**NHDES Waste Management Division**
**29 Hazen Drive; PO Box 95**
**Concord, NH 03302-0095**

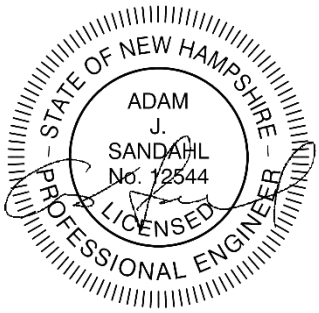
# Standard Permit for Solid Waste Landfill

**Granite State Landfill**
**Douglas Drive**
**Dalton, NH 03598**
**NHDES Site #: TBD**
**Project Type: SW-LNDFILL**
**Project Number: TBD**
**Permit: DES-SW-SP-XX-XXX (TBD)**
**Volume 5**
**Closure Plan, Performance History, Financial Report**

Kate Leith

Digitally signed by Kate Leith
Date: 2023.10.17 17:54:48 -04'00'

Prepared For:
Granite State Landfill, LLC
1855 VT Route 100
Hyde Park, VT 05655
Phone Number (802) 651-5454
RP Contact Name: John Gay
RP Contact Email: john.gay@casella.com




Prepared By:
CMA Engineers, Inc.
35 Bow Street
Portsmouth, NH 03801
Phone Number: (603) 431-6196
Contact Name: Adam Sandahl, P.E.
Contact Email: asandahl@cmaengineers.com

Date of Report: October 16, 2023

Cover Sheet for Reports Template - Revised December 2020

*Section VIII*

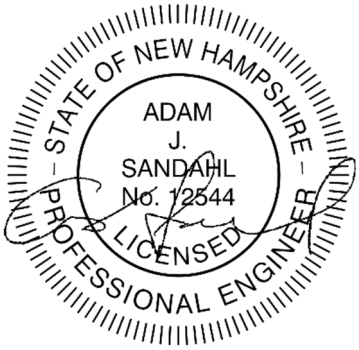
# *Closure Plan*

***Granite State Landfill, LLC***
***Permit Number: DES-SW-SP-XX-XXX***

CLOSURE PLAN

# GRANITE STATE LANDFILL

October 2023




*Prepared for:*

Granite State Landfill, LLC
1855 VT Route 100
Hyde Park, VT 05655

*Prepared by:*

CMA ENGINEERS

Civil | Environmental | Structural
35 Bow Street
Portsmouth, NH 03801

GRANITE STATE LANDFILL
CLOSURE PLAN
DES-SW-SP-XX-XXX
OCTOBER 2023

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# Closure Plan

## 1.0 FACILITY IDENTIFICATION

This Closure Plan describes the procedures and provisions for closing of the Granite State Landfill, LLC. (GSL) Landfill under the assumption that GSL obtains approvals for operations through full buildout. If GSL does not obtain such approvals, the Closure Plan will be modified accordingly.

Closure of the facility will involve expanding the gas management system and constructing and maintaining a capping system. Design drawings referenced in this Closure Plan were prepared by CMA Engineers, Inc. (CMA Engineers).

| | |
|---|---|
| Facility Name: | Granite State Landfill, LLC |
| Mailing Address: | 1855 VT Route 100 |
| | Hyde Park, VT 05655 |
| Location: | 172 Douglas Drive |
| | Dalton, New Hampshire |
| Permit No: | DES-SW-SP-XX-XXX (TBD) |

## 2.0 CLOSURE SCHEDULE

It is anticipated that closure of the landfill will take place over multiple construction phases. Construction of the active gas collection system will progress as to expand coverage into recently placed waste as lifts are completed. The initial phase will involve expanding the gas system into remaining areas of the landfill which are not yet covered by the active gas collection system. The second phase will include sequentially placing final cover over those portions of the landfill as areas are ready for closure. GSL may have completed final closure where the landfill had been filled to final grades. The final phase of closure construction would take place in northern areas of the landfill as filling progresses from south to north.

Based on projected waste acceptance rates and compaction, it is anticipated that Granite State Landfill will reach full capacity in 2046. The actual operating life will vary depending future waste acceptance rates and actual in-place density. Disposal operations will cease when the landfill is filled to final grades. Prior to that time, the gas management system will be expanded, and final cover will be constructed over those areas which have not yet received final cover. It is anticipated that each phase of cap construction will take place in accordance with the schedule outlined below.

| Work Item | Time Frame (in weeks) |
|---|---|
| Prepare construction plans for New Hampshire Department of Environmental Services (NHDES) review | 6 |
| NHDES review and approval | 26 |
| Gas management system expansion. (Includes installation of gas wells and associated well heads, laterals, header piping and valves) | 8 |
| Fine grade intermediate cover | 1 |
| Placement of Gas Transmission Layer (Select Sand) | 2 |
| Installation of geomembrane, drainage geocomposite and granular soil cover | 10 |
| Placement of screened till, topsoil and hydroseeding | 6 |

## 3.0 WASTE IDENTIFICATION

Wastes which may be accepted at the facility include:

- Municipal solid waste (MSW) as defined in State of New Hampshire Solid Waste rules.
- Construction and Demolition (C&D) waste which includes non-putrescible building and site material waste and rubble. Examples of such waste include, but are not limited to, bricks, concrete, and other masonry materials, wood, wall coverings, plaster, dry wall, plumbing, fixtures, insulation or roofing shingles, asphaltic pavement, glass, plastics, electrical wiring and components containing no hazardous liquids and/or metals that are incidental to any of the above.
- Non-liquid, non-hazardous Special Waste, as defined in Section 3.3.2 of the Facility Operating Plan (FOP), which has received prior approval of GSL, in accordance with Section 3.3.2.1 of the FOP. Special Waste may include but is not limited to the following:
  Waste from industrial processes;
    - Waste from pollution control processes including but not limited to water and wastewater treatment sludges and air pollution control residues;
    - Residue from a spill of a chemical substance or commercial chemical product or a waste listed above;
    - Commercial products which are off-specification, outdated, or unused;
    - Waste produced during the demolition or dismantling of industrial process equipment;
    - Waste produced during the demolition or dismantling of automobiles (auto fluff);
    - Ash managed in accordance with the requirements of Env-Sw 902;
    - Contaminated soils and media managed in accordance with Env-Sw 903;
    - Contaminated residuals from the clean-up of a facility generating, storing, treating, recycling, or disposing wastes, chemical substances or commercial products listed above;
    - Treated infectious waste which has been autoclaved, or otherwise treated and disinfected in accordance with the requirements of Env-Sw 904; and
    - Other non-hazardous solid waste, including asbestos waste, that requires special handling prior to disposal or acceptance in accordance with Section 3.3.2 and Section 3.3.3 of the Operating Plan.
    - NHDES Certified Waste Derived Products as follows;
        - CWDP #21 – MSW Incinerator Ash
        - CWDP #14 - Auto Shredder Alternative Daily Cover (ADC)
        - CWDP #13 – Biosolids Incinerator Ash ADC
        - CWDP #10 Bottom Ash from Wood Fired Boilers ADC
        - CWDP #6 - C&D & Soil Mixture ADC

- Any other Certified Waste Derived Products approved by NHDES.
- NHDES Certified Waste Derived Product requirements for the CWDPs listed above are provided on the NHDES website below: http://des.nh.gov/waste/solid-waste

- Other ADC
  - Airspace Saver Synthetic Tarps
  - Spray on ADC
  - Processing C&D to Produce a Waste Derived Product as ADC
  - Geosynthetic Tarps
  - Casting Sands
  - Contaminated Soils meeting Env-Sw 806.03(b) & Env-Sw 903.05(b)(2)
  - ERRCO-Epping C&D Processing Residuals

## 4.0 NOTIFICATIONS

Those users with waste disposal contracts with the facility will be notified by registered mail at least 60 days prior to the time when it is anticipated that the facility will cease accepting waste. The Waste Management Division is to be notified with the filing of a Notice of Intent to Close. The Notice is to contain the information required by Env-Sw 1106.02 including the date the facility intends to stop receiving waste, a reference to the approved Closure Plan, and the date the facility intends to commence closure activities.

## 5.0 CLOSURE REQUIREMENTS

The facility will be closed as final cover is placed. It is anticipated that cap construction will take place during the local construction season. Proposed final grades and cover section details are shown on the attached Final Grading Plan and Closure System Details. At least 120 days prior to the start of construction of the closure, construction plans are to be submitted to NHDES for review and approval as part of a Type II permit modification.

Prior to construction of the final cover, the active gas management system may be extended in the area to be capped. The gas management system includes gas extraction wells and associated well heads which are connected by lateral piping to a header pipe through which gas collected from the landfill is conveyed to the gas collection and control. New header piping at a higher elevation may be required and would be installed as necessary. Condensate drip legs will be provided to remove condensate which collects in the piping in the landfill. The proposed locations of gas wells and appurtenances and the header pipe are identified on the attached Closure Plan sheets.

Prior to placing cover materials, the intermediate cover will be fine graded. Next, a 6-inch layer of Gas

Transmission Sand (Select Sand) would be placed. The geomembrane cap consisting of textured 40-mil linear low-density polyethylene (LLDPE) will be installed over the Select Sand subgrade and overlain by drainage geocomposite, 18 inches of granular soil cover, a 6-inch screened till layer, and 4 inches of topsoil, followed by seeding and mulching. A crushed rock drain is to be provided at the toe of slope to allow water in the geocomposite above the geomembrane cap to drain freely to the perimeter swale.

The cap drainage system includes intermediate swales typically spaced a minimum of 100 feet apart horizontally on the landfill slopes. The drainage swales will be shaped within the waste on a bench and be covered with 12 inches of intermediate cover and 6 inches of Select Sand. The overlying geomembrane and drainage geocomposite will be covered with 12 inches of Select Gravel and 10 inches of NHDOT Type C stone for erosion protection within the swale. The intermediate swales will drain to dropchutes conveying stormwater off the cap to the landfill perimeter.

## 6.0 POST-CLOSURE REQUIREMENTS

Following facility closure, post-closure monitoring is to be performed. The purpose of post-closure monitoring is to observe that the physical integrity of the site is maintained and to perform groundwater and landfill gas monitoring. Formal inspections of facility systems are to be performed no less than twice each year, initially. The report following each formal inspection is to be submitted to NHDES. Observations of site conditions are also to be made during routine monitoring. Items not performing as intended are to be repaired in a timely manner to maintain the integrity of the closed landfill. Post-closure monitoring is to be performed in accordance with applicable law. Reductions in monitoring frequency for various post-closure tasks may be requested if data demonstrates the item is stabilizing.

Post-closure monitoring will involve:

- Review of the site perimeter to assure that access to the site is restricted. Access is restricted by fencing/gates, thick vegetation, and wetlands. Access to the property will be maintained via the main gate to permit post-closure monitoring;
- Inspection of the stormwater management system, including culverts, swales, catch basins and the detention ponds. The stormwater detention ponds will be cleaned to assure that they function as intended. Culverts will be checked to see that they are clear and sediments that have accumulated in swales will be removed. Catch basins will be cleared of sediment, debris, and any blockage;
- Inspection of landfill cap to note that vegetation is well established and has been mowed as required to prevent trees and shrubs from growing on the cap and to look for evidence of settlement or damage due to erosion. The surface of the landfill will be monitored for settlement. Benchmarks and control points have been established at the site to provide survey control for topographic surveys of the final cap;
- Settlement identified during the post-closure inspections which results in ponding or impedes

drainage will be repaired. In the event there is erosion of the cover soils, the damage is to be repaired and the cause investigated and eliminated to the extent practical;

- Monitoring the perimeter berm for evidence of erosion. Any damage noted is to be repaired and the cause determined and addressed;
- Inspection of the gas management system in accordance with the requirements outlined in the Gas System Operation and Maintenance Manual;
- Inspection of the leachate collection system appurtenances to include checking pumps and controls to determine that they are functioning properly and to collect data regarding the quantities of leachate collected from the various phases of the facility. Samples of the primary leachate are collected in April, July and November and analyzed for the parameters outlined in Env-Sw *806.08(d)5.* A consistent and abnormal increase in the rate of leachate removed from the facility is to be investigated to assess the cause;
- Reviewing the performance of the leak detection system by monitoring flows in the secondary leachate collection system. In the event the flow steadily increases above historic levels, an investigation as to the cause is to be conducted;
- Groundwater and surface water quality monitoring in accordance with the Groundwater Permit for the facility. Groundwater monitoring wells will be checked during each sampling round. Damage to a well or its protective casing will be repaired to facilitate continued usage of the well; and
- Landfill gas monitoring will be conducted in accordance with the current Gas Monitoring Plan.

## 7.0 RECORD KEEPING AND REPORTING

Within 30 days following each inspection, a report is to be provided in duplicate to the Waste Management Division of NHDES signed by a person duly authorized to sign for and on behalf of GSL. Both copies of the report are to bear an original signature. In addition to the inspection reports, an annual report is to be filed for the facility containing the information outlined in Env- Sw 1105.14 including an evaluation of environmental monitoring data and other information pertaining to facility conditions. The report is to include a statement by a Professional Engineer identifying whether the facility is achieving post-closure performance expectations and whether adjustments to the post closure monitoring and maintenance provisions are recommended in light of the performance evaluation.

Following closure, facility records are to be maintained at the GSL permitting and compliance office. Records are not to be moved or destroyed unless such action is approved by NHDES pursuant to a Type V Permit Modification.

## 8.0 OTHER PERMITS

A Type II Permit Modification is required prior to closure construction. At this time, it is not anticipated that any post-closure permits will be required. Permits such as the facility Groundwater Management Permit (GMP) are to be renewed as required.

## 9.0 CLOSURE COST ESTIMATE

A closure cost estimate calculated assuming a third party performs closure and post-closure activities in accordance with this Closure Plan is attached. The costs incorporated are based on bid prices for similar projects and GSL's experience at this and other facilities. Post-closure costs have been calculated for a 30-year post-closure period and presented in present 2023 dollars in Attachment B. The closure cost estimate is to be updated as appropriate to reflect modifications to the Closure Plan, or as new landfill phases are developed or portions of the facility are closed.

# *Attachment A*

## *Reduced Size Closure Plan Drawings (8.5x11)*
## *Full Size Bound Separately*

Hard Copy Submittal Only

# *Attachment B*

## *Closure and Post Closure Cost Estimates*

NHDES-S-05-023

# Cost Estimate Form for the Closure of a Lined Landfill

Submit to:
Waste Management Division, SWMB
PO Box 95, Concord, NH 03302-0095
(603) 271-2925 or solidwasteinfo@des.nh.gov
https://www.des.nh.gov

RSA 149-M/Env-Sw 1400

| | |
|---|---|
| **Facility Name:** Granite State Landfill | |
| **Facility Address:** Douglas Drive, Dalton, NH 03598 | |
| | |
| **NHDES Permit #:** DES-SW-SP-XX-XXX (TBD) | |
| **Owner:** Granite State Landfill, LLC | |
| **Phase:** Stages 1 and 2 | **Acreage:** 70 acres |

| | Task | Unit | Unit Cost | Quantity | Total Cost |
|---|---|---|---|---|---|
| **I** | **Design of Final Closure Plans** | | | | |
| | Engineering Cost | *LS* | $300,000.00 | 1 | $300,000.00 |
| | Plans | *LS* | $30,000.00 | 1 | $30,000.00 |
| | Modification/Closure Plan Review Fees | *LS* | $15,000.00 | 1 | $15,000.00 |
| **II** | **Mobilization, Demobilization & Insurance** | | | | |
| | Total Cost | *LS* | $300,000.00 | 1 | $300,000.00 |
| | Other - Health and Safety Plan | *LS* | $10,000.00 | 1 | $10,000.00 |
| **III** | **Erosion Control** | | | | |
| | Silt Fence | *LF* | $3.16 | 10,000 | $31,600.00 |
| | Erosion Matting/ Blanket | *LS* | $5,000.00 | 1 | $5,000.00 |
| | Hay Bale Sediment Barrier | | | | $0.00 |
| | Hay Mulch Cover | | | | $0.00 |
| | Check Dams | *LS* | $2,500.00 | 1 | $2,500.00 |
| | Other | *LS* | $10,000.00 | 1 | $10,000.00 |
| **IV** | **Waste Relocation** | | | | |
| | Test Pits (to define limits of refuse and/or groundwater to refuse contact) | | | | |
| | Clearing & Grubbing | | | | |
| | Waste Regrading (Refuse Excavation/Relocation & Compaction) | | | | |
| | Other | | | | |
| **V** | **Capping** | | | | |
| | **A Cap (Material and Installation)** | | | | |
| | Geomembrane | *SF* | $1.00 | 3,054,000 | $3,054,000.00 |
| | Soil | | | | |
| | Testing | | | | |
| | Anchor Trench | *LS* | $20.00 | 8,100 | $162,000.00 |
| | Other - Drainage Geocomposite | *SF* | $1.00 | 3,054,000 | $3,054,000.00 |
| | **B Gas Vents Devices** | | | | |
| | Gas Vents/Wells | *EA* | $300.00 | 200 | $60,000.00 |
| | Other | | | | |
| | **C Layers** | | | | |
| | Drainage Layer - Free Draining Sand - 12" thick | *CY* | $15.00 | 113,100 | $1,696,500.00 |
| | Intermediate Cover Placement | | | | $0.00 |
| | Sand - Protective Gas Venting Layer - 6" thick | *CY* | $15.00 | 56,500 | $847,500.00 |
| | Topsoil/Loam or Manufactured Soil - 4" | *CY* | $20.00 | 37,300 | $746,000.00 |
| | Other - Screened Till (6" bedding & 6" moisture retention layers) | *CY* | $24.00 | 113,100 | $2,714,400.00 |
| **VI** | **Stabilization, Run-off Control** | | | | |
| | Seed & Mulch (Include Lime, Fertilizer, Seed & Hay Mulch) | *AC* | $4,000.00 | 70.1 | $280,400.00 |
| | Surface Water Diversion Swales | *LF* | $40.00 | 20,000 | $800,000.00 |
| | Stone Rip-Rap | *CY* | $55.00 | 1,000 | $55,000.00 |
| | Catch Basins, Manholes & Drop Inlets | | | | |
| | Toe Drain | *LF* | $50.00 | 8,100 | $405,000.00 |
| | Detention Pond and Associated Outlet Devices | | | | |
| | Other | | | | |
| **VII** | **Monitoring Devices** | | | | |
| | Settlement Monuments/Plates | *EA* | $1,000.00 | 70 | $70,000.00 |
| | Groundwater Monitoring Wells | | | | |
| | Gas Monitoring Probes | | | | |
| | Other | | | | |

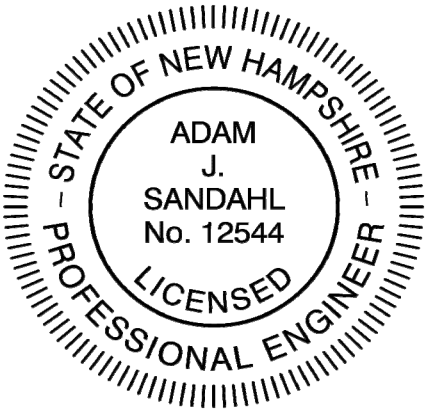
| | Task | Unit | Unit Cost | Quantity | Total Cost |
|---|---|---|---|---|---|
| **VIII** | **Roadway** | | | | |
| | Access Roadway | *LF* | $100.00 | 1,500 | $150,000.00 |
| | Drainage Ditches | *LF* | $40.00 | 1,500 | $60,000.00 |
| | Culvert Inlet & Outlet Headwalls | | | | |
| | Guide Rail | | | | |
| | Dust Control - Calcium Chloride | | | | |
| | New/Replaced Pavement | | | | |
| | Other | | | | |
| **IX** | **Miscellaneous** | | | | |
| | Signs | | | | |
| | Perimeter Fence | *LS* | $50,000.00 | 1 | $50,000.00 |
| | Entry Gate - Double Unit | | | | |
| | Miscellaneous Work and Cleanup | | | | |
| | Stormwater Improvements | *LS* | $10,000.00 | 1 | $10,000.00 |
| | Other | | | | |
| **X** | **Surveying** | | | | |
| | Baseline, Bench Marks, and Survey Control | *LS* | $25,000.00 | 1 | $25,000.00 |
| | Other | | | | |
| **XI** | **Construction Phase Testing** | | | | |
| | Compaction Testing | | | | |
| | QAQC | *AC* | $5,000.00 | 70.1 | $350,500.00 |
| | Other | | | | |
| **XII** | **Engineering** | | | | |
| | Resident Engineer, Project Manager, Project Engineer | *LS* | $500,000.00 | 1 | $500,000.00 |
| | Record Drawings/ As-Built | *LS* | $25,000.00 | 1 | $25,000.00 |
| | Other | | | | |
| | Qualified Professional Oversight of all Closure Activities | *LS* | $50,000.00 | 1 | $50,000.00 |
| **XIII** | **Other (list)** | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | **Sub-total** | | | | $15,869,400.00 |
| | **Contingency (10 % minimum)** | | | | $1,586,940.00 |
| | **Total Cost** | | | | $17,456,340.00 |

Signature of Preparer:_____ Date: 06/12/2023

*(Must be a Professional Engineer)*

This form provides a basis for estimating closure costs for a lined landfill. This form is not inclusive of all costs that may be associated with the landfill closure.

The cost estimate must include all items needed to comply with all NHDES permits. Please use the spaces provided above noted as "Other" or attach an additional sheet if necessary.



