# CONSTRUCTION QUALITY ASSURANCE / CONSTRUCTION QUALITY CONTROL PLAN

**CARROLL LANDFILL**

**CARROLL, NEW YORK**

SEALAND WASTE, LLC

**Prepared on behalf of:**

**Sealand Waste, LLC**
85 High Tech Drive
Rush, New York 14543

**Prepared by:**

**DAIGLER ENGINEERING P.C.**
2620 Grand Island Blvd.
Grand Island, New York 14072-2131

**March 2012**
**Last Revised October 2015**

# CONSTRUCTION QUALITY ASSURANCE / CONSTRUCTION QUALITY CONTROL PLAN

**CARROLL LANDFILL**

**CARROLL, NEW YORK**

SEALAND WASTE, LLC

**Prepared on behalf of:**

**Sealand Waste, LLC**
85 High Tech Drive
Rush, New York 14543

**Prepared by:**

DAIGLER ENGINEERING P.C.
2620 Grand Island Blvd.
Grand Island, New York 14072-2131

**March 2012**
**Last Revised October 2015**

**CONSTRUCTION QUALITY ASSURANCE /**
**CONSTRUCTION QUALITY CONTROL PLAN**
CARROLL LANDFILL

Sealand Waste, LLC

# TABLE OF CONTENTS

# TABLE OF CONTENTS

# TABLE OF CONTENTS

# TABLE OF CONTENTS

# TABLE OF CONTENTS

## List of Tables



## List of Figures

**follows**



## List of Appendices

# 1 INTRODUCTION

Sealand Waste, LLC (Sealand), a private enterprise headquartered in Rush, New York, is proposing to purchase the 53.9-acre parcel of land containing the existing Jones Carroll Landfill, a Construction and Demolition (C&D) Debris landfill in the Town of Carroll, Chautauqua County, New York from Carol L. Jones. The site is located on Dodge Road in the Town of Carroll, Chautauqua County, New York, approximately one mile north of the New York/Pennsylvania State line.

Sealand intends to continue the land disposal activity beyond the three acre limit identified in the most recent New York State Department of Environmental Conservation (NYSDEC) Permit (#9-0624-00025/00002-0 expired October 31, 2007). In support of the land disposal operation, the facility will also include stormwater and leachate management infrastructure, C&D waste recycling and yard waste composting operations. This Construction Quality Assurance/Construction Quality Control Plan discusses the quality assurance and quality control requirements for construction of the baseliner and the final cover systems, as well as the post construction care procedures for the constructed baseliner. This Plan has been prepared to meet the intent of Section 2.8 of the 6 NYCRR Part 360 Regulations, as referred to by 360-7.4(a)(3), for those components.

Construction Quality Assurance and Construction Quality Control have been defined in the 6 NYCRR Part 360 Regulations, as follows:

- Construction quality assurance (CQA) means a planned system of activities that provides assurance that the facility was constructed as specified in the design. CQA includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. CQA refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications and Permit for the project. This can also include quality control for those actions taken before construction to ensure that the materials chosen and workmanship comply with the Department approved engineering plans, reports, and specifications.

- Construction quality control (CQC) means a planned system of inspections that are used to directly monitor and control the quality of a construction project. CQC includes those actions normally performed by the contractor and installer to achieve the highest quality in the constructed or installed system. CQC refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project.

- Conformance Testing refers to testing completed by the QA Engineer.

The purpose of the CQA/CQC Plan is to develop systematic procedures to assure and document that design and permit requirements are properly implemented during construction. The Plan presents procedures that will be used in the construction of the following elements:

- Double composite baseliner system;
- Final cover system; and,
- Mechanically stabilized earth (MSE berms).
- The CQA/CQC Plan presents the management organization, personnel and laboratory requirements, testing protocols, and requirements for documentation and record keeping demonstrating that construction of the landfill components referenced herein will be completed in conformance with Subdivision 3607.4(b) of the Solid Waste Management Facilities Regulations.

The CQA/CQC Plan for construction of the landfill and related facilities addresses the procedures that will be employed by parties independent of the Contractors or Subcontractors to assure and document that the design and permit requirements are properly implemented. Any significant changes in the specifications, materials, test methods, etc. for the construction of the landfill will be submitted to the New York State Department of Environmental Conservation (NYSDEC or Department) for approval.

Appendix A includes the Technical Specifications for the critical project components, and Appendix B provides a summary of construction stakeout and record survey requirements.

# 2 MANAGEMENT ORGANIZATION

## 2.1 GENERAL

Sealand will retain an engineering consulting firm to serve as the Project Engineer. In accordance with Section 360-1.2(b)(121) and subdivision 360-2.8(a) of 6 NYCRR Part 360 Regulations, the Project Engineer must be licensed to practice engineering in the State of New York and will be responsible for observing, documenting, and certifying, without influence from the facility owner, that activities related to quality assurance of the construction of the landfill and related facilities conform with the approved construction plans and specifications, and conditions of the applicable permit to construct and operate.

