (Technical Specifications).

GEOSYNTHETICS TESTING TABLES

TABLE 3

GEOMEMBRANE MQC/CQA TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM MQC TESTING FREQUENCY	MINIMUM CQA TESTING FREQUENCY
Thickness	ASTM D5994	Every Roll	One per 100,000 ft^2
Asperity Height (3)	ASTM D7466	Every 2nd Roll	One per 100,000 ft^2
Drainage Stud Height / Friction Spike Height (4)	ASTM D7466	Every 2nd Roll	One per 100,000 ft^2
Density	ASTM D792 Method B or ASTM D1505	One per 200,000 lb	One per 100,000 ft^2
Carbon Black Content	ASTM D1603 or D4218	One per 20,000 lb	One per 100,000 ft^2
Carbon Dispersion	ASTM D5596	One per 45,000 lb	One per 100,000 ft^2
Resin - Melt Flow Index	ASTM D1238	One per 200,000 lb	One per 100,000 ft^2
Tensile Properties (8)	ASTM D6693	One per 20,000 lb	One per 100,000 ft^2
Tear Resistance	ASTM D1004 Die C Puncture	One per 45,000 lb	One per 100,000 ft^2
Puncture Resistance	ASTM D4833	One per 45,000 lb	One per 100,000 ft^2
Oxidative Induction Time (OIT) Standard OIT or High Pressure OIT	ASTM D3895 or ASTM D5885	One per 200,000 lb	--
Notched Constant Tensile Load Stress Cracking (NCTLSC) (6)	ASTM D5397	One per 200,000 lb	--
2% Modulus (5) (6)	ASTM D5323	Per Formulation	--
Axi-symmetric Break Resistance Strain (5) (6)	ASTM D5617	Per Formulation	--
Oven Aging at 85oC (6)	ASTM D5721		
Std. OIT - retained after 90 days High Pressure OIT - retained after 90 days	ASTM D3895 ASTM D5885	Per Formulation	--
UV Resistance (6) High Pressure OIT	GRI GM11 ASTM D5885	Per Formulation	--

Notes:

1) At least one test shall be performed for each resin lot. A resin lot shall be as defined by ASTM D4354.
2) Tests are applicable to smooth, textured, and studded HDPE or LLDPE geomembranes unless noted.
3) Test applicable to textured geomembranes only.
4) Test applicable to geomembranes used as part of geomembrane/engineered turf closure systems.
5) Tests applicable to LLDPE geomembranes only.
6) For NCTLSC, 2% Modulus, Axi-symmetric break resistance strain, oven aging, and UV resistance, Manufacturer's

certification may be accepted in lieu of actual test results.

7) Target values for the required properties/tests will be provided in the Construction Documents (Technical Specifications).
8) For LLDPE geomembranes, measurement and reporting of tensile yield strength and elongation at yield are not required.

TABLE 4
GEOMEMBRANE SEAM TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM CQC TESTING FREQUENCY	MINIMUM CQA TESTING FREQUENCY
Peel Strength	ASTM D6392 [1,3]	One per 500 ft	One per 500 ft
Shear Strength	ASTM D6392 [2,3]	One per 500 ft	One per 500 ft
Vacuum Testing Welded Seams	—	100 percent of extrusion welds	Observation/documentation of 100 percent of extrusion welds
Air Pressure Testing Welded Seams	—	100 percent of fusion welds	Observation/documentation of 100 percent of fusion welds

Notes:

1) For peel adhesion, seam separation shall not extend more than 10 percent into the seam interface. Testing shall be discontinued when the sample has visually yielded.
2) For shear tests, the sheet shall yield before failure of the seam.
3) For either test, sample failure shall be a Film Tear Bond (FTB).
4) CQC testing will be performed by the Installer.
5) Tests are applicable to smooth, textured, and studded HDPE or LLDPE geomembranes unless noted.
6) Target values for the required properties/tests will be provided in the Construction Documents (Technical Specifications).

TABLE 5
GEOTEXTILE MQC/CQA
TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM MQC TESTING FREQUENCY	MINIMUM CQA TESTING FREQUENCY
Polymer Composition	Certification		
Mass per Unit Area	ASTM D5261	One per 90,000 ft^2	One per 100,000 ft^2
Grab Strength and Elongation	ASTM D4632 (1)	One per 90,000 ft^2	One per 100,000 ft^2
CBR Puncture Strength	ASTM D6241	One per 90,000 ft^2	—
Trapezoidal Tear Strength	ASTM D4533 (2)	One per 90,000 ft^2	One per 100,000 ft^2
Static Puncture Strength	ASTM D6241	One per 540,000 ft^2	One per 540,000 ft^2
Ultraviolet Resistance	ASTM D4355	Per formulation	—
Apparent Opening Size (5)	ASTM D4751	One per 540,000 ft^2	One per 540,000 ft^2
Permittivity (5)	ASTM D4491	One per 540,000 ft^2	One per 540,000 ft^2

Notes:

1) Minimum of values measured in machine and cross machine directions with 1-inch clamp on Constant Rate of Extension (CRE) machine.
2) Minimum value measured in machine and cross machine direction.
3) Tension testing machine with a 1.75-inch diameter ring clamp, the steel ball being replaced with 0.31-inch diameter solid steel cylinder with a flat tip centered within the ring clamp.
4) At least one test shall be performed for each lot. A lot is defined by ASTM 4354.
5) Apparent opening size and permittivity testing shall be performed for geotextile filter only.
6) Target values for the required properties/tests will be provided in the Construction Documents (Technical Specifications).

TABLE 6
ENGINEERED TURF MQC/CQA
TESTING REQUIREMENTS

TEST NAME	TEST METHOD	MINIMUM MQC TESTING FREQUENCY	MINIMUM CQA TESTING FREQUENCY
Engineered Turf			
CBR Puncture	ASTM D6241	One per 300,000 ft^2	One per 400,000 ft^2
Tensile Property	ASTM D4595	One per 300,000 ft^2	One per 400,000 ft^2
Yarn Weight (Total Product Weight)	ASTM D5261	One per 300,000 ft^2	One per 400,000 ft^2
Tensile Strength of Yarn	ASTM D2256	One per 300,000 ft^2	One per 400,000 ft^2
Ballast Material			
Sand Infill - Gradation	ASTM C-33-03	--	1 per 250 cy
Sand Infill - Thickness	Manual Probe	--	20 per acre
Cementitious Binder - Thickness	Manual Probe	--	20 per acre
Cementitious Binder - Hydration	Manual Probe	--	1 test per 100 ft^2
Armored Fill - Saturation	Manual Probe	--	20 per acre

Notes:

1) At least one test shall be performed for each lot. A lot shall be as defined by ASTM D4354.
2) Target values for the required properties/tests will be provided in the Construction Documents (Technical Specifications).
3) If fusion seaming method is used then trial seams shall be performed as stipulated in Section 8.6.1.