NHDES-S-05-025

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

RSA 149-M/Env-Sw 1400

# Cost Estimate Form for Post-Closure of a Landfill

**(lined or unlined)**

Submit to:

Waste Management Division, SWMB

PO Box 95, Concord, NH 03302-0095

(603) 271-2925 or solidwasteinfo@des.nh.gov

https://www.des.nh.gov

**Facility Name:** Granite State Landfill

**Facility Address:** Douglas Drive, Dalton, NH 03598

**NHDES Permit #:** DES-SW-SP-XX-XXX (TBD)

**Owner**: Granite State Landfill, LLC

**Phase:** Stages 1 and 2 — **Acreage:** 70

| | Task | Unit | Unit Cost | Quantity | Total Cost |
|---|---|---|---|---|---|
| **I** | **Water Monitoring** | | | | |
| | Surface Water Sampling & Analysis | | | | |
| | Other (Permit Requirement) _____ | | | | |
| | Ground Water Sampling & Analysis | *LS* | $60,000.00 | 1 | $60,000.00 |
| | Other (Permit Requirement) _____ | | | | |
| | Other - Repair of Wells | *LS* | $1,000.00 | 1 | $1,000.00 |
| **II** | **Gas Monitoring** | | | | |
| | Landfill Gas Migration Monitoring | *LS* | $10,000.00 | 1 | $10,000.00 |
| | Operation and Maintenance of Gas Collection System | *LS* | $178,400.00 | 1 | $178,400.00 |
| | Replacing 20% of the Active Gas Collection System | *LS* | $30,200.00 | 1 | $30,200.00 |
| | Other | | | | |
| **III** | **Settlement Monitoring** | | | | |
| | Field Survey | *LS* | $3,000.00 | 1 | $3,000.00 |
| | Data Tabulation | | | | |
| | Other | | | | |
| **IV** | **Leachate Collection/Monitoring** | | | | |
| | Sewer Charges | *LS* | $571,200.00 | 1 | $571,200.00 |
| | Water Monitoring | | | | |
| | Electricity | | | | |
| | Maintenance of Collection System | | | | |
| | Sampling & Analysis | *LS* | $4,800.00 | 1 | $4,800.00 |
| | Other - Pump Station O&M | *LS* | $25,300.00 | 1 | $25,300.00 |
| **V** | **Clean Air Act Requirements** | | | | |
| | Monitoring & Analysis | *LS* | $ 36,000.00 | 1 | $36,000.00 |
| | Emissions Fees | *LS* | $ 90,000.00 | 1 | $90,000.00 |
| **VI** | **Repair & Site Maintenance Costs** | | | | |
| | Snow Removal | *LS* | $500.00 | 1 | $500.00 |
| | Roadway Maintenance | | | | |
| | Mowing | *AC* | $100.00 | 70 | $7,000.00 |
| | Soil Cover Maintenance and Planting | *LS* | $3,100.00 | 1 | $3,100.00 |
| | Maintenance of Gas Venting System | | | | |
| | Subsidence Repair | *LS* | $2,000.00 | 1 | $2,000.00 |
| | Stormwater Maintenance | *LS* | $2,000.00 | 1 | $2,000.00 |
| | Other | | | | |
| **VII** | **Inspections** | | | | |
| | Annual Report | *LS* | $6,250.00 | 1 | $6,250.00 |
| | Annual Site Inspections | *LS* | $6,250.00 | 1 | $6,250.00 |
| | Other | | | | |
| **VIII** | **Other** | | | | |
| | Qualified Professional Oversight of all Activities | | | | |
| | | | | | |
| | | | | | |
| | **Sub-total** | | | | $1,037,000.00 |
| | **Contingency (10 % minimum)** | | | | $103,700.00 |
| | **Total Yearly Cost** | | | | $1,140,700.00 |
| | **Total 30-Year Cost (2023 Dollars)** | | | | $ 13,951,000.00 |

STATE OF NEW HAMPSHIRE – ADAM J. SANDAHL No. 12544 LICENSED PROFESSIONAL ENGINEER

Signature of Preparer: _____ Date: 06/12/2023

*(Must be a Professional Engineer)*

This form provides a basis for estimating post-closure costs for a lined or unlined landfill. This form is not inclusive of all costs that may be associated with the landfill's post-closure monitoring and maintenance requirements. The cost estimate must include all expenses associated with compliance of all NHDES permits. Please use the spaces provided above noted as "Other" or attach additional sheets if necessary.

Table 1
Estimated Post-Closure Monitoring/Maintenance Costs
Granite State Landfill, LLC
Jul-23

| Task | | Annual Cost Years 1-5 | Annual Cost Years 6-10 | Annual Cost Years 11-20 | Annual Cost Years 21-30 |
|---|---|---|---|---|---|
| I-a | Water Quality Monitoring | $ 60,000.00 | $ 45,000.00 | $ 30,000.00 | $ 30,000.00 |
| I-b | Repair of Monitoring Wells | $ 1,000.00 | $ 1,000.00 | $ 1,000.00 | $ 1,000.00 |
| II-a | Landfill Gas Migration Monitoring | $ 10,000.00 | $ 10,000.00 | $ 10,000.00 | $ 10,000.00 |
| II-b | Landfill Gas Collection System O&M | $ 178,400.00 | $ 124,700.00 | $ 59,300.00 | $ 39,300.00 |
| II-c | Replacing 20% of the Active Gas Collection System | $ 30,200.00 | $ 30,200.00 | $ 30,200.00 | $ 30,200.00 |
| III | Settlement Monitoring | $ 3,000.00 | $ 3,000.00 | $ 3,000.00 | $ 700.00 |
| IV-a | Leachate/Condensate Disposal | $ 571,200.00 | $ 252,300.00 | $ 175,600.00 | $ 153,600.00 |
| IV-b | Leachate Monitoring | $ 4,800.00 | $ 4,800.00 | $ 3,200.00 | $ 3,200.00 |
| IV-c | Leachate Pump Station O&M | $ 25,300.00 | $ 18,100.00 | $ 15,700.00 | $ 14,100.00 |
| V | Air Quality Monitoring | $ 126,000.00 | $ 63,000.00 | $ 33,000.00 | $ 18,000.00 |
| VI | Repair & Site Maintenance Costs | $ 14,600.00 | $ 11,000.00 | $ 7,750.00 | $ 6,000.00 |
| VII | Inspections | $ 12,500.00 | $ 8,500.00 | $ 8,500.00 | $ 8,500.00 |
| VIII | Other | $ - | $ - | $ - | $ - |
| IX | 10% Contingency | $ 103,700.00 | $ 57,200.00 | $ 37,800.00 | $ 31,500.00 |
| | **TOTAL** | **$ 1,140,700.00** | **$ 628,800.00** | **$ 415,050.00** | **$ 346,100.00** |

Notes:
A summary of the assumptions made in developing the estimate is attached
Costs presented are in 2023 dollars
Costs are based on our experience and data and information provided by GSL. Actual costs may vary.

Table 2
Present Value of Post-Closure Monitoring/Maintenance Costs
Granite State Landfill, LLC
Jul-23

**Assumptions:**

| | |
|---|---|
| **Discount Rate (ir)** | **2.60%** |
| **Inflation Rate (j1)*** | **3.00%** |
| **Inflation Rate (j2)*** | **1.00%** |

| Years After Closure | Annual Post Closure Cost | Annual Present Value Cost |
|---|---|---|
| | | |
| 1 | $ 1,140,700.00 | $ 1,146,179.00 |
| 2 | $ 1,140,700.00 | $ 1,151,684.00 |
| 3 | $ 1,140,700.00 | $ 1,090,162.00 |
| 4 | $ 1,140,700.00 | $ 1,073,819.00 |
| 5 | $ 1,140,700.00 | $ 1,057,720.00 |
| 6 | $ 628,800.00 | $ 574,317.00 |
| 7 | $ 628,800.00 | $ 565,707.00 |
| 8 | $ 628,800.00 | $ 557,226.00 |
| 9 | $ 628,800.00 | $ 548,872.00 |
| 10 | $ 628,800.00 | $ 540,644.00 |
| 11 | $ 415,050.00 | $ 351,511.00 |
| 12 | $ 415,050.00 | $ 346,241.00 |
| 13 | $ 415,050.00 | $ 341,051.00 |
| 14 | $ 415,050.00 | $ 335,938.00 |
| 15 | $ 415,050.00 | $ 330,901.00 |
| 16 | $ 415,050.00 | $ 325,941.00 |
| 17 | $ 415,050.00 | $ 321,054.00 |
| 18 | $ 415,050.00 | $ 316,241.00 |
| 19 | $ 415,050.00 | $ 311,500.00 |
| 20 | $ 415,050.00 | $ 306,830.00 |
| 21 | $ 346,100.00 | $ 252,022.00 |
| 22 | $ 346,100.00 | $ 248,244.00 |
| 23 | $ 346,100.00 | $ 244,522.00 |
| 24 | $ 346,100.00 | $ 240,857.00 |
| 25 | $ 346,100.00 | $ 237,246.00 |
| 26 | $ 346,100.00 | $ 233,689.00 |
| 27 | $ 346,100.00 | $ 230,186.00 |
| 28 | $ 346,100.00 | $ 226,735.00 |
| 29 | $ 346,100.00 | $ 223,336.00 |
| 30 | $ 346,100.00 | $ 219,987.00 |
| **Total Cost in 2023 $** | **$ 16,459,000.00** | |
| **Total Present Value Cost** | | **$ 13,951,000.00** |

Notes:

Annual present value cost calculated by multiplying the annual post closure cost
by a discount factor (DF) calculated as follows:

DF = (1 + ir - j - ir*j)^-t

where:

ir = 2.6% per OMB Circular A-94 for a 30 year period (2022 version [https://www.whitehouse.gov/wp-content/uploads/2022/05/Appendix-C.pdf])
j = Inflation rates are taken from CPI Tables Northeast, All Urban Consumers
t = years since closure

Annual present value cost is rounded up to the nearest dollar

*Intrest rates over the past 2 years have averaged 5.6% per year per the CPI tables referenced above. In the 7 years prior, intrest rates averaged 1%. Assume that intrest rates will remain elevated at 3% for the next 2 years before retruning to 1% thereafter.

**Granite State Landfill (GSL) Supplemental LFG Closure Construction Opinion of Cost**
**Cost for Replacement of 20% of the Active LFG System at Closure per Env-Sw 1403.02(g)(7)**
**Prepared by Sanborn Head & Associates, Inc.**
**Date: June 30, 2023**

| Item Description | Units | Unit Cost | Quantity | Item Cost | 20% of Existing Quantity | Replacement Item Cost |
|---|---|---|---|---|---|---|
| Wellheads | EA | $900.00 | 108 | $ 97,200.00 | 22 | $ 19,800.00 |
| Vertical LFG Extraction Wells | VF | $150.00 | 10,290 | $ 1,543,500.00 | 2,058 | $ 308,700.00 |
| 24"Ø Header Pipe | LF | $160.00 | 8,000 | $ 1,280,000.00 | 1,600 | $ 256,000.00 |
| 12"Ø Header Pipe | LF | $80.00 | 9,875 | $ 790,000.00 | 1,975 | $ 158,000.00 |
| 6"Ø Lateral Pipe | LF | $65.00 | 10,905 | $ 708,825.00 | 2,181 | $ 141,765.00 |
| 12"Ø Control Valves | EA | $5,000.00 | 20 | $ 100,000.00 | 4 | $ 20,000.00 |
| | | | | | Subtotal | $ 904,265.00 |
| | | | | | **Total, Rounded up to the Nearest Hundred** | **$ 904,300.00** |

Notes:

1. Material quantities in table were calculated based on the projected active gas collection system in-place at time of closure.
2. Unit costs are subject to change based on market rates, cost of oil, cost of labor, and material availability.
3. This opinion of cost includes only LFG system components installed inside the landfill limit of waste containment.
4. It was assumed that horizontal LFG collection trenches will not be replaced at closure.
5. Pipe quantities are two-dimensional (2D) and do not account for slope of pipe. Solid pipe vertical risers at wellheads are incidental to unit costs.

**Supporting Documentation for 2023 Post-Closure Costs**

July 2023

The following assumptions were made in developing the post-closure cost estimate. The estimated initial annual cost is summarized in the NHDES Post-Closure Cost Estimate form and the estimated annual costs for the entire 30-year post-closure period are summarized in Table 1 with the present value for the annual costs presented in Table 2. The costs were developed based on information provided by Granite State Landfill and our experience.

**Item Ia – Water Quality Monitoring**

Years 1 – 5

- Annual Costs for sampling and reporting are estimated to be **$60,000**. These costs will remain unchanged in the first five years of the post-closure monitoring program.

Years 6 - 10

- We have assumed that after the first five years of monitoring, that a reduction from tri-annual to bi-annual sampling will be allowed by NHDES, based on our experience at many unlined landfill closure sites. This will reduce the annual costs by approximately $15,000 to an annual cost of **$45,000**.

Years 11 – 30

- We have assumed that after ten years of monitoring that a further reduction in sampling parameters or locations will be allowed by NHDES. This will reduce the annual sampling costs to an estimated **$30,000**

**Item Ib – Repair of Monitoring Wells**

Years 1 - 30

- Carry an annual cost of $1,000, which provides additional funds for minor repairs.

**Item IIa - Landfill Gas Migration Monitoring**

- The annual costs of **$10,000** for the quarterly monitoring of landfill gas migration will be required to be completed throughout the post-closure monitoring period. It is possible that NHDES may permit some reductions to the frequency and locations, after several years of monitoring and data gathering, but this is not relied upon in the estimate.

**Item IIb – Landfill Gas Collection System Operation and Maintenance**

*Maintenance Costs*
Years 1 - 5

- Routine maintenance of control system and flare, monthly monitoring of collection system and balancing. Assumed 4 hours per week for weekly tasks and 10 hours per month for monthly tasks. Estimated labor costs at $75/hr are $2,625/month, or approximately **$31,500** per year.

Years 6 – 10

- With reduction in landfill gas generation following closure, the routine maintenance of control system and flare, and regular monitoring of collection system and balancing is anticipated to be reduced. Assumed 12 hours per month with estimated labor costs at $75/hr are $900/month, or approximately **$10,800** per year.

Years 11 -30

- With further reduction in landfill gas generation following closure, the routine maintenance of control system and flare, and monitoring of collection system and balancing is anticipated to be reduced. Assumed 6 hours per month with estimated labor costs at $75/hr are $450/month, or approximately **$5,400** per year.

Years 1 - 30

- Semi-annual maintenance of blower bearings, testing automated devices, gas canister maintenance/refill, and coordinating any unscheduled maintenance. Assuming 4 hours per event, $300 per event or **$600** per year.

- Annual calibration and maintenance of GEM field instrument are estimated to be **$2,000** per year.

- Replacement of condensate knockout pump every 10-years. Assuming a cost of $5,000 installed an annual cost of **$500** has been included.

- Assuming unscheduled responses to alarm conditions occurs 4 times per year. At 6 hours per event, and 24 hours per year, **$1,800** has been included in the annual cost for alarm conditions.

- Included **$4,000** per year for replacement parts for blower/flare/controls etc.

**Therefore, the annual costs for years 1 through 5 shall include $40,400 per year, Years 6-10 shall include $19,700 and years 11-30 shall include $14,300.**

*Operational Costs*

Years 1 – 5

Landfill gas wells will tend to accumulate liquid over time. Based on the existing operational experience, we have assumed that the purchase and installation of 2 pneumatic pumps for insertion in the landfill gas extraction wells will be required by year 5. These 2 pumps can then be rotated between remaining wells as needed to remove accumulated liquid from the wells. Assume the pumps discharge through a short hose to the LFG lateral pipe. Assume the pumps cost about $10,000 each, installed. The total pump cost will be **$20,000.**

The pumps require a compressed air delivery system, including a compressor and air drying equipment. The cost of a typical air compressor of sufficient capacity with an 80-gallon receiver tank is about $4,000, and air drying equipment, including a refrigerated dryer and a desiccant dryer, costs about $3,500. The equipment has to be sheltered from the elements. Therefore, assume $5,000 for a shelter and installation of the equipment. The total assumed cost of the compressed air system is **$12,500**.

Assume that a compressed air distribution system has to be constructed to deliver air to the pneumatic pumps at the LFG wells. Assume 2,000 linear feet of pipe is required for initial construction with an average burial depth of 1-foot installed with a "Ditch Witch" type of pipe installation. Based on an assumed pipe cost of $4.50 per linear foot and an installation cost of approximately $5.00 per linear foot, plus $3,500 of fittings and detail work at the terminations, the cost is **$22,500**.

Therefore, the cost of the pumps and compressed air delivery system is about $55,000, **or $11,000 per year to be added to the routine annual costs in years 1 through 5.**

Assume that quarterly surface scans will be required for the first five years of the post-closure period, along with 20 hours per quarter of labor and equipment associated with addressing methane emission exceedances. Assume that the cost of a surface scan, excluding reporting, is about $3,000, and the labor and equipment cost associated with correcting exceedances is about $6,000 per quarter. Therefore, **the annual cost for surface scans and repair is about $27,000 in years 1 through 5.**

Years 6 - 30

Assume that annual surface scans are required for years 6 through 30, with no repair of cap associated with exceedances required through the period. Assume the same $3,000 per surface scan cost and $2,000 for reporting. Therefore, **the annual cost for surface scans is $5,000 for years 6 through 30.**

*Electricity Costs*

Years 1 - 10

Based on historical information, the annual electricity cost to operate the LFG system in the current configuration is estimated to be approximately **$100,000 per year**.

Years 11 - 20

Assume that starting in year 11, the LFG collection system operates on one blower and one flare. Assume the electricity cost, in 2023 dollars, would be 40 percent of the current total electricity cost, or about **$40,000 per year for 10 years.**

Years 20 - 30

Assume that the one blower and one flare operate on a part-time basis with a 50 percent duty cycle. Therefore, the annual electricity cost would be about **$20,000 per year for the last 10 years of the period.**

**Item IIc – Replacing 20% of the Active Gas Collection System**

This item is to replace 20% of the active landfill gas system per Env-Sw 1403.02(g)(7) within the footprint of the landfill through Stage VI. This cost is presented as an annual value with the full replacement cost spread out over 30 years. **The annual cost for replacement of 20% of the landfill gas system is $30,200 for years 1 through 30.**

**Item III – Settlement Monitoring**

Years 1 - 30

- **Assume settlement survey costs will average about $3,000 per year for years 1 through 20. Years 20 through 30 will not require instrument survey and only a visual inspection at an estimated cost of $700 per year.**

**Item IV-a – Leachate/Condensate Disposal**

Leachate and landfill gas condensate generated at GSL will be hauled to an off-site wastewater treatment facility. Based on information provided by NCES, the average disposal and transportation cost to the Concord NH WWTF is $0.115 per gallon of leachate. We assume that the cost will be higher since the Granite State Landfill is farther from Concord than the NCES site. For this calculation, we are assuming the leachate disposal and transportation cost will be $0.120 per gallon of leachate.

Years 1 - 5

- Assume 50 acres of the 70.1-acre footprint have been capped at least five years prior to final closure of the landfill. The average leachate flow rate for this area will average 100 gallons per acre per day (gpad), which would produce 5,000 gallons per day (gpd).

- Assume the remaining 20.1 acres of cap are constructed in Year 1 and that leachate is produced in this area at the rate of 400 gpad or 8,040 gpd.

- **Therefore, the annual cost for years 1 through 5 is approximately $571,200.**

Years 6 - 10

- Assume flow rate of 75 gpad over 50 acres, or 3,750 gpd.
- Assume a flow rate of 100 gpad for the remaining 20.1 acres, or 2,010 gpd.
- **Therefore, the annual cost for years 6 through 10 is approximately $252,300.**

Years 11 - 20

- Assume a flow rate of 50 gpad over 50 acres, or 2,500 gpd.
- Assume a flow rate of 75 gpad over 20.1 acres, or 1,508 gpd.
- **Therefore, the annual cost for years 11 through 20 is approximately $175,600.**

Years 21 - 30

- Assume flow rate of 50 gpad over the entire 70.1 acres, or 3,145 gpd.

**Therefore, the annual cost for years 21 through 30 is approximately $153,600.**

**Item IV-b - Leachate Monitoring**

Years 1 - 10

- Assume leachate is collected for analysis for the parameters required by the Solid Waste Rules three times per year from all Stages.
- Based on current costs for analytical testing, the annual laboratory cost is $2,400.
- Assume labor and expenses total $800 per round or $2,400 annually.
- **Therefore, the annual cost for years 1 through 10 is $4,800.**

Years 11 - 30

- Assume based on diminishing flows and stabilization of the leachate that the frequency of sampling may be cut by one-third so that the cost of monitoring is two-thirds of the initial cost. During years 11-20 following closure, sampling will be conducted twice per year. With stabilization, it is likely that the parameters for which analyses are required could also be reduced resulting in a further reduction in the monitoring cost, which is not reflected here.
- **Therefore, the annual cost for years 11 through 30 is about $3,200.**

**Item IV-c Leachate Pump Station Operation & Maintenance**

Years 1 - 30

- Assume routine inspections coincide with gas system maintenance under Item 2 at a cost of **$3,600** per year.
- Assume replacement parts and repairs for system components cost approximately **$3,100** per year.
- Assume pipes are cleaned every two years at a cost of $5,200 (annualized cost of **$2,600).**
- **Therefore, the annual maintenance cost for years 1 through 30 is about $9,300.**

Electricity Costs

Years 1 - 5

- Assume the annual electricity cost for years 1 through 5 is about **$16,000**.

Years 6 -10

- Assume the leachate flow rates drops to about 55 percent of flow at closure on average over the 5 year period due to the cap so that the annual electricity cost for years 6 through 10 is about **$8,800.**

Years 11 - 20

- Assume the leachate flow rates drop to about 40 percent of the flow at closure on average over the 10 year period so that the annual electricity cost for years 11 through 15 is about **$6,400.**

Years 21 - 30

- Assume the leachate flow rates drop to about 30 percent of the flow at closure on average over the 10 year period so that the annual electricity cost for years 21 through 30 is about **$4,800.**

**Item V – Air Quality Monitoring**

Surface Scans

Years 1 - 5

Assume that quarterly surface scans will be required for the first five years of the post-closure period, along with 20 hours per quarter of labor and equipment associated with addressing methane emission exceedances. Assume that the cost of a surface scan, excluding reporting, is about $3,000, and the labor and equipment cost associated with correcting exceedances is about $6,000 per quarter. Therefore, **the annual cost for surface scans and repair is about $36,000 in years 1 through 5.**

Years 6 - 30

Assume that annual surface scans are required for years 6 through 30, with no repair of cap associated with exceedances required through the period. Assume the same $3,000 per surface scan cost. Therefore, **the annual cost for surface scans is $3,000 for years 6 through 30.**

Emission Fees

Assume that NHDES Emissions Fees will remain constant for the first five years of the post-closure period at **$90,000** per year. Assume the fee drops to **$60,000** in years 6-10, **$30,000** in years 11-20 and **$15,000**, by year 21.