Sealand will select the engineering consulting firm based on an assessment of detailed qualifications and resumes of the assigned staff that demonstrate the firm's or individual's experience and competence on similar landfill construction and geosynthetic system installations in New York State.

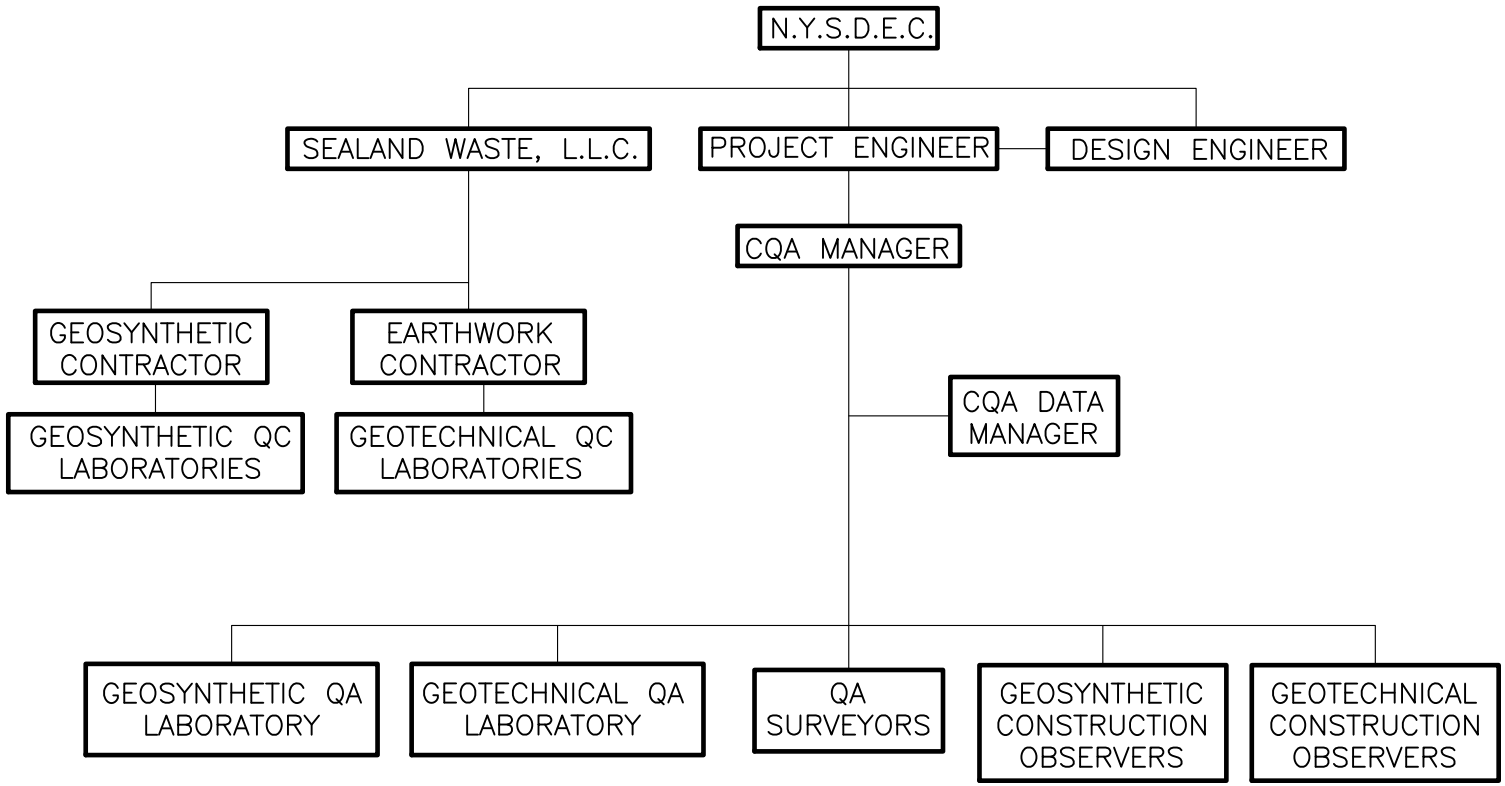
Subordinates of the Project Engineer, the Earthwork Contractor and the Geosynthetic Contractor will be responsible for implementing the requirements of the CQA/CQC Plan. The Project Engineer will also be responsible for supervising the activities of the CQA laboratories.

The management organization to be used for construction of the landfill and related facilities is shown on Figure 2-1 and is described below. Before construction is started, Regional NYSDEC staff will be notified in writing as to what persons/entities will occupy each of the responsible positions identified in Figure 2-1. The lines of communication between the persons/entities identified below are shown on Figure 2-2.

## 2.2 MEETINGS

A pre-construction meeting shall be held upon award of the construction contract with the designated representative of the Owner, Design Engineer, Project Engineer, the Contractors, and Subcontractors. Responsible Region 9 NYSDEC staff will be made aware of the time and place for the pre-construction meeting in advance, in the event Department staff wish to attend.