**Item VI – Repair and Site Maintenance Costs**

Years 1 - 5

- Assume snow removal of **$500** per year.
- Assume mowing costs will be approximately $100/acre or **$7,100** per year.
- Assume costs for repair of minor erosion of the final capping system will involve a day for an excavator, truck and laborer every two years at a cost of $6,000 (annualized cost of **$3,000**).
- Assume costs for repair of capping system settlement at a cost of $10,000 every five years (annualized cost of **$2,000**).
- Assume stormwater maintenance including removal of sediments which collect in ponds and swales will be required on a yearly basis. Costs assumed to be **$2,000** per year.
- **Therefore the annual cost for years 1 through 5 is approximately $14,600.**

Years 6 - 10

- Snow removal and mowing costs remain the same. Stabilization of the capping system and slowing of settlement results in a reduction in the repair work required.

- **An annual cost of $11,000 is estimated.**

Years 11 - 20

- Further stabilization of the capping system and the annualized cost is reduced to **$7,750** per year.

Years 21 - 30

- Further stabilization of the capping system and the annualized cost is reduced to **$6,000** per year, and primarily includes mowing costs**.**

**Item VII - Inspections**

Years 1 - 5

- Assume semi-annual site inspections and reporting for the first 5 years of the post-closure period to be **$12,500** per year. Work includes groundwater reporting, site inspection reporting, settlement reporting and reporting on the landfill gas collection system.

Years 6 - 30

- Site inspections continue to be conducted semi-annually, assume the reporting becomes more straightforward over time. Assume that annual inspection and reporting costs are **$8,500** per year.

# *Attachment C*

## *Technical Specifications*

| | |
|---|---|
| 02222 | Excavation |
| 02223 | Filling |
| 02231 | Select Aggregates |
| 02232 | Stone Fill |
| 02234 | Select Sand/Gas Transmission Layer |
| 02270 | Erosion Control |
| 02273 | Drainage Geocomposite |
| 02275 | Non-Woven Geotextile Filter Fabric |
| 02276 | Linear Low-Density Polyethylene (LLDPE) Liner |
| 02541 | Gravels |
| 02619 | High Density Polyethylene Pipe and Fittings |
| 02930 | Loaming and Seeding |

# SECTION 02222
# EXCAVATION

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Excavation and processing of excavated materials.

B. Stockpiling of fill materials.

C. Excavation for liner subgrade and utilities.

D. Excavation and disposal of unsuitable and excess materials.

E. Excavation of MSW and transport of excavated materials to the location designated on the Plans.

### 1.02 RELATED REQUIREMENTS

A. Section 01400 - Quality Assurance/Quality Control

B. Section 01500 - Construction Facilities and Temporary Controls

C. Section 02223 - Filling

D. Section 02270 - Erosion Control

E. Section 13001 – Site Safety and Contingency Work Plan

### 1.03 PROTECTION

A. Protect the bench-marks established for project construction.

B. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods required to prevent cave-in or loose soil from falling into the excavation.

C. Notify the Engineer of unexpected subsurface conditions and discontinue affected work in area until notified to resume work.

D. Grade the perimeter to prevent surface water run-off into the excavation.

E. Barricade or otherwise protect, consistent with the project safety program, open excavations occurring as part of this work and post with warning lights.

F. Protect adjacent structures and facilities from damage caused by settlement, movement, undermining and other hazards created by earthwork operations.

G. Dust Control: Use all necessary means to control dust caused by the Contractor's operation. Prevent dust from being a nuisance to the public. The use of calcium chloride is not acceptable. Moisture addition must be limited so as not to adversely affect soil handling. The use of other agents for dust control is subject to the approval of the Engineer.

H. Dewatering: Remove water from excavations to a point lower than the proposed subgrade of the work.

I. Odor Control: The Contractor shall limit the area of waste excavation each day to the extent practical in order to minimize potential generation of odors. At the end of each day of waste excavation, Contractor shall install a minimum of 4-inches of common borrow cover over exposed waste materials. Odor controls shall be in accordance with a project specific Odor Control Plan developed for each construction project.

1.04 JOB CONDITIONS

A. SITE CONDITIONS: Data referring to subsurface conditions in Appendix A are not intended as representations or warrants of continuity of such conditions between soil borings. The information is made available for the convenience of the Contractor and the Owner will not be responsible for interpretations or conclusions drawn by the Contractor.

1.05 DISTURBANCE OF EXCAVATED AND FILLED AREAS DURING CONSTRUCTION

A. The Contractor shall take the necessary steps to avoid subgrade disturbance during excavations, including dewatering and restricting the use of equipment in areas above optimum moisture level.

B. All areas disturbed during excavation that will not meet compaction requirements shall be removed and replaced with fill meeting structural requirements at no extra cost to Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Common Borrow - Soil to be utilized from on-Site borrow source or procured from off-site and utilized as common borrow fill shall meet the requirements of Common Borrow in Section 02223, for use by the contractor as general fill and other areas indicated on the project drawings.

B. Unclassified Waste - Waste materials including soil cover and cover to be excavated from areas as indicated on the Drawings. May include refuse, wood chips, metal, masonry, concrete, boulders, or debris and other unclassified waste.

C. Till- Soil to be procured from on-Site borrow source or offsite and utilized by the Contractor as the screened till layer, in the anchor trench, and other areas indicated on the Drawings shall meet the requirements of Screened Till in Section 02223.

D. Unsuitable Fill - Excavated material not meeting the requirements for reuse as topsoil or intermediate or daily cover which may not be used as fill due to excess moisture, trash, organics, or other unsatisfactory materials.

## PART 3 EXECUTION

### 3.01 PREPARATION

A. Set and verify required lines and grades prior to starting the excavation. This work should be performed and verified by a registered land surveyor or professional engineer licensed to practice in the State of New Hampshire.

B. It will be the responsibility of the Contractor to establish a construction baseline on-site. The Contractor shall perform all necessary construction layout from this baseline, maintain the baseline as necessary, and perform whatever survey is required to control his work.

### 3.02 EXCAVATION

A. Excavation consists of the removal and stockpiling or disposal of materials encountered when establishing required grade elevations as shown on the Plans and in accordance with these Specifications. If boulders greater than twelve (12) inches diameter are encountered within six (6) inches of the depth of excavation, they shall be removed, and the resulting hole shall be backfilled with Common Borrow or Screened Till.

B. Excavation for utilities: trenches for the pipes shall be excavated to the required line and grade and of sufficient width to permit thorough compacting and tamping of the fill material under the haunches and around the pipe. In general, utility trenches shall be excavated to 6 inches below the bottom of the utility line to accommodate bedding material as specified hereinafter. Soft or unsuitable material encountered below the normal bedding line of the pipe shall be removed as directed, replaced with regular fill, and thoroughly compacted.

C. Excavation for structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 feet, and extending a sufficient distance from structures to permit installation of service, other construction required, and for inspection.

D. Excavation of Unclassified Waste Material: Excavation of existing cover material and waste material shall be completed to the limits indicated on the Drawings. All work will be completed in accordance with the Site Safety and Contingency Work Plan developed by the Contractor. Excavated waste materials and shall be placed in the active landfill at a location designated by the Owner.

Excavation of waste materials shall be performed in a manner which controls odors, dust, vectors, and migration of waste. At a minimum, the “active area” of the excavation shall be covered with a minimum four (4) inches of suitable fill at the end of each day.

3.03 COMPACTION OF EXCAVATED SUBGRADE

A. Upon completion of the excavation to proposed subgrade, the conditions shall be inspected by the Engineer for acceptance. The entire area shall be fine graded to remove undulations or isolated high or low spots. The subgrade shall be proof rolled, and any soft yielding areas shall be excavated and backfilled with common borrow or screened till.

B. Compaction equipment in open areas shall consist of vibratory rollers, or other equivalent compaction equipment reviewed by the Engineer.

C. Compaction equipment in confined areas (in trenches and adjacent to walls, piers, footings and standpipes) shall consist of hand-guided vibratory equipment or mechanical tampers approved by the Engineer.

E. Upon completion of the excavation in areas outside the landfill where fill will be placed, the subgrade shall be compacted using a vibratory roller to the satisfaction of the engineer, or by other suitable equipment as approved by the Engineer.

3.04 STOCKPILING

A. Place, grade, and shape stockpiles for proper drainage. Erosion control devices shall be used as necessary to minimize sediment transport away from the area.

B. Fill unsuitable for use as regular fill and excess materials shall be handled in accordance with Part 3.05.

3.05 DISPOSAL OF UNSUITABLE and EXCESS MATERIALS

The Contractor shall dispose of all unsuitable and excess materials on-site in a location or locations designated by the Owner or as shown on the Plans. Contractor shall take no material from the site.

Unsuitable and excess materials are defined as follows:

A. Unsuitable Material - Material containing significant clay, silt, or organic material, or material greater than eight inches (8") in diameter, or other materials identified on the contract drawings.

B. Excess Materials - Materials not meeting the definition in “A” above but which do not meet any of the specifications for materials required for this project, and/or materials in excess of the total quantity of materials required for this construction project.

C. No material shall be removed from the site. Unsuitable and excess materials shall be stored at separate locations on site as directed by the Owner.

## 3.06 STABILITY OF EXCAVATIONS

A. Slope sides of excavations to comply with OSHA regulations and local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible due to space restrictions or instability of material excavated. Maintain the sides and the slopes of excavations in a safe condition until completion of backfilling.

B. Shoring and bracing: Provide adequate shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition. Trench shoring and bracing shall comply with local codes and authorities having jurisdiction. Maintain shoring and bracing in excavation regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses. All temporary shoring and bracing plans shall be designed and stamped by a New Hampshire licensed professional engineer.

## 3.07 DEWATERING

A. Control of surface water is a critical requirement of the work. All necessary actions shall be taken to minimize the effect of precipitation and runoff on the work. Upgradient runoff shall be diverted from active or completed work areas, and all work shall be graded and crowned to promote runoff.

B. The Contractor shall prevent surface water and subsurface or groundwater from flowing into excavations or onto any work and from flooding the project site and surrounding area.

C. Water shall not accumulate in excavations. Contractor shall remove water to prevent softening of subgrades and soil changes detrimental to stability of the subgrade. The Contractor shall dewater excavated areas as required to perform the work, and in such a manner as to preserve the undisturbed state of subgrade material.

D. The Contractor shall provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

E. The Contractor shall prevent migration of sediment in accordance with erosion control requirements of this Contract.

## 3.08 COLD WEATHER PROTECTION

A. Protect excavation bottoms against freezing when the atmospheric temperature is less than 35º F. The Contractor shall take whatever actions are necessary during the period of construction, to prevent freezing of any areas which are to receive fill as part of this work. No fill shall be placed on areas which are frozen. The Contractor shall also comply with the requirements of Section 203, Paragraph 3.7.8 of the NHDOT Standard Specifications.

3.09 REMOVAL OF UNSATISFACTORY SOIL MATERIALS

A. Unsatisfactory soil materials shall be as defined in Paragraph 3.05 (unsuitable materials).

B. Excavate unsatisfactory soil materials encountered that extend below required elevations, to the additional depth directed by the Engineer. Do not over-excavate without prior authorization of the Engineer.

C. Such additional excavation, provided it is not due to fault or neglect of Contractor, will be measured as directed by Engineer and paid for in accordance with the measurement and payment section.

D. Material that is above or below optimum moisture for compaction of the particular material in place as determined by the Engineer, and is disturbed by the Contractor during construction operations so that proper compaction cannot be reached shall be construed as unsuitable bearing material or unsatisfactory soil material. This material shall be removed and replaced with compacted gravel fill at no additional charge to the Owner.

END OF SECTION

# SECTION 02223
# FILLING

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Furnishing, placing, and compaction of suitable fill (borrow), intermediate layer material and bedding sand.
B. Placing and compaction of screened till.
C. Coordination with the Engineer for completion of all required tests.

### 1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals
B. Section 01400 - Quality Assurance/Quality Control
C. Section 02222 – Excavation
D. Section 02231 – Select Aggregates
E. Section 02232 - Stone Fill
F. Section 02234 - Select Sand
G. Section 02270 - Erosion Control
H. Section 02930 - Loaming and Seeding

### 1.03 REFERENCES

A. ASTM D422-63(2007)e2 - Standard Test Method for Particle-Size Analysis of Soils

B. ASTM D1557 Method "C" - Moisture-Density Relations of Soils and Soil-Aggregate Mixture using 10 lb. (4.54 kg) Hammer and 18-inch (457 mm) Drop.

C. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.

D. ASTM D6938 - 08a Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

E. ASTM D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

F. ASTM D5321 – Standard Test Method for Direct Shear Testing of Geosynthetic Material and Soil Interfaces.

### 1.04 TESTS

A. Soil testing and compaction tests shall be performed by the Engineer in coordination with the Contractor.
B. Test and analysis of fill materials shall be performed by the Engineer in coordination with the Contractor.

C. Tests and analyses of fill materials will be performed in accordance with ASTM D422, ASTM D1557, ASTM D6938-08a, ASTM D5084 and ASTM D5321 and conditions set forth in Section 02223, 2.02 "Quality Control and Quality Assurance."

PART 2 PRODUCTS

2.01 FILL

A. General

For all fill materials to be used, samples, sieve analysis, and laboratory data indicating maximum dry densities and optimum moisture for field control tests shall be obtained by the Engineer prior to use as fill on site. The Contractor shall excavate, screen, and stockpile materials as required for sampling by the Engineer prior to delivery and placement.

B. Common Borrow/Intermediate Cover Layer

Suitable borrow from on or off-site sources to be utilized as common borrow and intermediate Cover Layer material shall consist of soil with all rocks or material greater than 8" removed and between 10% and 80% passing the No. 200 sieve. Suitable fill shall be free from combustible, organic and frozen materials, loam, roots, topsoil, wood, trash, snow, ice, and other objectionable materials, or as identified by the Engineer.

C. Screened Till

Screened Till for use as the 6 inches of screened till layer, and anchor trench backfill shall consist of inorganic mineral soil free of organic material, loam, trash, snow, ice, frozen soil, or other unsuitable materials and shall conform to the following gradation:

| U. S. Standard Sieve Size | % Finer By Weight |
|---|---|
| 1 inch | 100 |
| No. 4 | 80-100 |
| No. 40 | 60-100 |
| #200 | 20 – 70 |

Screened till shall have a hydraulic conductivity of less than $1x10^{-4}$ cm/sec as demonstrated by ASTM D5084, when placed and compacted as specified as a subgrade fill beneath the topsoil layer.

D. For other fill materials see Section 02234 Select Sand, Section 02541 - Gravels, and Section 02930 - Loaming and Seeding, as applicable.

## 2.02 QUALITY CONTROL AND QUALITY ASSURANCE

A. During earthwork operations, the Engineer will be present on the site to monitor and document the Contractor's activities relative to contract compliance.

B. The Engineer shall complete laboratory analyses of a minimum of two (2) representative samples of common borrow and screened till. The Engineer shall conduct laboratory grain size analysis, moisture density testing, and permeability in accordance with ASTM D422, ASTM D1557, and ASTM D5084, respectively, to demonstrate conformance with Parts 2.01 and 3.02 of this Section.

C. The Contractor shall provide a sample for Engineer's laboratory analysis of at least one (1) representative sample of common borrow fill and screened till for each 5,000 cubic yards of material to be placed. The Engineer shall conduct laboratory grain size analysis and moisture density testing in accordance with ASTM D422 and D1557, respectively, to demonstrate conformance with Parts 2.01 and 3.02 of this Section.

D. The results of laboratory testing shall be reviewed by the Engineer prior to placement of fill materials. Costs for re-sampling and subsequent laboratory testing of all non-complying materials shall be borne by the Contractor.

E. Field tests will be performed by the Engineer on in-place fill and backfill materials to confirm that specified densities are being achieved with the minimum required coverages and compaction equipment utilized by the Contractor. The Engineer will select locations and frequency for in-place density testing. At a minimum, the frequency of field tests shall be as follows:

1. Common Borrow Fill: 1 test per 10,000 $ft^2$ installed
2. Screened Till: 1 test per 10,000 ft2 installed

F. Acceptable materials placed and compacted to below the specified density shall alternatively be:

1. Recompacted as required to achieve the specified density.
2. Removed and replaced with properly placed and acceptably compacted material.

G. Materials placed and compacted which do not conform to project specifications for the area placed shall be removed and replaced with suitable material by the Contractor.

H. The Contractor will bear all costs incurred in the recompaction, removal, and replacement of fill not meeting density requirements.

PART 3 EXECUTION

3.01 PREPARATION

A. Fill to be used must be reviewed by the Engineer.

B. The subgrade which is to receive the fill shall be fine-graded and compacted in accordance with Section 02222 "Excavation" and reviewed by the Engineer.

C. All excavated surfaces shall be within 0.10'(+) and 0.20'(-) ft. of required line and grade.

D. Surfaces to be filled against which are steeper than 4:1 shall be scarified or stepped and compacted to provide a bond with the new material.

E. Fill materials will not be placed or compacted on frozen ground or during unfavorable weather conditions. Backfill operations will not be resumed until the moisture content and fill density is satisfactory to the Engineer.

F. All fill material shall be placed "in-the-dry" on a prepared ground surface acceptable to the Engineer. The Contractor shall drain away ponded areas as required to perform the placement of fill in-the-dry.

3.02 FILLING AND COMPACTION

A. Approved suitable material shall be installed in lifts no greater than as specified.

B. Lifts shall be compacted to at least the specified percentage of maximum dry density, within 3% of optimum moisture content. Field testing of these lifts will be performed in accordance with ASTM D6938-08a, and Paragraph 2.02 of this Section.

C. Do not proceed with the next layer of fill until the preceding layer has been tested and approved by the Engineer.

D. Areas at which tests indicate insufficient compaction shall be recompacted and retested until the areas conform to the requirements of this specification.

E. For the materials specified herein, the following placement and compaction requirements are included:

| | Maximum Lift Before Compaction | Minimum % of Maximum Density per ASTM D1557 |
|---|---|---|
| Common Borrow Fill | 12" | 95 |
| Screened Till | 6" | 95 |

3.03 BACKFILLING OF UTILITES AND PIPING

A. After pipes and joints have been inspected and approved by the Engineer, screened till bedding or crushed stone (See Section 02232) shall be carefully placed and compacted and tamped in 6-inch layers under, around, and to the spring line of the pipe to firmly support the pipe, and prevent lateral movement.

B. Care shall be taken to provide recesses in the bedding or trench bottom, as required, to relieve each bell of any load.

C. Backfill from the top of the bedding to 12-inches above the pipe shall be completed in 12-inch layers with drainage sand, evenly on both sides of the pipe.

D. The remainder of the backfill may be material removed from the trench excavation and shall be placed in approximately 12-inch layers and compacted to 95% of the maximum dry density, as demonstrated by in-place density testing completed by the Engineer.

3.04 FINAL GRADING

A. Perform all finish grading required to attain the elevations shown on the Plans, to within 0.1 feet, to eliminate all ponded water, or as otherwise indicated.

B. Areas to be seeded shall be raked to remove all stones and other unsatisfactory material and shall be suitably compacted.

3.05 TREATMENT AFTER COMPLETION OF GRADING

A. After grading is complete and the Engineer has finished his reviews, the Contractor shall permit no further excavating, filling, grading, or vehicular access except to maintain erosion or sediment control. Use all means necessary to prevent erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.

END OF SECTION

# SECTION 02231
# SELECT AGGREGATES

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Furnishing and placement of crushed stone around perforated pipe.

### 1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals
B. Section 01400 - Quality Assurance/Quality Control
C. Section 02222 - Excavation
D. Section 02275 - Non-woven Geotextile Filter Fabric
E. Section 02619 - High Density Polyethylene Piping and Fittings

### 1.03 SUBMITTAL

A. The Contractor shall provide laboratory data from a minimum of 1 representative sample indicating that the crushed stone and select gravel meets the grain size distribution specified below.

## PART 2 PRODUCTS

### 2.01 3/4" CRUSHED STONE

A. Crushed stone shall be durable crushed rock consisting of the angular fragments obtained by breaking and crushing solid or shattered natural rock, and reasonably free from sand, clay, loam, or deleterious material and not more than one percent (1%) of satisfactory material passing a No. 200 sieve will be allowed to adhere to the crushed stone.

B. The crushed stone shall be uniformly blended according to the grading requirements for the respective stone sizes shown in the following table:

| Square Opening Sieve | % Passing by Weight |
|---|---|
| 3/4 " | 90 - 100 |
| 3/8 " | 20 - 55 |
| #4 | 10 - 30 |
| #20 | 0 - 10 |

PART 3 EXECUTION

3.01 PREPARATION

Areas to receive crushed stone shall have the specified geotextiles and/or other geocomposite layers overlying the liner as shown on the drawings.

3.02 INSTALLATION

A. Crushed stone shall be placed around the perforated pipes in accordance with the Drawings, and in a manner, which will produce a reasonable well-graded mass of stone. The stone shall not be dropped or dumped in a manner that will cause damage to the pipes or liners.

END OF SECTION

# SECTION 02232
# STONE FILL

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Procurement of stone fill and crushed stone materials.

B. Placement of stone fill and riprap for stabilization of drainage swales and slopes or as select materials to be used for erosion control as shown on the Drawings or as ordered by Engineer.

### 1.02 RELATED REQUIREMENTS

A. Section 02275 - Non-Woven Geotextile Fabric
B. Section 02270 - Erosion Control
C. Section 02273- Drainage Geocomposite

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. Stone Fill and riprap for Placement in Stormwater Ponds, Stabilization of Drainage Swales, and Culvert Outlet Protection:

1. Stone shall conform to NHDOT Specifications for Stone Fill Class C and Class D Section 585 “Stone Fill” as indicated on the Drawings.

2. Riprap shall conform to NHDOT Specification for Rip Rap Type I Section 583 “Riprap” as indicated on the drawings.

3. Stone fill shall be hard, durable, angular in shape; resistant to weathering and to water action; free from overburden, spoil, and organic material.

4. The acceptability of the processed stone will be determined by visual inspection or by suitable tests. If testing is required, suitable samples of stone shall be taken in the presence of the Engineer at least fourteen (14) days in advance of the time when the placing of stone fill is expected to begin.

5. Control of gradation will be by visual inspection. If necessary, the Contractor shall provide two (2) samples of rock, at least five tons (5T) each, meeting the gradation specified above. These samples shall be used as a reference for judging the gradation of the stone fill supplied.

6. Any difference of opinion between the Engineer and the Contractor shall be resolved by dumping and checking the gradation of two (2) random truckloads of stone. Mechanical equipment, a sorting site, and labor needed to assist in checking gradation shall be provided by the Contractor at no additional cost of the Owner.

PART 3 EXECUTION

3.01 PLACEMENT OF STONE FILL

A. Stone fill in the landfill shall be placed directly over the drainage geocomposite and pipes as shown on the Drawings.

B. Placement of stone fill over geomembrane and drainage geocomposite materials shall be by "low ground pressure" (LGP) rated equipment having a bearing pressure of no greater than 4.7 pounds per square inch measured at 12 inches above the geomembrane. No equipment will be allowed at any time directly on the liner or geotextile fabric.

C. Stone fill shall be placed by LGP equipment in lifts no less than 12 inches.

D. Non LGP equipment which is necessary to operate over the landfill shall be operated on additional depths of stone fill or other materials to provide an equivalent bearing pressure of 4.7 pounds per square inch at 12 inches above the geomembrane.

E. Coordinate placement of stone fill with the installation of other components of work shown on the Plans, taking all measures to prevent damage to these materials while placing the stone fill.

F. The stone fill layer will be spread to a consistent depth and uniform surface, being compacted only by passage of the low ground pressure machinery. No vibratory equipment is to be used in compacting the stone fill.

G. Stone fill in drainage swales shall be placed directly over a 12 oz. non-woven geotextile fabric within the prepared swales and on slopes, starting at the downstream end. Rip rap shall be placed over a 16 oz non-woven geotextile fabric within prepared swales, and slopes, starting at the downstream end.

H. Stone fill and rip rap for culvert outlet protection shall be placed directly over a 12 oz. and 16 oz. non-woven geotextile fabric, respectively, to the limits shown on the Plans.

I. All stone fill and rip rap shall be placed in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids. The entire mass of stone shall be placed, so as to be in conformance with the lines, grades, and thicknesses shown on the plans.

J. Stone fill and rip rap shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of stone fill in layers, or by dumping into chutes, or by similar methods likely to cause segregation, will not be permitted.

K. The larger stones shall be well distributed, and the entire mass of stone shall conform to the gradation specified in paragraph 2.01. All material going into stone fill protection shall be so placed and distributed that there will be no large accumulations of either the larger or smaller sizes of stone.

L. It is the intent of these specifications to require compact stone fill protection in which all sizes of material are distributed within their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

END OF SECTION

# SECTION 02234
# SELECT SAND/GAS TRANSMISSION LAYER

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Procurement of select sand, placement of the twelve (12) inch layer of select sand, and placement of the Six (6) inch gas transmission layer as shown on the Drawings.

### 1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals

B. Section 01400 - Quality Assurance / Quality Control

C. Section 02223 - Filling

D. Section 02273 - Drainage Geocomposite

### 1.03 REFERENCE STANDARDS

A. ASTM D422-63 (2007): Standard Method for Particle-Size Analysis of Soil

B. ASTM D1557: Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

C. ASTM D5084: Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

D. ASTM D5321: Test Method for Direct Shear Testing of Geosynthetic Material and Soil Interfaces

E. ASTM D4373: Standard Test Method for Rapid Determination of Carbonate Content of Soils

### 1.04 SUBMITTALS

A. The Contractor shall provide a sample for laboratory testing by the Engineer to determine that the select sand meets the specified grain size distribution and hydraulic conductivity for at least every 3,000 cy delivered to the site.

B. The Contractor shall submit all proposed low ground pressure (LGP) equipment for Engineer's review.

C. The Engineer shall complete direct shear box tests of the select sand and the proposed drainage geocomposite to demonstrate compliance of interface friction, in accordance with Part 2.01 of this Section.

D. The Contractor shall provide one sample for laboratory testing by the Engineer for calcium carbonate content from each source of select sand.

PART 2 PRODUCTS

2.01 SELECT SAND/GAS TANSMISSION LAYER

A. Select sand/gas transmission layer shall be well graded sand without excessive fines, free from loam clay, and organic matter and meeting the following grain size distribution:

| U.S. Standard Sieve Size | % Finer By Weight |
|---|---|
| 1 in. | 100 |
| #4 | 60-100 |
| #10 | 40-95 |
| #40 | 10-50 |
| #100 | 0-20 |
| #200 | 0-10 |

B. Select sand shall not contain more than 15 percent calcium carbonate as determined by ASTM D 4373. At least one test shall be performed on a representative sample from each source.

C. Select sand shall have a hydraulic conductivity greater than or equal to $1 \times 10^{-3}$ cm/sec as determined by ASTM D 2434.

D. Interface Shear Strength: Testing completed by the Engineer shall demonstrate that the interface shear strength is equal to or greater than a strength envelope of $29^0$ between the 40-mil textured LLDPE liner and the select sand.

a. The interface shear strength shall be determined by an interface shear test performed in accordance with ASTM D5321. The normal stresses applied shall be 1, 2, and 4 psi. The strain rate shall not exceed 0.04 inches per minute. The 40-mil textured LLDPE geomembrane shall be tested in the machine direction. The tests shall be continued until residual shear strengths are achieved, or to a maximum 2-inch displacement. The select sand shall be compacted to 93% of maximum dry density per ASTM D1557, and a moisture content of 2% wet of optimum.

b. The laboratory test reports shall include plots of shear strength versus normal stress for peak and large displacement values, and stress versus strain plots for tests run at each normal load application. A minimum of two (2) tests shall be completed.

c. Test results not meeting the minimum requirements shall be reviewed by the Engineer for possible conformance with the overall design objectives.

## PART 3 EXECUTION

### 3.01 PREPARATION

A. Verify that the stockpiled select sand is reviewed by the Engineer.

B. Verify the lines and grades to which the select sand is to be placed and compacted.

C. Verify that the area on which select sand is to be placed is free from debris, snow, ice, or water and that the ground surface is not frozen.

### 3.02 PLACEMENT OF MATERIALS

A. Placement of the select sand over geomembrane and drainage geocomposite materials shall be by "low ground pressure" (LGP) rated equipment having a bearing pressure of no greater than 4.7 pounds per square inch measured at 12 inches above the geomembrane. No equipment will be allowed at any time directly on the liner or geotextile fabric.

B. Select Sand placed on slopes of 3:1 or greater must be placed from the toe of the slope uphill to the crest. Any placement across or down slopes must be approved by the Engineer.

C. Select sand shall be placed by LGP equipment in lifts no less than the proposed minimum thickness for that area. In no case shall this be less than 12 inches.

D. Non LGP equipment which is necessary to operate over the landfill shall be operated on additional depths of sand or other materials to provide an equivalent bearing pressure of 4.7 pounds per square inch at 12 inches above the geomembrane.

E. Coordinate placement and compaction of the select sand with the installation of other components of work shown on the Plans, taking all measures to prevent damage to these materials while placing the select sand.

F. The select sand layer will be spread to a consistent depth and uniform surface, being compacted only by passage of the low ground pressure machinery. No vibratory equipment is to be used in compacting the select sand.

G. The select sand layer may not require testing for compaction densities if the Engineer believes that the sand is being placed in layers and compacted as required. If requested by Engineer, Contractor shall coordinate for testing by the Engineer to demonstrate a minimum 90% of maximum dry density is achieved.

END OF SECTION

# SECTION 02270
# EROSION CONTROL

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Installation and maintenance of temporary erosion control devices.

B. Erosion control measures to fully manage runoff and potential erosion conditions which may develop during construction and prior to the functioning of completed permanent erosion control devices.

C. Compliance with federal, state and local regulations pertaining to erosion control, and the Site Specific Permit conditions for this project.

### 1.02 RELATED REQUIREMENTS

A. Section 02222 - Excavation
B. Section 02223 - Filling
C. Section 02232 - Stone Fill
D. Section 02930 - Loaming and Seeding

### 1.03 DESIGN CRITERIA

A. Conduct all construction in a manner and sequence that causes the least practical disturbance of the physical environment.

B. Stabilize disturbed earth surfaces in the shortest practical time and employ any and all such temporary erosion control devices as may be necessary until such time as adequate soil stabilization has been achieved.

C. The erosion control devices shown on the Drawings and as specified herein represent the minimum required work for erosion control. The Contractor shall add to these minimum devices any and all measures to effectively prevent migration of sediment from the work area.

## PART 2 PRODUCTS

### 2.01 SANDBAGS

Heavy cloth bags of approximately one cubic foot capacity filled with sand or gravel.

2.02 MULCH

Mulch shall consist of cured hay. When air dried in the loose state, the contents of a representative bale shall lose not more than 15 percent of the resulting air-dry weight of the bale. It shall be free from primary noxious weed seeds and rough or woody materials.

2.03 EROSION CONTROL BLANKET

A. Erosion control blankets shall be North American Green SC150BN, or approved equivalent. Erosion control blankets shall consist of all-natural material with no plastic netting or mesh.

B. The Contractor shall store the blanket in a manner which protects them from damage by construction traffic and extended ultraviolet exposure.

C. Type of fasteners and their spacing shall be in accordance with the manufacturer's recommendations.

2.04 STONE FILL

As defined in Section 02232 "Stone Fill" and as required by the Plans. Stone used to contingent check claims shall be crushed stone as defined in Section 02232.

2.05 SILT FENCE

A. The silt fence shall be Propex Silt-Stop sediment control fabric or approved equal.

B. Support poles and fastenings to be used shall be as specified by the manufacturer.

C. Spacing and location of poles and fastenings shall be in accordance with the manufacturer's recommendations, or more frequently if required.

2.06 COMPOST SOCK

A. Compost sock shall be 8" Filtrexx SiltSoxx Natural or approved equivalent.

B. Compost fill and installation shall be in accordance with manufacturer's recommendations.

C. Compost socks are to be removed and disposed at the conclusion of the project.

2.07 TEMPORARY SEEDING

Prior to establishment of the final vegetation on disturbed areas, placement and establishment of temporary grasses will be completed if required. Seed for temporary control shall be annual or perennial ryegrass. Hay mulch shall be applied to temporary seeded areas at a rate of 1½ to 2 tons per acre.

2.09 BONDED FIBER MATRIX

A. Bonded fiber matrix shall be installed on all vegetated slopes steeper than 3:1. Acceptable manufacturers include:
    1. Mat Inc. (Soil Guard);
    2. Central Fiber Corporation (Spray Matt);
    3. Terra Novo (Earthguard Fiber Matrix); or
    4. Approved equal.

PART 3 EXECUTION

3.01 TEMPORARY EROSION CHECKS

A. Construct temporary erosion checks in ditches and other locations required to effectively control erosion.

B. The erosion control procedures shall conform to NHDOT Specifications, Division 600, Section 645 "Erosion Control".

C. Construct temporary barriers along the toe of embankments when necessary or as designated by the Engineer.

D. Construct temporary side drains in intervals as necessary or as designated by the Engineer.

E Haybale barriers and stone check dams shall be installed in drainage swales where shown on the Plans. Haybales will be staked and maintained prior to and during construction until disturbed areas have a healthy stand of grass and sediment transport has ceased. Additional haybale barriers may be required as conditions dictate and shall be placed as necessary.

F. Silt fence shall be installed along the limits of work where shown on the Plans, and at any other locations as necessary to control erosion as conditions dictate.

3.02 BONDED FIBER MATRIX

A. Contractor shall apply a Bonded Fiber Matrix on vegetated slopes steeper than 3:1 in accordance with the manufacturers' recommendations for long-term erosion control.

3.03 INSTALLATION OF EROSION CONTROL BLANKET

A. CHANNEL INSTALLATION

1. Erosion control blankets shall be installed as directed by the Engineer in accordance with manufacturer's instructions. The extent of erosion control blankets shall be as shown on Drawings.

2. Erosion control blankets shall be installed parallel to the flow of water. The first roll shall be centered longitudinally in mid-channel and anchored with staples, as required by the manufacturer. Subsequent rolls shall follow from channel center outward and be abutted to allow installation of a common row of staples.

3. Successive lengths of erosion control blankets shall be overlapped ("shingled") sufficiently for a common row of staples with the upstream end on top. Staple the overlap across the end of each of the overlapping lengths.

4. A trench shall be located at the upstream termination. Erosion control blanket shall be stapled to the bottom of the trench. Backfill and compact the trench.

B. SLOPE INSTALLATION

1. Erosion control blankets shall be installed as directed by the Engineer in accordance with manufacturer's instructions. The extent of erosion control blankets shall be as shown on Drawings, where required.

2. Erosion control blankets shall be oriented in vertical strips and anchored with staples, as required by the manufacturer. Adjacent strips shall be abutted to allow for installation of a common row of staples. Horizontal joints between erosion control blankets shall be overlapped sufficiently for a common row of staples ("shingled") with the uphill end on top.

3. Where exposed to overland sheet flow, a trench shall be located at the uphill termination. Erosion control blanket shall be stapled to the bottom of the trench. Backfill and compact the trench.

4. Where terminating in a channel, slope erosion control blanket shall overlap channel erosion control blanket sufficiently for a common row of staples.

3.04 EROSION CONTROL IMPLEMENTATION

A. During construction and thereafter, erosion control measures are to be implemented as shown on the Plans, and additionally as may be necessary to manage conditions as they occur. The smallest practical areas of land should be exposed at any one-time during development. When the land is exposed during development, the exposure should be kept to the shortest practical period of time as approved by the Engineer.

B. Erosion rills or gullies in the Work area or in areas topographically below the work area shall be regraded and seeded at no additional cost to the Owner until an accepted vegetative stand is established.

END OF SECTION

# SECTION 02273
# DRAINAGE GEOCOMPOSITE

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Furnishing and installation of drainage geocomposite materials, consisting of an HDPE drainage net bonded on both sides to non-woven polypropylene geotextile fabrics in accordance with the project drawings.

### 1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals

B. Section 01400 - Quality Assurance/Quality Control

C. Section 02223 - Filling

D. Section 02234 - Select Sand

E. Section 02276 - High Density Polyethylene (HDPE) Liner

### 1.03 QUALITY CONTROL

A. Provide the manufacturer's certification that the drainage geocomposite has been manufactured and successfully tested in accordance with the appropriate ASTM standards.

B. Drainage geocomposite shall be supplied in rolls marked or tagged with the following:

1) Name of manufacturer.

2) Product identification.

3) Lot number.

4) Roll number.

5) Roll dimensions.

### 1.04 SUBMITTALS

A. The Contractor shall submit manufacturer or laboratory data indicating that the proposed materials meet the specifications outlined in Part 2.02, 2.03 and 2.04 A, B and C of this section.

B. The Contractor shall submit quality control certificates issued by the manufacturer for the geonet and geotextile components of the drainage geocomposite. The certificates shall include roll numbers and identification, and results of quality control tests completed at the minimum frequency specified in Part 2 of this section.

C. The Contractor shall submit representative samples from the proposed drainage geocomposite to the Engineer for transmissivity testing and interface sheer strength testing per Part 2.04 of this section.

D. Requirements for testing of interface shear strength between the drainage geocomposite and the textured LLDPE geomembrane and the drainage geocomposite and the proposed select sand are included in Part 2.04 of this section.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Drainage Gecomposite

1. GSE Fabrinet UF 250 mil Geocomposite

2. Approved equivalent

2.02 NON-WOVEN POLYPROPYLENE GEOTEXTILE FILTER FABRIC

A. The filter fabric on all of the geocomposite materials shall consist of an 8 oz non-woven continuous polypropylene filament fibers. It shall be tear resistant and be capable of conducting water.

B. The fabric shall retain its durability and strength when it is wet.

C. The Contractor shall provide quality control certificates from the manufacturer for the fabric used in the manufacturing of the drainage geocomposite. The filter fabric shall have the following minimum physical properties as determined by the appropriate test method.

| Physical Property | Test Method | Frequency | Minimum Average Roll Values Physical Properties |
|---|---|---|---|
| Fabric Weight | ASTM D5261 | 1/90,000 SF | 8.0 oz./yd$^2$ |
| Water Flow Rate | ASTM D4491 | 1/540,000 SF | 100 gpm/ft$^2$ |
| Grab Strength[1] | ASTM D4632 | 1/90,000 SF | 225 lbs |
| Grab Elongation[1] | ASTM D4632 | 1/90,000 SF | 50% |
| Puncture Resistance | ASTM D4833 | 1/90,000 SF | 600 lbs |
| Apparent Opening Size[2] | ASTM D4751 | 1/540,000 SF | Sieve Seize #80 |

1. Weakest Principal Direction

2. AOS sieve # must be ≥ #80

2.03 HIGH DENSITY POLYETHYLENE (HDPE) DRAINAGE NET

A. The Contractor shall provide quality control certificates from the manufacturer for the drainage net used in the manufacturing of the drainage geocomposite. The HDPE drainage net shall have the following minimum physical properties as determined by the appropriate test method.

| Physical Property | Test Method | Frequency | Minimum Average Value |
|---|---|---|---|
| Polymer Density | ASTM D1505 | 1/50,000 SF | 0.94 g/cm$^3$ |
| Carbon Black Content | ASTM D4218 | 1/50,000 SF | 2% |
| Nominal Thickness | ASTM D5199 | 1/50,000 SF | 250 mil |
| Tensile Strength MD | ASTM D5035 | 1/50,000 SF | 100 lb/in |

2.04 DOUBLE-SIDED DRAINAGE GEOCOMPOSITE

A. The double-sided drainage geocomposite shall be manufactured by heat bonding geotextile filter fabric to both faces of the HDPE drainage net. No burn through geotextiles shall be permitted. No glue or adhesive shall be permitted.

B. The bond between the geotextile and HDPE drainage net shall exhibit a minimum average peel strength of 1 lb. per inch and a minimum per roll of 0.5 lb. per inch (ASTM D7005). Peel strength of the manufactured geocomposite shall be tested at a minimum of every 50,000 square feet, by the Manufacturer.

C. The drainage geocomposite shall have a minimum transmissivity of $2.7x10^{-4}$ $m^2/s$ when tested with ASTM D4716 between select sand and textured LLDPE liner at a normal load of 300 psf and a gradient of 0.40 with a seat time of 100 hours in accordance with GRI-GM8.

D. Transmissivity tests shall be completed by the Engineer at a minimum frequency of 1 per 50,000 square feet and at least one per lot.

E. Contractor shall provide samples of geocomposite materials to the Engineer for transmissivity testing prior to shipment to the site.

D. Interface Shear Strength – Testing Completed by Engineer

1. Contractor shall provide samples of the proposed materials required for interface testing, as specified below, to the Engineer for testing prior to shipment to the site. Laboratory testing shall demonstrate that the interface shear strength is equal to or greater than a strength envelope of $32^0$ between:
    - the double-sided drainage geocomposite and the proposed 40-mil Agru MicroSpike® LLDPE geomembrane.
    - The select sand and the double sided geocomposite.

2. The interface shear strength shall be determined by an interface shear test performed in accordance with ASTM D5321. The normal stresses applied shall be 1, 2, and 4 psi, all under inundated conditions. The strain rate shall not exceed 0.04 inches per minute. The drainage geocomposite and the 40-mil Agru MicroSpike® LLDPE geomembrane shall be tested in the machine direction. The tests shall be continued until residual shear strengths are achieved, or to a maximum 2-inch displacement.

   The laboratory test reports shall include plots of shear strength versus normal stress for peak and large displacement values, and stress versus strain plots for tests run at each normal load application. A minimum of two (2) tests shall be completed for each interface.

3. Test results that do not meet the minimum requirements are to be reviewed by the Engineer for possible conformance with the overall design objectives.

2.05 STORAGE

A. Materials shall be stored on-site in a manner consistent with the manufacturer's recommendations.

B. Damaged materials will not be used for installation.

PART 3 EXECUTION

3.01 INSTALLATION

A. The installer shall handle all geocomposite rolls in such a manner as to ensure they are not damaged in any way, and the following shall be complied with:

   The geocomposite shall be placed as shown on the plans and with the preferential flow direction (if any) perpendicular to the topographic contours. Wherever possible, the geocomposite shall be rolled down the slope over the "textured" LLDPE in such a manner as to continually keep the geocomposite in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles. The geocomposite cannot be placed in the horizontal direction (i.e., across the slope).

   In the presence of wind, all geocomposite rolls in place shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

   Installation of geocomposite shall be done in a manner to protect underlying geomembrane, as applicable. No cutting of geocomposite shall be allowed directly on geomembrane. Use of four- or six-wheel ATV's weighing less than 650 lbs may be permitted to operate directly over the geocomposite provided that they do not exceed a speed of 5 mph, and refrain from abrupt starts, stops and turns. If operation of ATV is not done in a manner to protect the geocomposite and the integrity of the geotextile, the

Engineer may prohibit their use, at no additional cost to the Owner, and require that damaged areas be repaired. Any other equipment used shall provide protection of the geomembrane and geocomposite and meet low ground pressure requirements.

B. When joining two pieces along the roll length, the geotextile filter fabric and net shall be lapped a minimum of 4 inches, and plastic ties shall secure the net at intervals no greater than every 5 feet. The bottom layers of the geotextile shall be overlapped, and the top layers shall be stitched along the entire length of the seam. Metallic ties are unacceptable. The composite shall not be welded to this geomembrane. Heat fusion of seams will not be allowed except at butt seams.

C. When joining two pieces end to end, the net shall be lapped a minimum of 12 inches and sewn or heat bonded to each other. Any exposed edge of geonet shall be covered with a continuous strip of geotextile (same as geocomposite), and heat bonded to the upper and lower layers of geocomposite.

D. Care shall be taken to keep the composite clean and free from debris prior to installation. If composite is not free of soil and debris before installation, it shall be cleaned by the Contractor just prior to installation. Geocomposite damaged during or prior to installation shall be removed and replaced at no additional cost to the Owner.

E. The Contractor shall sequence construction so that select sand or other geosynthetics can cover the geocomposite within 14 days of deployment. Areas that have been exposed for longer than 14 days shall be protected from UV degradation with an acceptable material (i.e., sacrificial geotextile, or opaque plastic).

F. The Contractor shall limit the dust accumulation on the upper geotextile after installation and prior to placement of select sand, stone or geosynthetics. Excessive dust accumulation, as determined by the Engineer, may require replacement of geocomposite materials.

3.02 REPAIR

A. Any holes or tears in the geocomposite shall be repaired by placing a patch extending a minimum of twelve (12) inches beyond the edge of hole or tear. The patch shall be secured by tying fasteners through the patch material and to the geotextile and geonet of the installed panel at a minimum spacing of 6 inches. A geotextile cap shall be heat bonded to the geotextile of the panel and patch shall extend a minimum of 6 inches beyond the patch.

3.03 PLACEMENT OF OVERLYING MATERIALS

A. The Contractor shall place all overlying sand, stone and geosynthetic materials in a manner so that the underlying material is not damaged, excessive stresses are not introduced, and wrinkles are minimized.

B. Contractor shall utilize hand placement of materials or casting of materials in advance of dozer grading of cover soils or stone to minimize wrinkles and to prevent geocomposite from folding over on itself.

END OF SECTION

# SECTION 02275
# NON-WOVEN GEOTEXTILE FILTER FABRIC

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## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Furnishing and installation of non-woven geotextile filter fabric.

### 1.02 RELATED REQUIREMENTS

A. Section 02232 - Stone Fill

### 1.03 QUALITY CONTROL

A. Provide the manufacturer's certification that the geotextile filter fabric has been manufactured and successfully tested in accordance with the appropriate ASTM standards.

## PART 2 PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

A. Propex Geosynthetics

B. Skaps Industries

C. TNS Advanced Technologies

D. Approved Equivalent

### 2.02 GEOTEXTILE FILTER FABRIC

A. The filter fabric shall consist of non-woven continuous filament fibers which are formed into a sheet by heat bonding. It shall be tear resistant and be capable of conducting water. Fabric materials provided shall be 12oz. beneath NHDOT “C” Stone and 16 oz. beneath NHDOT Rip Rap, or as indicated on the Drawings.

B. The fabric shall retain its durability and strength when it is wet and shall be non-biodegradable.

C. The fabric shall be capable of withstanding direct exposure to sunlight for 30 days without measurable deterioration.

D. The filter fabric shall have the following minimum physical properties as determined by the appropriate test method:

| Physical Property | Test Method | Minimum Average Roll Value | |
|---|---|---|---|
| Fabric Weight | ASTM D5261 | 12 oz./S.Y. | 16 oz./S.Y. |
| Water Flow Rate (through fabric) | ASTM D4491 | 70 gpm/S.F. | 50 gpm/S.F. |
| Grab Strength (Weakest Principal direction) | ASTM D4632 | 300 lbs. | 380 lbs. |
| Grab Elongation (Weakest principal direction) | ASTM D4632 | 50% | 50% |
| Trapezoid Tear (Weakest principal direction) | ASTM D4533 | 155 lbs. | 140 lbs. |
| CBR Puncture Resistance | ASTM D6241 | 850 lbs. | 1000 lbs. |
| Apparent Opening Size | ASTM D4751 | Sieve Size #70 | Sieve Size #70 |

PART 3 EXCECUTION

3.01 INSTALLATION

A. Fabric shall be hand placed in all locations as shown on the Plans, and where specified. The fabric shall be deployed on slopes in continuous lengths, parallel to slope direction.

B. When jointing two pieces, the filter fabric shall be lapped a minimum of 18 inches, shingled to shed water and heat bonded together.

C. Filter fabric damaged during or prior to installation or during placement of overlying soil or stone shall be removed and replaced at no additional cost to the Owner.

END OF SECTION

# SECTION 02276
# LINEAR LOW-DENSITY POLYETHYLENE (LLDPE) LINER

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Furnishing of Textured 40-mil LLDPE liner

B. Quality Control for liner materials

C. Field installation of the liner

### 1.02 RELATED REQUIREMENTS

A. Section 01400 - Quality Assurance/Quality Control

B. Section 01720 - Project Record Drawings

C. Section 02223 – Filling

D. Section 02231 – Select Aggregates

E. Section 02232 - Stone Fill

F. Section 02234 - Select Sand

G. Section 02273 - Drainage Geocomposite

### 1.03 OPERATIONAL CONDITIONS

The LLDPE geomembranes will be subjected to operating temperatures of no less than -15°C (5°F) and up to 60°C (140°F). The physical properties of the proposed geomembrane shall be thoroughly reviewed to ensure long-term performance.

### 1.04 APPLICABLE STANDARDS, CODES AND REGULATIONS

Unless otherwise specified, workmanship and materials for the construction of the earthworks and associated geomembranes work shall be in accordance with the requirements of the relevant Federal, State and Local Regulations and other Regulatory Authority requirements, as applicable.

Latest editions of published Codes & Standard, including any other standards referenced therein, shall apply as of the date of issue of this Technical Specification. Where any conflict occurs between mandatory regulations, standards and codes, and other regulatory authority requirements, the most stringent requirement shall apply.

#### 1.04.1 STANDARDS AND CODES

A. ASTM D792 Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

B. ASTM D1004 Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

C. ASTM D1204 Standard Test Method for Linear Dimensional Changes of Non rigid Thermoplastic Sheeting or Film at Elevated Temperature.

D. ASTM D1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

E. ASTM D1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique.

F. ASTM D1603 Standard Test Method for Carbon Black Content in Olefin Plastics.

G. ASTM D3895 Standard Test Method for Oxidation Induction Time of Polyolefin by Differential Scanning Calorimetry.

H. ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle Furnace Technique.

I. ASTM D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

J. ASTM D5199 Standard Test Method for Measuring Nominal Thickness of Geosynthetics

K. ASTM D5323 Standard Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes.

L. ASTM D5596 Standard Test Method for Microscopic evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

M. ASTM D5617 Standard Test Method for Multi-Axial Test for Geosynthetics.

N. ASTM D5721 Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.

O. ASTM D5820 Standard Practice for Pressurized Air Channel Evaluation Testing of Dual Seamed Geomembranes.

P. ASTM D5885 Test Method for Oxidation Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.

Q. ASTM D5994 Standard Test Method for Measuring the Core Thickness of Textured Geomembranes.

R. ASTM D6392 Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

S. ASTM D6693 Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes.

T. ASTM D7238 Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.

U. ASTM D7240 Standard Practice for Leak Location using Geomembranes with an insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test).

V. ASTM D7466 Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

W. GRI GM6 Pressurized Air Channel Test for Dual Seamed Geomembranes.

X. GRI GM9 Cold weather Seaming of Geomembranes.

Y. GRI GM11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA Condensation Exposure Device.

Z. GRI GM14 Selecting Variable Intervals for Taking Geomembrane Destructive Seam samples Using the Method of Attributes.

AA. GRI GM17 Test Properties, Testing Frequency and Recommended Warranty for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.

BB. GRI GM19 Standard Specification for Seam Strength and Related Properties of

Thermally Bonded Polyolefin Geomembranes.

1.05 QUALITY SYSTEMS REQUIREMENT

The Engineer reserves the right to inspect the materials and workmanship at any time. Materials or workmanship found not conform to this Specification may be rejected during the execution of the work. The Contractor shall be responsible for the removal and replacement of any work that is rejected, including any other work damaged as a result.

1.06 QUALIFICATIONS

A. Manufacturer Qualifications

The liner manufacturer shall have at least five (5) years continuous experience in the manufacture of polyethylene geomembranes and/or experience totaling 10,000,000 sq. ft. of manufactured polyethylene geomembrane within the past year. The manufacturer shall permit the owner or his authorized representatives to visit the manufacturing plant.

B. Liner Installer

Installation shall be performed according to IAGI Installation Specification.

The Geomembrane Installer shall have installed a minimum of 10 projects involving a total of 5,000,000 ft2 of LLDPE or similar geomembrane product during the last 3 years.

The liner installer shall have successful experience in the installation of LLDPE sheet using the dual hot wedge seaming method on projects with similar requirements to this project; and which is acceptable to or licensed by the manufacturer of the primary materials for the installation of these materials.

(a) Supervisor

Installation shall be performed under the direction of a single competent English speaking installation supervisor who shall remain on-site and be in responsible charge throughout the liner installation, including subgrade acceptance, liner layout, seaming, testing and repairs, and all other related activities. The installation supervisor shall have supervised the installation of at least 5,000,000 sf of polyethylene geomembrane.

(b) Master Seamer

The Geomembrane Installer shall provide a minimum of one Master Seamer for work on the project. The Master Seamer must have completed a minimum of 3,000,000 ft2 of geomembranes seaming work using the type of seaming apparatus proposed for the use on this Project. The Master Seamer may be the same person as the Supervisor. The installation supervisor or master seamer must be on-site whenever seaming is being performed.

(c) Quality Control

The Contractor shall establish a Quality Control (QC) Representative who shall be responsible in the field for the quality and integrity of the LLDPE liner installation. This responsibility shall include the inspection, testing, and documentation of all liner installation work as performed by the installer. The QC Representative shall have performed these duties on a minimum of 3,000,000 sf of LLDPE membrane installation.

C. Laboratory

The Engineer shall engage a qualified, independent laboratory acceptable by the Owner for use in completing the off-site tests of destructive samples specified herein.

Results of independent laboratory testing shall be transmitted directly from the lab to the Engineer and Contractor as soon as the data is available.

D. Contractor Responsible for Subcontractors

The roles of any subcontractor shall not relieve the Contractor of any responsibilities whatsoever under this contract. The Contractor shall be responsible for the actions and performance of the manufacturer, installer, supervisor, and QC representative under this contract. A Contractor's representative shall be on-site during all geomembrane installation activities

1.07 SUBMITTALS

A. Prior to release of the geomembrane for shipment to the job site, the Contractor shall submit the following to the ENGINEER:

1. Written certification that the material was manufactured and tested in accordance with the requirements of GRI-GM17.

2. Quality control certificates for each batch of resin and production of geomembrane in accordance with the testing requirements of GRI-GM17.

3. Quality control certificates shall be signed by the responsible Quality Assurance (QA) personnel employed by the Manufacturer.

4. Conformance testing shall be performed in accordance with the requirements and standards specified in GRI-GM17 and as specified herein for the LLDPE membrane and its installation. Certificates of compliance shall be submitted for each roll to be used on the project prior to its release for shipment to the job site. Certificates of Compliance for LLDPE welding rod to be used on the project shall be submitted.

5. Shop Drawings showing the following:

a. Proposed layout of the LLDPE membrane system.

b. Details of jointing the LLDPE membrane, anchoring, penetrations, repair, testing, areas of slack for anticipated thermal contraction.

6. Manufacturer's completed projects resume.

7. Installer's completed project resume.

8. Installer's crew identification list and resumes.

9. Installation schedule.

10. Manufacturer's and installer's warranty as described in Part 1.07.

11. The Contractor shall provide representative samples of the proposed geomembrane to the Engineer to complete direct shear box testing of the proposed 40-mil textured LLDPE geomembrane and select sand to demonstrate compliance of interface friction as required in Section 02223 (Filling).

12. The Engineer shall complete direct shear box testing of the proposed 40-mil textured LLDPE geomembrane and drainage geocomposites to demonstrate compliance of interface friction as required in Section 02273 (Drainage Geocomposite).

B. Roll Identification:

1. Each roll shall have a permanently affixed label with the following information:
   a. Name of manufacturer
   b. Date of manufacture
   c. Thickness of material (actual)
   d. Roll number
   e. Roll length
   f. Roll width

C. Record Drawings and QC Reports (See Parts 3 and 4)

1.08 QUALITY ASSURANCE

A. General:

Quality of the liner installation shall be the responsibility of the Contractor. The Contractor, in fulfilling this responsibility, will be assisted by his designated Manufacturer, Installer, and QC representative. The Contractor will be responsible for performing the Quality Assurance/Quality Control tasks outlined herein. The Engineer may conduct additional independent testing and inspections. These actions will not remove any responsibility of the Contractor under this Contract.

B. Lines of Authority:

The Contractor shall establish an Installation Supervisor and a QC Representative who will assist the Contractor in his responsibilities in the quality of the liner installation. The QC Representative shall assist in coordinating the timing and sequencing of liner installation and testing with the Engineer.

C. Manufacturer QC Documentation:

All materials must strictly comply with the requirements of this Specification. For all materials, a Manufacturer QC documentation shall be provided to the Engineer before the materials are to be installed.

The Manufacturer QC documentation shall include, but is not limited to, the following:

- Roll Number;
- Resin Lot;
- Product Code;
- Manufacturing Date;
- Roll Length;
- Roll Test Data Report;
    - Average Thickness (ASTM D5994)
    - Minimum Thickness (ASTM D5994)
    - Asperity Height (ASTM D7466)
    - Tensile Properties (ASTM D6693)
    - Tear Resistance (ASTM D1004)
    - Puncture Resistance (ASTM D4833)
    - Density (ASTM D1505)
    - Carbon Black Content (ASTM D4218)
    - Standard Oxidative Induction Time (ASTM D3895) or
    - High Pressure Oxidative Induction Time (ASTM D5885)
    - Oven Aging at 85°C, % Retained after 90days (ASTM D5885)
    - UV Resistance, % Retained after 1600hours (ASTM D7238 / ASTM D5885)

1.09 MATERIAL AND WORKMANSHIP WARRANTY

A. Contractor shall provide a written material warranty signed by the Manufacturer and a workmanship warranty signed by the Installer, both for the repair/replacement of defective materials and workmanship characterized by leakage, abnormal aging or deterioration of materials, and other failures of the flexible membrane to perform as required. The specified warranty period is ten (10) years for materials and two (2) years for workmanship after date of final acceptance. The terms and conditions of the warranties are presented in Exhibits D and E to the Agreement.

B. The warranty shall be a direct warranty from the Manufacturer (or Installer as the case may be) to the Owner. The warranties shall be signed and presented to the Owner prior to Substantial Completion. No payment over 90 percent of all payments to be due under the appropriate payment items for LLDPE liner shall be made until the warranties, in their

correct form hereunder, are received and approved by the Owner.

1.10 SUBGRADE CERTIFICATION

A. Prior to installation of liner materials, the Contractor shall submit a certification, signed also by the installer, that they have inspected the subgrade and accept the conditions for liner installation.

1.11 GEOMEMBRANE PRE-CONSTRUCTION MEETING

A. As soon as practical after the Contractor mobilizes the installation crew, but before any installation activities occur, a specific pre-construction conference shall be held.

The following persons shall be present:

1. Engineer Project Manager and Resident Engineer
2. General Contractor and Superintendent
3. Engineer Subconsultant QA Representative (if applicable)
4. Geomembrane Installer Site Superintendent and Quality Control Representative
5. Affected Subcontractors

B. Agenda:

1. Introductions and Explanation of Roles
2. General Overview of Specifications and Plans
3. Review Proposed Installation Schedule
4. Review of Installer/Contractor QC Procedures
5. Review of Engineers QA Procedures
6. Destructive Test Sites
7. Leak Location Survey
8. Review of Contractor Personnel - Roles and Responsibilities
9. Reports and Record Drawing Information
10. Site Cleaning

PART 2 MATERIALS

2.01 GENERAL

Geomembrane shall be Agru MicroSpike® 40-mil LLDPE or approved equivalent.

All materials must strictly comply with the requirements of this Specification. For all materials, a Technical Data Sheet with the required testing shall be provided to and approved by the Engineer before the materials are to be installed.

The Contractor shall allow sufficient time for the Engineer to review the certified test results provided to not impact the geomembrane delivery schedule.

Materials not protected against solar radiation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. Materials and equipment damaged prior to, and during installation shall not be used and must be replaced at the Contractor's expense.

Production samples of materials shall be provided to the Engineer and will be held throughout the period of the contract for the purpose of providing a reference against which all subsequent items may be gauged for compliance with this Specification.

The LLDPE geomembrane shall be a new, first-quality product designed specifically for the purpose of hydraulic containment and of the thickness specified. The membrane shall be uniform, free of holes, blisters, bubbles, gels, nicks, cuts, undispersed raw materials, or any sign of contamination by foreign matter.

The rolls shall be handled and stored with care to prevent any damage to the geomembrane. During the transport of the material from the manufacturing plant to site and storage of the geomembrane rolls on site, the geomembrane shall not be stacked higher than 3 rolls high.

## 2.02 GEOMEMBRANE MATERIAL

The geomembranes shall be comprised of Linear Low Density Polyethylene (LLDPE) and shall meet the required physical, mechanical and endurance properties shown in Table 5 (below).

Table 5: 40-mil LLDPE Geomembrane (Textured) Technical Properties

| Property | Test Method | Frequency(1) | Unit | Test Value |
|---|---|---|---|---|
| Thickness (min.avg) | ASTM D5994 | Every Roll | mils | 40 |
| Thickness (min) | | | | 40 |
| Asperity Height(3) (min.avg) | ASTM D7466 | Every Roll | mils | 20 |
| Resin Density | ASTM D1505 | 1/Batch | g/cm³ | <0.92 |
| Melt Index (max) | ASTM D1238 | 1/Batch | g/10min | 1 |
| Sheet Density(8) | ASTM D1505 | Every 10 Rolls | g/cm³ | <0.939 |
| Carbon Black Content(9) | ASTM D4218 | Every 2 Rolls | % | 2-3 |
| Carbon Black Dispersion | ASTM D5596 | Every 6 Rolls | Category | 1&2 |
| OIT - Standard (avg) | ASTM D3895 | Per Formulation | min | 140 |
| Tensile Properties (min.avg)(2) | ASTM D6693 | Every 2 Rolls | | |
| Strength at Break | | | ppi | 112 |
| Elongation at Break | | | % | 400 |
| Tear Resistance (min.avg) | ASTM D1004 | Every 5 Rolls | lbf | 25 |
| Puncture Resistance (min.avg) | ASTM D4833 | Every 5 Rolls | lbf | 50 |
| Dimensional Stability | ASTM D1204 | Certified | % | ± 2 |

Notes:
(1) Testing Frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar)
(2) Machine Direction (MD) and Cross Machine Direction (XMD or TD) average value should be on the basis of 5 specimens each direction.
(3) ASTM D7466 is identical to GRI-GM12.

(8) Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
(9) Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.
(10) Condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. Condensation at 60°C.
(11) UV Resistance is base on percentage retained value regardless of the original HP-OIT value.
*All values are nominal test results, except when specified as minimum or maximum.

## 2.03 GEOMEMBRANE MANUFACTURING QUALITY CONTROL

The geomembrane shall be monitored throughout the manufacturing process for product integrity and consistency. The manufacturer shall test rolls in accordance with Table 5 (above) with results showing conformance with the required physical properties listed in Table 5 (above).

Certified test results shall be submitted to and approved by the Engineer before the LLDPE geomembrane rolls are to be installed from the manufacturing plant. The Geomembrane Installer shall allow sufficient time for the Engineer to review the certified test results provided to not impact the geomembrane delivery schedule.

The Geomembrane Installer shall submit a list which indicates date of production, resin batch number, manufacturing line number and identification number and square feet of each geomembranes roll. Rolls shall be listed in the order of production with the status of the roll (rejected or approved for shipment). All rolls shall be included in the list whether or not approved for shipment.

Any roll(s) that do not meet the required physical properties or have not been tested at the required frequency Table 5 shall be rejected and removed from site.

## 2.04 LLDPE RESIN

Resin used in the manufacture of LLDPE geomembranes shall be first quality single source, compounded polyethylene resin manufactured specifically for the purpose of producing LLDPE geomembranes.

Reclaimed polymer shall not be added to the resin. The manufacturer may rework its own pre-consumer material from the rolls being produced. Reworked material from the same formulation as the parent material shall not exceed 10% of the total resin required.

The manufacturer shall sample and test for the properties listed in Table 6 (below) per batch resin. Certified test results shall be submitted to and approved by the Engineer before the LLDPE geomembrane rolls are to be installed. The Geomembrane Installer shall allow sufficient time for the Engineer to review the certified test results provided to not impact the geomembrane delivery schedule.

Table 6: Resin Physical Properties

| Property | Test Method | Unit | Test Value |
|---|---|---|---|
| Density(1) | ASTM D1505 | g/cm³ | <0.915 |
| Melt Flow Index | ASTM D1238 | g/10 min. | <1 |

Notes:
(1) Base resin density without carbon black added.

## 2.05 EXTRUDATE MATERIAL

The extrudate rod or bead shall be high quality polyethylene and shall be of the same resin type as the resin used to produce the geomembranes. All additives shall be thoroughly dispersed

throughout the extrudate rod or bead. There shall be no contamination by foreign matter in the extrudate rod or bead.

2.06 ROLL IDENTIFICATION

Geomembrane shall be supplied in rolls of width accordance to the product Technical Data Sheet in Table 5. The rolls supplied should not allow any longitudinal seams. As a minimum, each roll shall be labeled as follows:

- Roll Number;
- Name of Manufacturer;
- Batch Number of Raw Material;
- Date of Manufacture;
- Material Thickness;
- Roll Length and Area;
- Product Type and Grade.

Rolls will need to have permanent marking every 16 feet along the smooth edges that include, as a minimum, the following information:

- Roll Number;
- Distance from start of the roll (in feet or meters).

2.07 DELIVERY

Rolls of geomembrane will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

2.08 STORAGE

The on-site storage location for geomembrane rolls, provided by the Contractor to protect the geomembranes from puncture, abrasion and excessive dirt and moisture should have the following characteristics:

- Level (no wooden pallets);
- Smooth;
- Dry;
- Protected from theft and vandalism;
- Adjacent to the area to be lined.

The rolls shall be handled and stored with care to prevent any damage to the geomembrane. During the transport of the material from the manufacturing plant to site and storage of the geomembrane rolls on site, the geomembrane shall not be stacked higher than 3 rolls high.

2.09 HANDLING

Materials are to be handled to prevent damage.

2.10 SAMPLES

The Contractor shall submit samples of the geomembrane material and field seams to the Engineer for approval prior to the start of construction. The Contractor shall submit 8.5''x 11'' samples of geomembrane materials which have been made in conformance with this Specification.

2.11 GEOMEMBRANE WARRANTY

The Contractor shall provide warranties for the geomembrane manufacturing and geomembrane installation in accordance with this specification.

2.12 MATERIAL WARRANTY

The geomembrane manufacturer shall furnish a written geomembrane warranty, which warrants the geomembrane material for a minimum of ten (10) years from the date of installation and final acceptance of the geomembrane.

The warranty shall be against manufacturing defects and workmanship. The warranty shall be limited to replacement of material only and shall be pro-rated.

2.13 INSTALLER WARRANTY

The Geomembrane Installer shall guarantee the geomembranes installation against defects in the installation and workmanship for two (2) years, commencing with the date of final acceptance of the geomembrane. A written geomembrane warranty will be required.

PART 3 SUBGRADE INSTALLATION

3.01 SUBGRADE PREPARATION

The Geomembrane Installer shall ensure that all surfaces to be lined including corners and around penetrations shall be finished smooth and free of rocks, stones, sticks, roots, sharp objects and debris of any kind or any object which may damage the geomembrane. The surface is to provide a firm unyielding compacted subgrade for the geomembrane. All desiccation cracking shall be repaired by the Contractor to the satisfaction of the Engineer.

Where a suitable surface cannot be achieved by treatment of in-situ material, an imported smoothing fine course shall be placed. The smoothing fine course shall consist of sandy clay which shall be free of organic matter and coarse or sharp particles. The smoothing course shall be the minimum thickness necessary to maintain 6'' minimum cover over irregularities or protrusions in the sub-grade formation unless shown otherwise on the Drawings. The surface shall be watered and rolled with a smooth steel drum roller to obtain a smooth uniform finish.

The Geomembrane Installer shall provide daily written subgrade acceptance certifications to the Engineer for the surface to be covered by the geomembranes in that day's operation. The surface shall be maintained in a manner, during installation, to ensure subgrade stability.

All subgrade damaged by construction equipment and deemed unsuitable for geomembranes deployment, in the opinion of the Engineer, shall be repaired prior to placement of the geomembranes. All repairs shall be approved by the Engineer.

Surfaces to be lined shall be flat on any plane within ± 2'' vertical tolerance in any area of 100 ft2. All intersections between planes shall be made along straight lines.

3.02 SUBGRADE MAINTENANCE

Where surface finishing is completed ahead of geomembrane installation, the surface shall be maintained until immediately prior to geomembrane installation. This surface will need to be re-inspected again by the Engineer and approved prior to installation of the geomembrane. Sufficient

equipment shall remain on the site until and during installation to enable reinstatement of the surface in the event of damage due to inclement weather or desiccation cracking. Any reinstatement work shall be at the expense of the Contractor. The Engineer reserves the right to instruct the Contractor to perform remedial work to satisfy the criteria.

## PART 4 GEOMEMBRANE INSTALLATION

### 4.01 GENERAL

Geomembrane installation shall be performed in accordance with the International Association of Geosynthetic Installers (IAGI) HDPE and LLDPE Geomembrane Installation Specification. Where there is discrepancy between the IAGI HDPE and LLDPE Geomembrane Installation Specification and this Specification, this Specification shall govern.

Rolls of geomembrane shall be handled and securely stored to prevent damage prior to installation. Geomembrane shall be unrolled in a controlled manner directly into the final position. The method of unrolling shall not cause scratches or crimps in the material, nor shall it disrupt the integrity of the finished sub-grade.

The geomembrane shall be placed in a relaxed state such that the material can respond to thermal changes without excessive buckling, wrinkling, or tensioning. Slack shall be included in the geomembrane on the batter side of the tie-in seam along the toe of all internal slopes. The included slack at the tie-in seam will minimize tension on the tie-in seam due to contraction of the geomembrane at temperatures cooler than ambient during installation.

For material temperatures between 5°F and 32°F, the deployment and seaming will be performed in accordance with GRI GM9. No geomembranes material shall be unrolled or deployed if the material temperatures are lower than 5°F, unless otherwise approved in writing by the Engineer. Only the quantity of geomembranes that will be anchored and seamed together in one day shall be deployed.

In general, seams shall be orientated parallel to the line of maximum slope. In corners and odd shaped geometric locations, the total length of the field seam shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations as approved by the Engineer.

All LLDPE panels that are to be welded together shall be manufactured by the same geomembrane manufacturer, made from the same resin type and made using the same formulation. Adjacent LLDPE panels that do not satisfy all of these requirements shall not be welded together. Any panels welded together that violate any of these criteria shall be rejected and removed from site at the Geomembrane Installer's expense.

The geomembranes shall not be allowed to "bridge" over voids or low areas in the subgrade. The geomembranes shall rest in intimate contact with the subgrade.

Temporary ballasting such as sandbags or tires shall be placed on the geomembrane to prevent wind damage during and after installation. It should be noted that this temporary ballasting shall be of a suitable construction to prevent against damage of the geomembrane. The Contractor shall be required to ensure that the spacing of these sandbags / tires are appropriately designed (this could include tying the sandbags / tires together in a horizontal and vertical direction) to prevent against uplift and potential damage of the geomembrane. Any geomembrane material that has

been damaged as the result of the wind, in the opinion of the Engineer, shall be removed and replaced at the Contractor's expense.

All personnel working on the geomembrane surface shall wear soft-soled shoes and shall not engage in any activity which may damage the geomembrane.

Machinery, other than seam welding machinery or All-Terrain Vehicles (ATV) approved for use by the Engineer in writing, shall not be operated on the geomembrane.

The use of ATVs for the deployment of the geomembrane will be allowed. For ATVs to be used, the Contractor must demonstrate that the ATV exerts a maximum allowable pressure on the ground surface (or geomembrane surface) of 8 psi. The maximum allowable pressure on the ground surface (or geomembrane surface) is influenced by the tread pattern of the tires on the ATV. The maximum allowable ground surface (or geomembrane surface) pressure is not the reading from a tire pressure gauge. The ATVs shall only be used to deploy rolls of geomembrane and shall not be used to transport personnel, equipment, sandbags, or the like.

Equipment used for placing and compacting the sand blanket or stone fill shall not be driven directly on the geomembrane or composite. Such equipment shall be closely monitored during placement to ensure that no damage occurs to the geomembrane or composite.

A minimum thickness of 12 in of select sand or stone fill cover shall be maintained between the geomembrane and drainage geocomposite and earth moving equipment. Only low ground pressure (LGP) tracked vehicles, having a maximum ground pressure of 4.7 psi shall be used at the minimum thickness.

For calculating equivalent ground pressure for non-LGP equipment operating on top of greater thicknesses, equivalent ground pressure shall be calculated at 12 in above the liner surface and shall meet LGP.

In all cases, the placement of sand blanket or stone fill shall be done with caution and in a manner least likely to cause wrinkles in, or damage to, the geomembrane and composite. To eliminate wrinkles, significant methods must be employed including but not limited to use of hand labor and equipment to cast and place sand.

Drainage sand, stone fill and topsoil materials shall be placed upslope or laterally on slopes greater than 5H:1V.

## 4.02 SEAMING

### A. General

Seaming of geomembranes shall be carried out strictly in accordance with the manufacturer's written instructions and in accordance with GRI GM19. The contractor shall provide a complete description of the processes to be used and shall identify the equipment proposed for accomplishing the seaming.

No geomembranes material shall be seamed when the sheet temperature is below 5°F and above 170°F as measured by an infrared thermometer (or surface thermocouple), unless otherwise approved by the Engineer. For material temperatures between 5°F and 32°F, seaming shall be performed in accordance with GRI GM9.

B. Personnel

The Contractor shall nominate a Project Seam Welding Supervisor before commencing work and shall demonstrate that the Seam Welding Supervisor has a proven background in installation of similar lining systems and materials to those specified. All personnel employed in welding shall be competent and experienced in the use of the equipment. The Contractor shall ultimately be responsible for ensuring the quality assurance program is followed.

C. Seam Welding Equipment

Only specialized purpose-designed equipment approved by the Engineer shall be used. For long-run work, the machine shall be mounted on a carriage to operate at a controlled speed. In all cases, the temperature at the point of fusion shall be monitored and controlled with an interlock to the drive mechanism so that welding is stopped if the temperature falls outside the range at which satisfactory welding can be achieved.

Where the welding procedure includes provision for heated extrudate to be incorporated in the weld, any degraded extrudate, which has been overheated or heated and cooled in the barrel, shall be purged with fresh material prior to the resumption of welding.

Equipment shall be maintained on a regular basis to ensure efficient performance throughout.

The field tensiometer shall have a current certificate of calibration in accordance with the manufacturer's calibration recommendations.

D. Seam Strength Requirements

Each test specimen should fail in the parent material and not in the weld as demonstrated by test welds and destructive test samples in accordance with Part 5: Geomembrane Inspection & Testing. Breadth and depth of fusion between sheets shall be as required to meet these criteria. Where heated extrudate is included in the weld, the extrudate material after fusion shall be fully compatible physically and chemically with the geomembrane material.

The geomembrane material shall not be overheated during welding such that crystallization, oxidation, perforation, or degradation of the geomembrane occurs.

E. Weather Conditions

Welding shall not be commenced or continued during rain, fog, excessive winds, snowing, sleeting, or hailing. Welding shall not be commenced or continued when ambient temperatures (as measure 3' above the seam being welded) is outside the range of 5°F to 100°F. When ambient temperatures are between 5°F and 32°F, seaming shall be performed in accordance with GRI GM9.

The seams adjacent to the corners of the ponds and the toe of the slopes shall be made during the coolest part of the day and shall not be made when the geomembrane is exposed to direct sunlight.

F. Geomembrane Preparation

The surface of the geomembrane to be welded shall be clean, dry and free from any foreign matter and contaminants, such as clay and sand.

G. Seam Lap

The minimum lap of adjacent geomembrane sheets shall be 6'', unless specified as greater by the geomembrane manufacturer or the welding equipment supplier.

Fishmouths, or excessive wrinkles at the seam overlap, shall be minimized. When necessary, cut along the ridge of the wrinkles back into the panel to create a flat overlap. The cut shall be terminated with a keyhole cut (nominal 0.5'' diameter hole) to minimize crack/tear propagation. The overlay shall subsequently be seamed. The keyhole cut shall be patched with an oval or round patch, of the same base geomembrane material extending a minimum of 6'' beyond the cut in all directions.

H. Fusion Welding (Primary Welds)

Seam welding of LLDPE geomembranes shall be accomplished primarily by fusion welding using either a hot wedge or hot air welder.

Geomembrane surface area to be fusion welded must be cleaned from dust, mud, debris and shall be protected against moisture build-up between sheets.

The seam shall consist of a double weld produced by surface fusion with an air gap between. Pressure nipping rollers shall press the molten surfaces together immediately behind the hot air or hot wedge welder to complete the weld.

All seams shall be labeled on the geomembrane with the following information:

1. Machine identification number
2. Operator, date, time
3. Direction of travel of seaming equipment
4. Date of testing and results

I. Extrusion Welding (Secondary Welds)

Extrusion welding shall only be used where fusion welding is not possible, such as at pipe penetrations, patches, repairs, and short runs of seams (less than a roll width).

Geomembrane surface area to be extrusion welded must be cleaned by using disc grinder or equivalent to remove the oxidized layers and dirt. The leading edge of the upper geomembrane needs to be beveled or tapered to a 45° angle and the bottom geomembrane grind marks shall be about 5% of the liner thickness.

Extrusion welding shall be achieved by fusion of an extrudate to the top surface of both sheets at the lap. The depth and width of engagement of the extrudate shall be as required to achieve the strength requirements. The means of deposition of the extrudate shall provide for full integration with the surface of the sheets, so that the weld becomes homogeneous with the geomembrane.

All seams shall be labeled on the geomembrane with the following information:

1. Machine identification number
2. Operator, date
3. Direction of travel of seaming equipment
4. Date of testing and results

J. Connections at Penetration and to Structures

Connections to geomembrane penetrations and adjoining structures shall be made in accordance with the details shown on the construction drawings. Connections shall be at least equivalent in strength to the normal lap seams and the security of containment shall not be diminished. Local stresses in the geomembrane at connections shall be minimized.

Penetrations shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown in the construction drawings.

K. Geomembrane Anchorage

Anchor trenches shall be excavated in accordance with the details on the construction drawings. The anchor trenches shall be kept well drained to avoid softening during rain periods and maintained to not dry, desiccate and crack.

The Contractor shall seek approval from the Engineer prior to the commencement of anchor trench backfilling. Backfilling shall be carried out in planned, logical sequence to avoid overstressing of the geomembrane. The front edge of the anchor trench will be rounded, with no sharp stones that might damage the liner. The backfill material shall be compacted to prevent future settling.

L. Cleaning Up

On completion of the work on site, the Contractor shall clean up and leave the whole area to the satisfaction of the Engineer.

## PART 5 GEOMEMBRANE INSPECTION, TESTING & REPAIR

All areas found to be defective shall be repaired at the expense of the Geomembrane Installer. The Engineer shall be notified of defective areas prior to the repair taking place.

The Geomembrane Installer shall ensure a plan is marked up showing the locations of repairs made and the type of repair made. The Geomembrane Installer shall submit a marked-up drawing showing the locations of the repairs to the Engineer for review and approval.

### 5.01 VISUAL INSPECTIONS

The entire surface of every sheet of geomembrane material shall be inspected by the Geomembrane Installer during placing to identify any tears, abrasions, indentations, cracks, thin areas, or other defects.

Any defects such as holes, tears, blisters, lamination, undispersed raw materials or visible non-uniformity or contamination by foreign matter which in the opinion of the Engineer is detrimental

to the long service life required of the membrane geomembrane, shall be grounds for rejection of the membrane geomembrane material.

Where additional faults are found, the Engineer reserves the right to reject the roll. The Contractor shall replace any rejected rolls and repair any defects to the Engineer's satisfaction at the Geomembrane Installer's expense.

5.02 SEAM TESTING

All geomembrane weld seams shall be subjected to both non-destructive and destructive field testing. Additionally, representative samples of field seams shall be taken for laboratory testing by an independent, appropriately qualified geosynthetic testing laboratory.

The tests in this Section shall be carried out at the specified frequencies.

Testing of each length of seam shall be carried out within 48 hours of its completion.

The acceptance criteria for peel and shear strength testing shall be in accordance with GRI GM19.

Site Test Equipment: The Contractor shall maintain on -site, in good working order, the following items:

1. Field Tensiometer

    a. The tensiometer shall be motor driven and have jaws capable of traveling at a measured rate of 2 in/min.
    b. The tensiometer shall be equipped with a gauge which measures the force in unit pounds exerted between the jaws.
    c. The tensiometer shall be calibrated and certified for use on this project. A copy of the calibration certificate shall be submitted to the Engineer.

2. Coupon Cutter

    A die cutter machined to cut 1"x5" liner sample coupons for field testing shall be provided and maintained in good working condition.

3. Vacuum Box

    a. The vacuum box shall consist of a rigid housing with a transparent viewing window on the top and a soft, closed-cell neoprene gasket completely attached to the bottom of the housing.
    b. The housing shall be equipped with a bleed valve.
    c. A separate vacuum source shall be connected to the vacuum box such that a negative pressure of 2 - 3 psi (5" - 6" mercury) can be created and maintained inside the box.
    d. A solution consisting of soap and water shall be dispensed on the seam immediately ahead of the vacuum box.
    e. Vacuum box testing shall not proceed when temperatures are below 32°F.

4. Air Pressure Test Equipment - This method shall apply when the split hot wedge seaming method is used.

a. Equipment shall consist of an air pump capable of generating and maintaining a positive pressure of between 20 and 30 psi.
b. A manometer capable of reading up to 30 psi attached to a needle or nipple shall be used to pressurize the air channel in the seam.

A. Test Welds (In Field)

Test seams shall be made by each welding technician and tested in accordance with ASTM D6392 at the beginning of each seam period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seams. The test seam shall be approximately 6 feet long for fusion welding and 3 feet long for extrusion welding with the seam centered lengthwise.

At a minimum, trial welds shall be made by each technician as follows:

- Prior to commencement of each shift;
- One time every 4 hour thereafter;
- Following any break in operation;
- Following any significant adjustment to welder controls.

Additional tests may be required with changes in environmental conditions.

Two 1-inch-wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and direct shear strength tests.

The test weld will be considered acceptable if the test piece fails in the un-welded geomembrane away from the seam. If the field test fails, further test welds shall be made after appropriate adjustment of the welder controls and retested until an acceptable weld is obtained. Field test results shall be recorded, and test pieces marked and stored. The Engineer reserves the right to take further test pieces from the test welds for independent tests off-site.

Testing shall be conducted on three specimens for peel strength, and two specimens for shear strength.

B. Test Weld Strength Requirements

Prior to field testing a test weld, a representative specimen from the parent material on the upper and lower section of geomembrane used to conduct the test weld shall be collected and tested on the field tensiometer. The resulting strength shall be used as a benchmark for the criteria used to measure passing weld specimens.

Welds shall be considered passing when 100% of welds fail at locations away from the weld with a strength equal to or greater than 90% of parent strength in shear and 60% of parent strength in peel.

C. Non-Destructive Testing (In Field)

All seams shall be non-destructively tested in accordance with the following sections.

Air Pressure Testing

Double fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D5820 and ASTM D4437. Every geomembrane seam shall be subjected to air pressure testing. The testing shall be achieved by inflation of the space between the welds to approximately 30 psi pressure and following the 2 minute "relaxing period" (whereby the air temperature and pressure stabilizes), the air pressure will be monitored 5 minutes and the pressure loss recorded. If pressure loss does not exceed 4 psi after 5 minutes, the seam shall be considered leak tight and therefore considered to be acceptable.

Vacuum Testing

For single welded seams testing shall be achieved using vacuum testing. Vacuum testing shall be performed by the Geomembrane Installer in accordance with ASTM D4437 and ASTM D5641.

The Vacuum pump shall be charged, and the tank pressure adjusted to approximately 5 psi. If no bubbles appear while the vacuum is held for 5 seconds, then the seam is satisfactory.

D. Destructive Testing (In Field & In Laboratory)

Samples for destructive testing shall be taken from finished seams at locations as directed by the Engineer. A sampling frequency of one sample per 500 feet of seam length shall be used for the first two destructive samples collected from each welder. Upon passing results of the first two destructive samples of each welder, the interval shall increase to 1,000 feet of seam. The sample shall be taken by the Geomembrane Installer from a location specified by the Engineer. The Engineer may decrease the sampling interval based upon difficult welding conditions or suspicion of unacceptable welds.

Each sample shall be 3 feet long, parallel to the seam by 1 foot wide, with the seam central in width. The sample shall be cut into three equal sections distributed as indicated in Table 9 (below).

a. Prior to cutting the laboratory sample, two (2) one-inch-wide sample strips shall be cut using an approved template from each end of the sample. Two additional sample strips will be cut to determine parent material yield strength.
b. These strips shall be tested by the Installer in the field tensiometer. Parent, peel, and shear yield strength will be recorded in accordance with Section 4.01.B.
c. If acceptable, the sample shall be cut into three 12 in lengths.

Samples shall be cut by the Installer, indelibly numbered, and identified,
And the locations recorded and submitted to the Engineer for laboratory testing.

The preparation of the sample and field testing by the Geomembrane Installer shall be witnessed by an Independent Construction Quality Assurance (CQA) firm representative.

If any samples fail field testing, additional samples shall be taken to define the extent of sub-standard seam. Destructive testing of the seams must be carried out as the seams are

welded together on a continuous basis. Destructive testing shall not be conducted at the end of the geomembrane installation.

For laboratory testing, the laboratory shall cut 10 identical 1-inch-wide replicate specimens from their sample. The laboratory shall test five (5) specimens for seam shear strength and five (5) for peel strength. The laboratory shall test the samples in accordance with GRI GM19 and report the results to the Contractor and the Engineer simultaneously.
The third sample section (Table 9, Sample Section No. 3) shall be submitted to the Engineer for record keeping. The third sample section shall not be used by the Geomembrane Installer to confirm marginally failing test results obtained from their sample.

For field seams, if a laboratory test fails, that shall be considered an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer from locations 10 feet on either side of the failed sample (c/c by sample). Field and Laboratory testing shall be conducted on these verification samples. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test locations shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 165 feet in length shall be destructively tested.

E. Penetration Testing(in field)

Penetrations: The membrane shall be installed around pipes as shown on the Drawings. Install to provide an effective, watertight seal. Construction and installation of the pipe boot shall be performed in the presence of the Engineer or his designated representative. Testing of all pipe boots shall be required.

Liner installer shall coordinate with Contractor on space required for extrusion welding and vacuum testing around pipe/boot penetrations.

Boot fabrication and testing shall be as follows:

1. Boots shall be fabricated in the field to fit the pipe penetration.

2. The boot shall be temporarily removed, skirt attached to a temporary base sheet with the barrel of the boot welded shut, and air tested to 2-3 psi (min/max); apply soapy water to all prefabricated seams to locate any leaks.

3. If no leaks are found, remove temporary base sheet, open boot barrel, and reinstall on pipe.

4. Extrusion weld boot flap to liner, and boot barrel to HDPE pipe.

5. Place liner sleeve over boot barrel covering end of boot and weld sleeve to boot barrel and pipe.

6. Air test sleeve (2-3 min/max psi) for 5 minutes to evaluate boot barrel seal. If no pressure drop is observed, grind and extrude air test penetration and vacuum test extrusion.

7. Vacuum test extrusion seams of boot and skirt joint with liner.

All pipe boots, vents, and patches shall be of the same material as the membrane sheet. Gaskets, sealing materials, or other means used to secure the membrane shall be compatible with and have a lifespan at least equal to that of the LLDPE membrane.

## 5.03 GEOMEMBRANE DEFECTS

### A. Identification of Defects

Panels and seams shall be inspected by the Geomembrane Installer, Contractor and Engineer during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials, and signs of contamination by foreign matter.

### B. Evaluation of Defects

Each suspect location on the geomembrane (both in geomembranes seam and non-seam areas) shall be non- destructively tested using one of the methods described in Section 5.2.2: Non-Destructive Testing. Each location which fails non-destructive testing shall be marked, numbered, measured, and posted on the daily "installation" drawings and subsequently repaired.

If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.

### C. Wrinkles

Any wrinkles that can fold over shall be repaired either by cutting out excess material or, if possible, allowing the geomembrane to contract as the temperature decreases. In no case shall material be placed over the geomembrane that could result in the geomembrane folding. All folded geomembrane shall be removed. No material shall be placed in areas where the geomembrane is not in contact with the supporting subgrade.

## 5.04 GEOMEMBRANE REPAIR

### A. Geomembrane Repair Procedures

Any portion of the geomembrane with a flaw or that fails a non-destructive test shall be repaired by one of the following methods:

- Patching for holes, defects, or tears 0.5 inch or larger in diameter or length – used to repair large holes, tears, large panel defects, and destructive sample locations that are less than 20 ft2 (total area);
- Extrusion – used to repair relatively small defects in panels and seams, but not greater than 0.5 inch in length;
- Capping – used to repair failed welds or geomembrane seams where welds cannot be non-destructively tested;
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles) from the installed geomembrane.

Once the repair has been completed, further non-destructive or destructive testing shall be carried out to ensure the repairs are completed to the requirements of this Specification.

B. Verification of Seam Repairs

Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be re-seamed and re-tested until a passing test result. The number, date, location, technician, and test outcome of each patch shall be recorded.

5.05 TESTING & INSPECTION RECORDS

Full records of geomembrane testing and inspection shall be submitted progressively to the Engineer, as the work proceeds. Final completion will not be certified until all records have been submitted and approved by the Engineer.

Records shall include, but not limited to, the following:

- Contractor's panel layout drawing showing panel numbers and seam numbers, to be marked up progressively with the roll number used for each panel, and with the locations of samples taken for destructive testing;
- Manufacturer's roll production test reports for all rolls used in the work;
- Subgrade certification reports;
- Daily vacuum box or seam inflation test reports referenced to seam numbers;
- Daily test weld field test reports referenced to seam numbers, equipment identification, and operator, and including weather and temperature conditions and any adjustments to equipment controls;
- Destructive test field report and record of submission for laboratory testing referenced to seam number;
- Laboratory test reports to be available within two weeks of testing;
- Record drawing indicating geomembrane seam locations, destructive test locations, cap strip locations, patches and all repairs for the geomembrane system.

Part 6 GEOMEMBRANE COMPLETION

The Geomembrane Installer shall undertake post installation testing of geomembrane as soon as practical after installation. Installation and material defects detected by post installation testing shall be covered under the Installation warranty and shall be repaired to the satisfaction of the Engineer.

6.01 GEOMEMBRANE COMPLETION ACCEPTANCE CRITERIA

Upon completion of the geomembrane completion phase (complete with repair and re-testing of leaks), the geomembrane installation shall be deemed as substantially complete and handover shall be approved by the Engineer.

Following handover, leakage rates shall be monitored by the Owner during first filling for the presence of leakage. If leakage is detected within the first year, the installer shall re-mobilize on-site and locate and repair the leaks per the requirements of Section 2.11.2: Geomembrane Installer Warranty.

The Engineer shall release the work as being complete upon receipt and approval of the following:

- Checks on application and final finish;
- The installation of LLDPE geomembranes has been completed and signed off;
- Repairs to defects have been completed;
- Site has been left clean with no litter;
    - All required documentation has been provided to the Engineer in accordance with Section 5.5: Testing & Inspection Records.

END OF SECTION

# SECTION 02541
# GRAVELS

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Procurement from off-site source and placement of gravels and crushed stone (fine and coarse) as shown on the Plans.

### 1.02 RELATED REQUIREMENTS

A. Section 01300 - Submittals

B. Section 01400 - Quality Assurance/Quality Control

C. Section 02222 - Excavation

D. Section 02223 - Filling

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Materials shall conform to NHDOT Specifications, Division 300, Section 304 "Aggregate Base Course".

B. The materials shall consist of hard durable particles or fragments of stone or gravel. Crushed stone and crushed ledge rock shall be made from rock from which the overburden has been stripped, and consist of clean, durable fragments of ledge rock of uniform quality reasonably free of elongated pieces.

C. Materials that break up when alternately frozen and thawed or wetted and dried shall not be used.

D. Select Gravels indicated on the plans and specifications shall conform to the requirements of Item 304.3 Crushed Gravel.

### 2.02 GRADATION

A. Crushed stone (fine and coarse gradations) and gravels shall be free from injurious amounts of organic material, loam, snow, ice, frozen soil, and other objectionable materials, and shall conform to the following gradations:

| Item No. | 304.2 | 304.3 | 304.4 | 304.5 |
|---|---|---|---|---|
| Item | Gravel | Crushed Gravel (and Select Gravel) | Crushed Stone (fine) | Crushed Stone (coarse) |
| Sieve Size | Percent Passing by Weight | | | |
| 6 in | 100 | -- | -- | -- |
| 3 ½ in | -- | -- | -- | 100 |
| 3 in | -- | 100 | -- | 85-100 |
| 2 ½ in | -- | -- | -- | -- |
| 2 in | -- | 95-100 | 100 | -- |
| 1 ½ in | -- | -- | 85-100 | 60-90 |
| 1 in | -- | 55-85 | -- | -- |
| ¾ in | -- | | 45-75 | 40-70 |
| #4 | 25-70 | 27-52 | 10-45 | 15-40 |
| #200 (total sample) | 0-12 | 0-12 | 0-5 | 0-5 |

2.03 QUALITY CONTROL

A. The Contractor shall provide certification that the gravel used in construction complies with the required gradations. Furnish the certification in accordance with Section 01300 "Submittals", and Section 01400 "Quality Assurance/Quality Control".

B. When materials are produced from processing of on-site boulders and rock, Contractor shall provide results of laboratory testing every 1,000 CY of materials to be installed, to demonstrate conformance with the requirements of Part 2.02 A.

PART 3 EXECUTION

A. Materials shall be furnished and placed in their final location with as little segregation as possible.

3.02 PLACEMENT AND COMPACTION

A. Placement and compaction of materials used in the construction of gravel roadways shall conform to NHDOT Specifications, Division 300, Section 304 "Aggregate Base Course".

B. A layer of non-woven geotextile (Section 02275) shall be installed over the prepared subgrade and beneath the base course (coarse crushed stone) materials, prior to installation of the fine coarse crushed stone.

END OF SECTION

# SECTION 02619
# HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Quality assurance of pipe and fittings.

B. Delivery and storage of piping.

C. Installation of the piping.

D. Testing of installed piping.

### 1.02 RELATED REQUIREMENTS

A. Section 01400 - Quality Assurance/Quality Control

B. Section 02222 - Excavation

C. Section 02223 - Filling

D. Section 02276 – Linear Low Density Polyethylene (LLDPE) Liner

### 1.03 SERVICE AND TYPE REQUIREMENTS

Except as otherwise specified or authorized, high density polyethylene pipe and fittings shall be of the type, grade, schedule, or pressure rating indicated on the Plans and as approved by the Engineer for its service function.

### 1.04 QUALITY ASSURANCE

A. Provide all required manufacturer's certifications and test results in accordance with Section 01400 prior to delivery of the pipe on site.

B. Provide all test results of the HDPE piping system prior to substantial completion of the Project.

## PART 2 PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

A. Performance Pipe

B. ISCO pipe

C. Approved equivalent

2.02 MATERIALS

A. PIPE:

1. ASTM D1248 Type III, Class C of the standard dimensional ratio (SDR) indicated on the Plans. All leachate and landfill gas piping shall be of IPS pipe size.

2. Piping shall be manufactured in accordance with ASTM F 714. Provide manufacturer's certification that the piping has been tested in accordance with ASTM D2837.

3. The HDPE pipe shall have the following minimum physical properties as determined by the appropriate test method.

| Physical Property | Test Method | Required |
|---|---|---|
| Density | ASTM D1505 | 0.955 g/cm$^3$ |
| Tensile Yield Strength | ASTM D638 | 3200 |
| Tensile Modulus of Elasticity | ASTM D638 | 130,000 psi |
| Flexural Modulus | ASTM D790 | 135,000 psi |
| Melt Index | ASTM D1238 | 0.10 gm/10 min |

B. FITTINGS:

1. Butt fusion molded and fabricated fittings shall be pressure rated to match the system piping to which they are fused and manufactured in accordance with ASTM D 3261.
2. Provide factory fabricated dual containment fittings from the same manufacturer as the pipe materials.
3. Fittings shall have the same or higher pressure rating as the pipe.
4. The Drawings may not show all the fittings required and the Contractor shall provide all fittings required to complete the work.

C. GASKETS AND HARDWARE

1. All gaskets shall be Viton. Joint hardware shall be 304 stainless steel.

D. SUPPORT SPACERS FOR DUAL CONTAINMENT PIPE

1. Support spacers shall be manufactured from non-metallic, corrosion resistant material.
2. Supports shall have broad, smooth bearing surfaces.
3. Support spacers shall be manufactured to maintain the specified annulus between the carrier and containment pipes.
4. Supports shall allow unrestricted passage of monitoring or alarm system cables, possible flow of liquid from the carrier, and leak testing.

PART 3 EXECUTION

3.01 PIPING DELIVERY AND STORAGE

A. Piping delivered on site shall be clean, new, and bear the manufacturer's identification and SDR designation. Piping shall be unloaded and stored on site on pallets in accordance with the manufacturer's recommendations.

B. Piping damaged en route to the site or during the unloading will be rejected and shall be removed from the site and replaced with new piping meeting specification.

3.02 INSTALLATION OF PIPING

A. GENERAL:

1. Lay out piping as shown on the Plans. Any deviation from the layout shown must be approved by the Engineer.

2. Piping shall be cut from measurements taken at the site and not from the Plans. All necessary provisions shall be taken in laying out piping to provide for expansion and contraction.

B. INSPECTION OF PIPING:

1. Carefully inspect all pipe and fittings before installation, removing all dirt. The pipe should be installed with the markings up for visual inspection and verification.

2. All pipe shall have smooth exterior and interior surfaces, be first quality, be free from cracks, blisters, and other imperfections, and be true to shape or form throughout each length. Piping judged by the Engineer to be unacceptable shall be removed from the site and new undamaged pipe shall be provided at no extra cost to the Owner.

3. The interior of the pipeline shall be kept free from all dirt, joint material, and other foreign materials as the work progresses. Tight fitting stoppers or bulkheads shall be securely placed at the ends and any other openings of the pipe when work is stopped temporarily, or at the end of the days work to prevent dirt or trash from entering the pipe.

C. PIPE JOINTING:

1. Pipe joints and fittings shall be butt fused at 440 or 500$^{o}$F and shall be socket or sidewall fused at 500$^{o}$F. Fusing shall be performed using manufacturer approved equipment and shall be in accordance with the manufacturer's recommendations. When shown on the Plans, piping shall be joined using the stainless steel repair clamps equivalent Dresser Style 364 with Viton.

2. Flanged connections shall be completed with fabricated flange adapters and convoluted stainless steel back-up rings on installations below ground, and epoxy coated carbon steel backup rings shall be used above grade. Use Viton full face gaskets only. All fasteners shall be Type 18-8 or Type 304 stainless steel below grade, and zinc plated steel above grade. Hot dipped galvanized fasteners are not permitted.

3. Protect below grade bolts and flanges by covering with 6-mil thick polyethylene wrap. Duct tape wrap to HDPE pipe.

4. Electrofusion couplings, where used, shall be installed per manufacturer's recommendations. The outside diameter of the HDPE pipe and face shall be prepared in accordance with the manufacturers recommendations prior to installing the coupler.

D. CARRIER PIPE/FITTING SUPPORT SPACERS PLACEMENT

1. Support spacers shall be secured at a minimum of 4-foot intervals to align pipe for fusion welding adjacent to fittings and bends.

2. Support spacers shall not restrict longitudinal movement between the carrier and containment pipe.

3. If dual walled pipe is not manufactured with internal spacers, Contractor shall install a least three spacers on either side of all simultaneous butt fusion joints to maintain correct alignment of the carrier pipe within the containment pipe.

E. PIPE PENETRATIONS:

Penetrations of the HDPE piping through the LLDPE liner membrane shall be sealed between the exterior surface of the piping and the edge of the liner penetration as shown on the Plans. The method of sealing shall be an approved procedure by both manufacturers of the HDPE piping and LLDPE liner. The seals at all penetrations shall be inspected and approved by the Engineer prior to backfilling with Drainage Sand.

3.03 PIPE EMBEDMENT AND BACKFILL

A. The HDPE pipe and fittings shall be installed in full compliance with the manufacturer's recommendations.

B. The pipe shall be embedded with bedding, haunching, and initial backfill materials that provide stable and permanent support to the pipe. These materials shall be as shown on the Plans.

C. Care should be taken to ensure that the haunching of the pipe is performed without disturbing the pipe. Initial backfill shall be placed in 6-inch layers and hand tamped to assure compaction.

## 3.04 TESTING OF GRAVITY, SOLID WALL PIPELINES

Testing of a section of pipe shall be performed using the below stated equipment according to stated procedures and under the observation of the inspecting Engineer.

A. Pneumatic plugs shall have a sealing length equal to or greater than the diameter of the pipe to be inspected.

B. Pneumatic plugs shall be braced or blocked when installed in the test section.

C. All air used shall pass through a single control panel.

D. Three (3) individual hoses shall be used for the following connections:

1. From control panel to pneumatic plugs for inflation.

2. From control panel to sealed line for introducing the low pressure air.

3. From sealed line to control panel for continually monitoring the air pressure rise in the sealed line.

Procedures: All pneumatic plugs shall be seal tested before being used in the actual test installation. One (1) length of pipe shall be laid on the ground and sealed at both ends with the pneumatic plugs to be checked. Air shall be introduced into the plugs to 25 psig. The sealed pipe shall be pressurized to 5 psig. The plugs shall hold against the pressure without bracing and without movement of the plugs out of the pipe.

After a reach of pipe has been backfilled and cleaned, and the pneumatic plugs are checked by the above procedure, the plugs shall be placed in the line at each manhole and inflated to 25 psig. Low pressure air shall be introduced until internal pipe pressure reaches 4 psig greater than the average back pressure of any ground water that may be over the pipe. At least two minutes shall be allowed for the air pressure to stabilize.

After the stabilization period (3.5 psig minimum pressure in the pipe), the air hose from the control panel to the air supply shall be disconnected. The portion of the line being tested shall be termed "acceptable" if the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig (greater than the average back pressure of any ground water that may be over the pipe) shall not be less than the time shown for the given diameters in the following table:

| Pipe Diameter In Inches | Minutes |
|---|---|
| 4 | 2.0 |
| 6 | 3.0 |
| 8 | 4.0 |
| 10 | 5.0 |
| 12 | 6.0 |
| 15 | 7.5 |
| 18 | 9.0 |
| 21 | 10.5 |
| 24 | 12.0 |
| 30 | 14.0 |
| 36 | 17.0 |

For purposes of determining test pressure in areas where ground water is known to exist, the Contractor shall install sumps or monitoring wells adjacent to the pipeline to be tested.

A measurement from the top of ground water to top of pipe in the test section in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings. (For example, if the height of water is 11½ feet, then the added pressure will be 5 psig, and the 2.5 psig will then be 7.5 psig. The allowable drop of one pound and the timing remain the same.)

If installation fails to meet the above requirements for the air test, the Contractor shall correct the pipeline until an acceptable test is achieved.

The Contractor shall provide as required the proper plugs, bracing, and other equipment required to perform all tests. Testing of each section of HDPE installed shall include the portions of service connections that are to be installed under the Contract.

Where ground water is confirmed to be high, the Engineer, at his option, may elect to accept infiltration measurements in lieu of air testing.

These tests shall be conducted in the presence of the Engineer. Should a pipe section which has previously been tested indicate any water infiltration, or otherwise appear suspect to the Engineer, the Contractor shall conduct confirmation air tests on the line at no additional cost.

END OF SECTION

# SECTION 02930
# LOAMING AND SEEDING

## PART 1 GENERAL

### 1.01 REQUIREMENTS INCLUDED

A. Loam to be provided by the Contractor from an off-site source.

### 1.02 RELATED REQUIREMENTS

A. Section 02223 - Filling
B. Section 02270 - Erosion Control

### 1.03 SUBMITTALS

A. The Contractor shall furnish all materials to be used in performing the work under this Contract. Prior to use, the Contractor shall be required to furnish the following information to the Engineer.

1. Copies of delivery tickets showing the net weight of materials delivered to the job site.

2. Certification from the suppliers of ground limestone showing:

   a. Magnesium oxide content
   b. Total calcium oxide neutralizing equivalent, and
   c. Gradation of the ground limestone

3. Certification that the fertilizer meets the requirements of NHDOT Specifications, Division 600, Section 643 "Fertilizer for Grasses".

4. The bag tag for each variety of mix and bag of seed showing test results and the date of test.

### 1.04 CERTIFICATE OF PROVISIONAL ACCEPTANCE

A. The Owners Representative will inspect all work upon the written request of the Contractor received at least ten days before the anticipated date of inspection.

B. Seeded areas shall be reviewed for acceptance only after all areas have a close stand of grass with no bare spots greater than two inches in diameter, at least 90% of the grass established shall be permanent grass species and the lawns have been maintained for a minimum of ninety (90) days prior to inspection.

C. Furnish full and complete written instructions for maintenance of all lawns to the Owner at the time of provisional acceptance.

D. Owner's Representatives inspection shall determine if the seeded areas are acceptable and whether maintenance shall continue in any part.

E. After all necessary corrective work and clean-up has been completed, and maintenance instructions have been received by the Owner, the Owner's Representative will certify in writing the acceptance of the seeded areas. The Contractor's responsibility for maintenance of seeded areas shall cease on receipt of the Certificate of Provisional Acceptance.

1.05 EXAMINATION OF CONDITIONS

A. All areas to be seeded shall be inspected by the Contractor before starting work and any defects, such as incorrect grading, drainage problems, etc., shall be reported to the Owner's Representative prior to beginning this work. The commencement of work by the Contractor shall indicate his acceptance of the areas to be seeded, and he shall assume full responsibility for the work of this Section.

PART 2 PRODUCTS

2.01 TOPSOIL

A. Topsoil materials shall meet the requirements of NHDOT Specifications Division 600, Section 641 "Loam"

B. The topsoil shall be screened to remove all particles greater than one (1) inch in any diameter, and be reasonably free from subsoil, clay lumps, stones, brush, objectionable stumps, roots, litter, toxic substances, and other material or substances which may be harmful to plant growth or be a hindrance to grading, planting and maintenance operations.

C. A sample of the processed topsoil materials shall be provide to the Engineer for laboratory testing, to determine recommended fertilizer application rates and whether any additives are required. Contractor shall treat the topsoil to meet the specifications.

D. Topsoil shall be applied to areas disturbed during construction, where shown on the Plans, and as directed by the Engineer to a depth of four (4) inches after spreading and rolling.

2.02 LIME

A. Lime shall conform to NHDOT Specifications Division 600, Section 642 "Limestone".

2.03 FERTILIZER

A. Fertilizer to be used must be the equivalent of a standard 15-15-15 mixture and shall be approved by the Engineer. Fertilizer shall be a standard commercial grade fertilizer conforming to all State and Federal regulations and to the standards of the Association of Official Agricultural Chemists. The analysis shall represent respective percentages of nitrogen, phosphoric acid, and potash.

2.04 SEED

A. All seed shall be certified as to mixture, germination, and purity, and as being in conformity with the NHDOT Specifications, Division 600, Section 644 "Grass Seed".

B. The Contractor shall use approved slope erosion resistant seed mix for erosion control of sloped areas and use grass mix for level areas.

2.05 MULCH

A. Bonded Fiber Matrix, as described in Section 02270, shall be applied on all disturbed seeded areas.

PART 3 EXECUTION

3.01 SEEDING PERIODS

A. Unless otherwise authorized, the Contractor shall do all seeding during the following periods:

1. April 1 and July 1
2. August 15 and October 15
3. If seeding is done beyond October 15, the Contractor shall apply mulch at a rate of 2 to 2½ tons per acre, but no more than 3 tons/acre.
4. Seeding shall not be done during windy weather or when the ground is frozen, excessively wet, or otherwise untillable.

3.02 SEED BED PREPARATION

A. Seed will be applied to a well-conditioned smooth firm seedbed, prepared to a depth of three (3) inches. Clods or other obstructions generally larger than two (2) inches in diameter of thickness that will prevent uniform seeding shall be removed or reduced in size.

B. Hard or caked seed bed shall be reconditioned before the seed is applied.

C. Care must be taken by the Contractor to see that ruts or ridges are not created on the graded areas.

3.03 LIMING, FERTILIZING, AND SEEDING

A. Lime, fertilizer, and seed may be applied by any of the methods described in NHDOT Specifications, Division 600, Section 644 "Grass Seed". The rates of application shall conform NHDOT Specifications, Division 600, Section 642, 643, and 644 "Limestone", "Fertilizer for Grasses", and "Grass Seed".

B. Lime and fertilizer shall be applied based upon nutrient availability of the soil and worked into the soil at the time of seed bed preparation.

3.04 MULCHING

A. MULCH:

1. Bonded Fiber Matrix, as described in Section 02270, shall be applied on all disturbed seeded areas.

3.05 MAINTENANCE AND PROTECTION

A. Maintenance shall begin immediately after any area is seeded and shall continue for ninety (90) days or until final written acceptance by the Owner's Representative, whichever is longer.

B. Maintenance shall include reseeding, mowing, watering, weeding, liming, and fertilizing.

C. Watering of Seeded Areas:

1. First Week: The Contractor shall provide all labor and arrange for all watering necessary to establish an acceptable lawn. In the absence of an adequate rainfall, watering shall be performed daily or as often as necessary during the first week and in sufficient quantities to maintain moist soil to a depth of at least two inches.
2. Second and Subsequent Weeks: The Contractor shall water the lawn as required to maintain adequate moisture, in the upper two inches of soil, necessary for the promotion of deep root growth.
3. Watering shall be done in a manner which will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to apply one complete coverage to the seeded areas in an eight (8) hour period.

D. Protection:

1. Seeded and sodded areas shall be protected by a three-foot-high barrier constructed of two-by-four stakes or iron pipes set eighteen inches in the ground at ten foot intervals and connected by No. 10 wire. Flags of white cloth shall be secured to the wire at center points between stakes.
2. Barriers must be raised immediately after seeding or sodding and shall be maintained until acceptance.

E. Reseeding: After the grass in seeded areas has appeared, all areas and parts of areas which, in the opinion of the Owner's Representative, fail to show a uniform stand of grass, for any reason whatsoever, shall be reseeded and such areas and parts of areas shall be seeded repeatedly until all areas are covered with a satisfactory growth of grass. Reseeding together with necessary grading, fertilizing, and trimming shall be done at the expense of the Contractor.

F. Mowing:

1. Seeded Areas: The Contractor shall keep seeded areas mowed until written acceptance of the seeding by the Owner's Representative by cutting to a height of two inches (2") when growth reaches three inches (3") or as directed by the Owner's Representative.

2. Mowing shall include removal of clippings.

G. Fertilizing: A second application of fertilizer, as specified herein, shall be applied after one (1) season of growth of a minimum of two (2) months duration, but only during the months of April, May, August, or September. Fertilizer shall be applied at the rate of thirty (30) pounds per one thousand (1,000) square feet.

H. Liming: If more than one initial application of limestone is required by the soils analysis to bring the pH of the stockpiled topsoil/loam borrow to a specified range, the Contractor shall be responsible for all additional required lime applications.

3.06 GUARANTEE PERIOD

A. The Contractor shall guarantee all seeded areas for a period of one (1) year following the date of Provisional Acceptance. During the guarantee period, the Contractor shall make periodic inspections of seeded areas and to determine if any remedial actions are necessary to prevent erosion or damage to seeded areas.

B. At the end of the guarantee period, the Engineer and Owner shall observe the vegetation, at the written request of the Contractor, at least ten (10) days before anticipated date. Seeded area not demonstrating satisfactory vegetation, as determined by the Engineer and Owner, shall be repaired, reseeded, and maintained to meet all requirements specified herein.

C. After the completion of all necessary corrective work, the Engineer shall issue a certificate of final acceptance, which shall terminate the Contractors responsibility for the seeded areas.

END OF SECTION

# *Attachment D*

## *Closure Design Calculations*

| | | |
|---|---|---|
| CMA ENGINEERS<br>35 Bow Street<br>Portsmouth, NH 03801 | Project:<br>Project No:<br>Date:<br>Calc. By:<br>Checked By: | Granite State Landfill<br>1101<br>4/10/23<br>AJS<br>RJG |

**SLOPE STABILITY: STABILITY OF 2.5:1 SOIL SLOPES UNDER EQUIPMENT LOADING**
**GEOCOMPOSITE/LINER INTERFACE**
**Uniform slope thickness, buttressing forces neglected**

Method: Finite Analysis

| Input Variables: | Placement of Sand Layer | Longterm Stability and Placement of Topsoil |
|---|---|---|
| Thickness of cover soils (t) (ft) | 1 | 1.833 |
| Slope X:1 | 2.5 | 2.5 |
| Slope angle (b) | 21.80 | 21.80 |
| Length of slope (L) (ft) | 120 | 120 |
| Unit weight of cover soils (Ws) (pcf) | 120 | 120 |
| Min interface friction angle (a) | 32 | 32 |
| Cohesion force (C) (psf) | 0 | 0 |

Equipment Input Variables:

| Equipment | D6N LGP | D6N LGP |
|---|---|---|
| Ground Pressure (Gp) (psi) | 4.89 | 4.89 |
| Contact Area (Ca) (in^2) | 8103 | 8103 |
| Operating Weight (Ow) (lbs) | 39593 | 39593 |
| Track Width (Tw) (in) | 33.07 | 33.07 |
| Track Length (Tl) (ft) | 10.21 | 10.21 |

**Calculations (per foot width)**

| | Placement of Sand Layer | Longterm Stability and Placement of Topsoil |
|---|---|---|
| Weight of Cover Soil (Wc) (lbs):<br>Wc = t*L*Ws | 14400 | 26395 |
| Weight of Vehicle on Slope<br>On Top of Soil Cover (Wv') (lbs):<br>Wv' = (Ow/2 tracks)/Tw | 7183 | 7183 |
| Stress at FML (Qz) (psf):<br>Qz = (Ow/2 TRACKS)/((Tl+2t)*(Tw+2t))<br>assuming 1:1 distribution | 470 | 358 |
| Attenuation Ratio(q)<br>q = Qz/Gp | 0.67 | 0.51 |
| Attenuation Force (Wv) (lbs):<br>Wv = Wv'*(%q) | 4801 | 3657 |

| | | |
|---|---|---|
| CMA ENGINEERS<br>35 Bow Street<br>Portsmouth, NH 03801 | Project:<br>Project No:<br>Date:<br>Calc. By:<br>Checked By: | Granite State Landfill<br>1101<br>4/10/23<br>AJS<br>RJG |

**SLOPE STABILITY: STABILITY OF 2.5:1 SOIL SLOPES UNDER EQUIPMENT LOADING**
**GEOCOMPOSITE/LINER INTERFACE (continued)**

| | Placement of Sand Layer | Longterm Stability and Placement of Topsoil |
|---|---|---|
| Normal Force (Fn) (lbs):<br>Fn = (Wv+Wc)cos(b) | 17827 | 27903 |
| Frictional Resisting Force (Fr) (lbs):<br>Fr = Fn*tan(a) | 11140 | 17436 |
| Cohesive Resisting Force (Fc) (lbs):<br>Fc = C*L | 0 | 0 |
| Driving Force (Fd) (lbs):<br>Fd = (Wv+Wc)sin(b) | 7131 | 11161 |
| Braking Force (Fb) (lbs):<br>(Assume Fb=50%Wv)<br>Fb = 0.5*Wv | 2400 | 1829 |
| **Factor of Safety Dynamic Condition:**<br>FS = (Fr+Fc)/(Fd+Fb) | **1.2** | **1.3** |

NOTES:
Stability during placement of select sand calculated with 1 foot of material

Percentage of Attenuation through the depth of soil is calculated
by determining the contact stress from one track at the bottom
of the cover soil, assuming a 1:2 distribution

Contractor will be required to grade materials from bottom to top or laterally on all areas
However, sudden braking while going down slope would not likley cause failure as calculated above

REFERENCES:

EPA/600/2-87/097: "Geosynthetic Design Guidance for
Hazardous Waste Landfill Cells & Surface Impoundments"

| | |
|---|---|
| CMA ENGINEERS<br>35 Bow Street<br>Portsmouth, NH 03801 | Project: Granite State Landfill<br>Project No: 1101<br>Date: 4/10/23<br>Calc. By: AJS<br>Checked By: RJG |

**FLOW THROUGH DRAINAGE NET/FABRIC COMPOSITE**

| **Input Variables:** | **Design Case** | |
|---|---|---|
| Slope X:1 | 2.5 | |
| Gradient (i) | 0.40 | ft/ft |
| Length of slope (L) | 125 | ft |
| Width | 12 | inches |
| Type of Composite | 250-mil double sided | |
| Composite Transmissivity | 2.70E-04 | m^2/sec |
| | 2.91E-03 | ft^2/sec |
| Reduction Factors for Composite | | |
| Elastic Deformation (RFin) | 1.2 | |
| Creep (RFcr) | 1.2 | |
| Chemical Clogging (RFcc) | 1.1 | |
| Biological Clogging (RFbc) | 1.3 | |

| | HELP 10 yr | |
|---|---|---|
| Peak Drainage | 2.8622 | in/day |
| Peak Impingement Rate (e) | 3.31E-05 | in/sec |

Design Flow Through Sand and Drainage Composite

Qreq = eLw — 5.96E-01 — $in^3/sec$

Ultimate Flow Rate Through Drainage Composite

Qult = Trans*i*w — 2.01E+00 — $in^3/sec$

Allowable Flow Rate Through Drainage Composite

Qall = Qult * [ 1/ (RFin * RFcr * RFcc * RFbc)] — 9.75E-01 — $in^3/sec$

Factor of Safety for Flow Through Composite

FS = Qall / Qreq — **1.64**

| | |
|---|---|
| CMA ENGINEERS<br>35 Bow Street<br>Portsmouth, NH 03801 | Project: Granite State Landfill<br>Project No: 1101<br>Date: 4/10/23<br>Calc. By: AJS<br>Checked By: RJG |

**FLOW THROUGH DRAINAGE NET/FABRIC COMPOSITE (continued)**

NOTES:

Peak infiltration rate estimated by HELP for peak infiltration event over a run time of 10 years.

Method is conservative due to assumption that all of the infiltrated flow along the assumed length must pass through the drainage composite at the same time, and any component of flow in the drainage sand is neglected

Geocomposite Factors of Safety were derived from Koerner "Designing with Geosynthetics"
Moderate values for Elastic Deformation and Creep were assumed on the 2.7:1 slopes
Chemical Clogging on the cap is not considered to be problematic

Factors of Safety were calculated to demonstrate if the drainage geocomposite could transmit the necessary infiltr
Flow in the drainage sand was neglected

REFERENCES:

Koerner, Robert M., "Designing with Geosynthetics", Third Edition,
Prentice Hall, Englewood Cliffs, NJ, 1994.

Dominico, P.A. and F.W. Schwartz, "Physical and Chemical Hydrogeology",
John Wiley and Sons, 1990.

CMA ENGINEERS
35 Bow Street
Portsmouth, NH 03801

| | |
|---|---|
| Project: | Granite State Landfill |
| Project No: | 1101 |
| Date: | 4/10/23 |
| Calc. By: | AJS |
| Checked By: | RJG |

**SLOPE STABILITY: STATIC STABILITY OF 2.5:1 SOIL SLOPE**
**Capping Section With Double Sided Geocomposite**
**Uniform slope thickness**

Method: Finite Analysis

| Input Variables: | | |
|---|---|---|
| Thickness of cover soils (t) | 1.83 | ft |
| Slope X:1 | 2.5 | |
| Slope angle (b) | 21.80 | degrees |
| Length of slope (L) | 120 | ft |
| Unit weight of cover soils (Ws) | 120 | pcf |
| Interface Friction Angles (a) | 32 | degrees |
| Cohesive Strength (C) | | |
| Sand/(Liner or Composite) | 0 | psf |
| Composite/Liner | 20 | psf |

**Calculations (per foot width)**

| | **Sand/ Geocomposite** | **Geocomposite/ Liner** | |
|---|---|---|---|
| Weight of Cover Soil (Wc):<br>Wc = t*L*Ws | 26352 | 26352 | lbs |
| Normal Force (Fn):<br>Fn = Wc*cos(b) | 24467 | 24467 | lbs |
| Frictional Resisting Forces Below Liner (Frb):<br>Frb= Fn*tan(bsa) | NA | 15289 | lbs |
| Frictional Resisting Forces Above Liner (Fr):<br>Fr = Fn*tan(a) | 15289 | 15289 | lbs |
| Cohesive Resisting Force (Fc)<br>Fc = C*L | 0 | 2400 | lbs |
| Driving Force (Fd):<br>Fd = Wc*sin(b) | 9787 | 9787 | lbs |
| Factor of Safety (FS):<br>FS = (Fr + Fc)/Fd | **1.56** | **1.81** | |
| Tension at Anchor Trench (T):<br>T = Fd-Frb | NA | **None** | lbs |

| | |
|---|---|
| CMA ENGINEERS<br>35 Bow Street<br>Portsmouth, NH 03801 | Project: Granite State Landfill<br>Project No: 1101<br>Date: 4/10/23<br>Calc. By: AJS<br>Checked By: RJG |

**SLOPE STABILITY: STATIC STABILITY OF 2.5:1 SOIL SLOPE (continued)**

NOTES:

EPA Document: "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells & Surface Impoundments" Recommends a minimum Safety Factor of 1.2 for sliding

We designed to a generally accepted factor of safety of 1.5 for this analysis.

The drainage composite reduces head build up on the liner to a de minimus condition

Buttressing forces neglected but could be used in evaluation to increase factor of safety

REFERENCES:

EPA/600/2-87/097: "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells & Surface Impoundments"

EPA/600/52-89/057: "Stability of Lined Slopes and Surface Impoundments"

Proceedings of the 4th GRI Seminar: "Landfill Closures: Geosynthetics, Interface Friction, and New Developments," Drexel University, Philadelphia, PA, 1990

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**HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE**
**HELP MODEL VERSION 4.0 BETA (2018)**
**DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY**

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**Title:** NCES CAP4 Closure **Simulated On:** 9/10/2022 6:52

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**Layer 1**

Type 1 - Vertical Percolation Layer (Cover Soil)

L - Loam

Material Texture Number 8

| | | | |
|---|---|---|---|
| Thickness | = | 10 | inches |
| Porosity | = | 0.463 | vol/vol |
| Field Capacity | = | 0.232 | vol/vol |
| Wilting Point | = | 0.116 | vol/vol |
| Initial Soil Water Content | = | 0.4611 | vol/vol |
| Effective Sat. Hyd. Conductivity | = | 3.70E-04 | cm/sec |

**Layer 2**

Type 1 - Vertical Percolation Layer

S - Sand

Material Texture Number 2

| | | | |
|---|---|---|---|
| Thickness | = | 12 | inches |
| Porosity | = | 0.437 | vol/vol |
| Field Capacity | = | 0.062 | vol/vol |
| Wilting Point | = | 0.024 | vol/vol |
| Initial Soil Water Content | = | 0.0995 | vol/vol |
| Effective Sat. Hyd. Conductivity | = | 5.80E-03 | cm/sec |

**Layer 3**

Type 2 - Lateral Drainage Layer

Drainage Net (0.6 cm)

Material Texture Number 34

| | | | |
|---|---|---|---|
| Thickness | = | 0.3 | inches |
| Porosity | = | 0.85 | vol/vol |
| Field Capacity | = | 0.01 | vol/vol |
| Wilting Point | = | 0.005 | vol/vol |
| Initial Soil Water Content | = | 0.01 | vol/vol |
| Effective Sat. Hyd. Conductivity | = | 3.30E+01 | cm/sec |
| Slope | = | 37 | % |
| Drainage Length | = | 120 | ft |

**Layer 4**

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

| | | | |
|---|---|---|---|
| Thickness | = | 0.04 | inches |
| Effective Sat. Hyd. Conductivity | = | 4.00E-13 | cm/sec |
| FML Pinhole Density | = | 10 | Holes/Acre |
| FML Installation Defects | = | 10 | Holes/Acre |
| FML Placement Quality | = | 2 | Excellent |

**Layer 5**
Type 2 - Lateral Drainage Layer
S - Sand
Material Texture Number 2

| | | | |
|---|---|---|---|
| Thickness | = | 6 | inches |
| Porosity | = | 0.437 | vol/vol |
| Field Capacity | = | 0.062 | vol/vol |
| Wilting Point | = | 0.024 | vol/vol |
| Initial Soil Water Content | = | 0.0618 | vol/vol |
| Effective Sat. Hyd. Conductivity | = | 5.80E-03 | cm/sec |
| Slope | = | 0 | % |
| Drainage Length | = | 0 | ft |

---

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

**General Design and Evaporative Zone Data**

| | | | |
|---|---|---|---|
| SCS Runoff Curve Number | = | 74 | |
| Fraction of Area Allowing Runoff | = | 100 | % |
| Area projected on a horizontal plane | = | 6.01 | acres |
| Evaporative Zone Depth | = | 22 | inches |
| Initial Water in Evaporative Zone | = | 5.805 | inches |
| Upper Limit of Evaporative Storage | = | 9.874 | inches |
| Lower Limit of Evaporative Storage | = | 1.448 | inches |
| Initial Snow Water | = | 0 | inches |
| Initial Water in Layer Materials | = | 6.179 | inches |
| Total Initial Water | = | 6.179 | inches |
| Total Subsurface Inflow | = | 0 | inches/year |

---

Note: SCS Runoff Curve Number was User-Specified.

**Evapotranspiration and Weather Data**

| | | | |
|---|---|---|---|
| Station Latitude | = | 44.26 | Degrees |

| | | | |
|---|---|---|---|
| Maximum Leaf Area Index | = | 4 | |
| Start of Growing Season (Julian Date) | = | 151 | days |
| End of Growing Season (Julian Date) | = | 256 | days |
| Average Wind Speed | = | 6 | mph |
| Average 1st Quarter Relative Humidity | = | 64 | % |
| Average 2nd Quarter Relative Humidity | = | 67 | % |
| Average 3rd Quarter Relative Humidity | = | 75 | % |
| Average 4th Quarter Relative Humidity | = | 72 | % |

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Note: Evapotranspiration data was obtained for Bethlehem, New Hampshire

**Normal Mean Monthly Precipitation (inches)**

| Jan/Jul | Feb/Aug | Mar/Sep | Apr/Oct | May/Nov | Jun/Dec |
|---|---|---|---|---|---|
| 2.232615 | 2.07937 | 2.562587 | 3.529536 | 3.575821 | 4.285787 |
| 4.354622 | 5.137475 | 3.887641 | 4.475128 | 3.615679 | 2.775011 |

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Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 44.26/-71.61

**Normal Mean Monthly Temperature (Degrees Fahrenheit)**

| Jan/Jul | Feb/Aug | Mar/Sep | Apr/Oct | May/Nov | Jun/Dec |
|---|---|---|---|---|---|
| 22.8 | 28.6 | 30.1 | 42.2 | 58.3 | 67.7 |
| 75.2 | 73.7 | 59.5 | 46.7 | 33.5 | 25.1 |

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Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 44.26/-71.61
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 44.26/-71.61

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 363 | * | | 0.00 | 0.000 | 0.019 | 0.1288 | 0.0001 | 0.0200 | 3.40E-06 | 0.0000 | 0.0000 | 1.10E-05 |
| 364 | | | 0.02 | 0.000 | 0.000 | 0.1418 | 0.0001 | 0.0245 | 3.74E-06 | 0.0000 | 0.0000 | 1.07E-05 |
| 365 | * | * | 0.00 | 0.000 | 0.000 | 0.1418 | 0.0000 | 0.0003 | 3.84E-08 | 0.0000 | 0.0000 | 1.44E-05 |

* = Frozen (air or soil)

| Annual Totals for Year 10 | | | |
|---|---|---|---|
| | inches | cubic feet | percent |
| Precipitation | 45.10 | 983,928.0 | 100.00 |
| Runoff | 2.666 | 58,169.9 | 5.91 |
| Evapotranspiration | 25.926 | 565,605.6 | 57.48 |
| Drainage Collected from Layer 3 | 17.9588 | 391,795.1 | 39.82 |
| Percolation/Leakage through Layer 4 | 0.001840 | 40.1 | 0.00 |
| Average Head on Top of Layer 4 | 0.0002 | --- | --- |
| Percolation/Leakage through Layer 5 | 0.002383 | 52.0 | 0.01 |
| Change in Water Storage | -1.4528 | -31,694.7 | -3.22 |
| Soil Water at Start of Year | 5.3121 | 115,889.4 | 11.78 |
| Soil Water at End of Year | 3.8593 | 84,194.6 | 8.56 |
| Snow Water at Start of Year | 0.0000 | 0.0000 | 0.00 |
| Snow Water at End of Year | 0.0000 | 0.0000 | 0.00 |
| Annual Water Budget Balance | 0.0000 | 0.0000 | 0.00 |

**Average Annual Totals Summary**

**Title:** NCES CAP4 Closure
**Simulated on:** 9/10/2022 6:54

| | Average Annual Totals for Years 1 - 10* | | | |
|---|---|---|---|---|
| | (inches) | [std dev] | (cubic feet) | (percent) |
| Precipitation | 42.51 | [2.89] | 927,438.7 | 100.00 |
| Runoff | 5.868 | [2.128] | 128,012.4 | 13.80 |
| Evapotranspiration | 22.281 | [2.282] | 486,085.1 | 52.41 |
| Subprofile1 | | | | |
| Lateral drainage collected from Layer 3 | 14.6298 | [2.66] | 319,168.9 | 34.41 |
| Percolation/leakage through Layer 4 | 0.001487 | [0.00026] | 32.4 | 0.00 |
| Average Head on Top of Layer 4 | 0.0002 | [0] | --- | --- |
| Subprofile2 | | | | |
| Percolation/leakage through Layer 5 | 0.002087 | [0.000249] | 45.5 | 0.00 |
| Water storage | | | | |
| Change in water storage | -0.2692 | [1.8791] | -5,873.2 | -0.63 |

* Note: Average inches are converted to volume based on the user-specified area.

**Peak Values Summary**

**Title:** NCES CAP4 Closure
**Simulated on:** 9/10/2022 6:54

| | Peak Values for Years 1 - 10* | | |
|---|---|---|---|
| | (inches) | | (cubic feet) |
| Precipitation | 2.84 | | 61,880.2 |
| Runoff | 2.042 | | 44,542.3 |
| Subprofile1 | | | |
| Drainage collected from Layer 3 | 2.8622 | | 62,442.1 |
| Percolation/leakage through Layer 4 | 0.000252 | | 5.4918 |
| Average head on Layer 4 | 0.0498 | | --- |
| Maximum head on Layer 4 | 0.0113 | | --- |
| Location of maximum head in Layer 3 | 0.00 | (feet from drain) | |
| Subprofile2 | | | |
| Percolation/leakage through Layer 5 | 0.000017 | | 0.3699 |
| Other Parameters | | | |
| Snow water | 4.3118 | | 94,067.3 |
| Maximum vegetation soil water | 0.3638 | (vol/vol) | |
| Minimum vegetation soil water | 0.0658 | (vol/vol) | |

**Final Water Storage in Landfill Profile at End of Simulation Period**

**Title:** NCES CAP4 Closure
**Simulated on:** 9/10/2022 6:55
**Simulation period:** 10 years

| | Final Water Storage | |
|---|---|---|
| Layer | (inches) | (vol/vol) |
| 1 | 2.6466 | 0.2647 |
| 2 | 0.4726 | 0.0394 |
| 3 | 0.0030 | 0.0100 |
| 4 | 0.0000 | 0.0000 |
| 5 | 0.3650 | 0.0608 |
| Snow water | 0.0000 | --- |

*Section IX*

# *Financial Report*

# Section IX – Financial Report

Information for Section IX is provided on the application form. In accordance with the requirements of Env-Sw 1403.01, a Financial Assurance Plan is required to be established, implemented and maintained to guarantee the costs of facility closure and post closure care as required by the facility permit and the solid waste rules. The closure and post closure cost estimates are provided with this application as an appendix to the Closure Plan in Section VIII. Granite State Landfill, LLC will provide the required bonds to cover the costs of Stage 1 Cell 1 of the landfill development at a later date.

*Section X*

# *Performance History*

# Section X – Performance History

Granite State Landfill, LLC is submitting the Personal and Business Disclosure Forms separate from this application to the New Hampshire Department of Justice/Office of Attorney General. A copy of the Notice of Filing for these forms are included in Section IV of this application.