# CARROLL C&D LANDFILL
# CONSTRUCTION QA/QC MANAGEMENT ORGANIZATION CHART

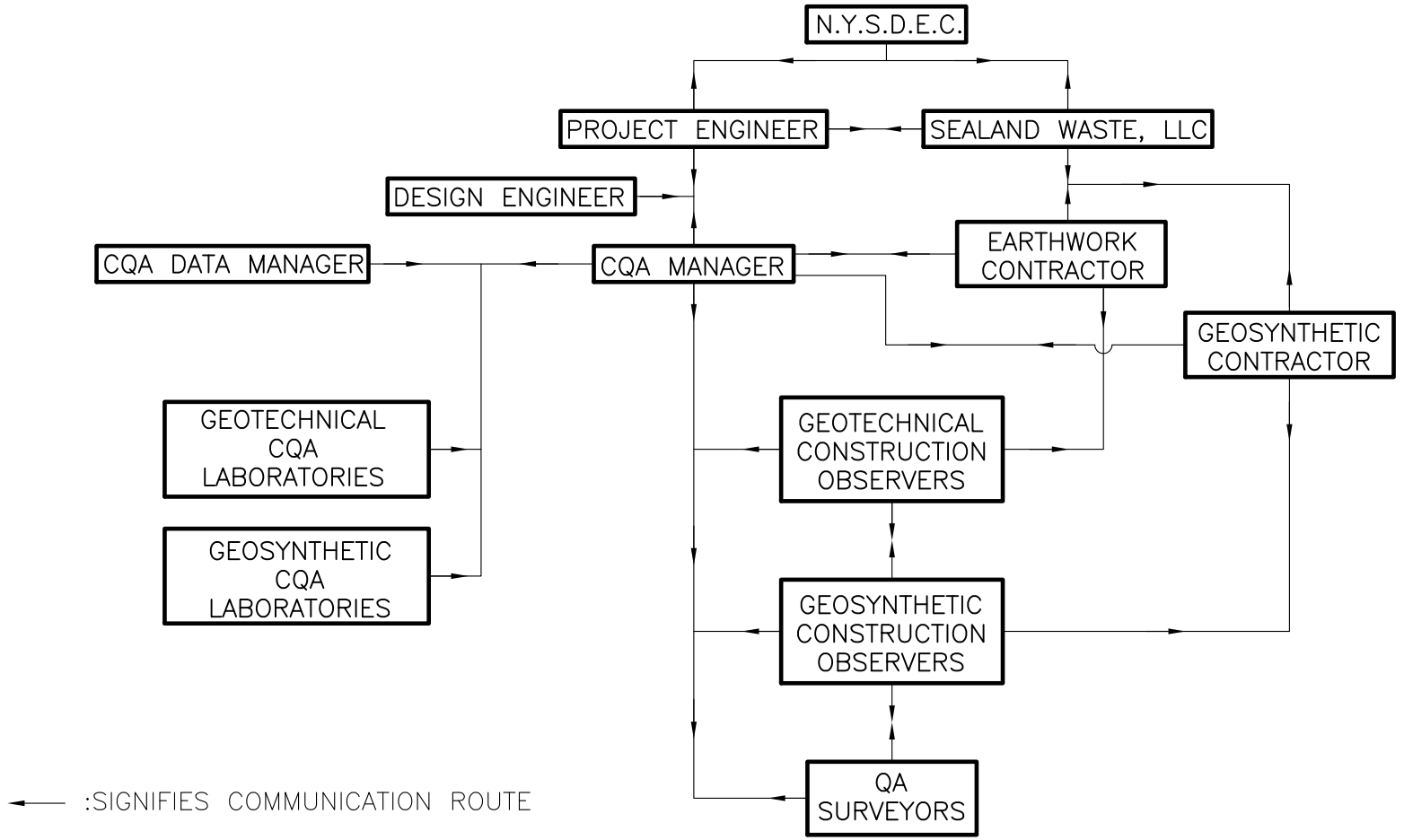





DAIGLER ENGINEERING P.C.
engineering · science · design
1711 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072

| | | | | |
|---|---|---|---|---|
| SEALAND WASTE, LLC | | QA/QC MANAGEMENT ORGANIZATION CHART | | FIGURE 2-1 |
| SCALE: NOT TO SCALE | REVISION # 0 | CARROLL LANDFILL EXPANSION APPLICATION | | |
| June 2014 | | TOWN OF CARROLL | CHAUTAUQUA COUNTY | NEW YORK |

# CARROLL C&D LANDFILL
# LINES OF COMMUNICATION DIAGRAM




DAIGLER ENGINEERING P.C.
engineering · science · design
2620 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072

| | | | | |
|---|---|---|---|---|
| SEALAND WASTE, LLC | | LINES OF COMMUNICATION DIAGRAM<br>CARROLL LANDFILL EXPANSION APPLICATION | | FIGURE 2-2 |
| SCALE: NOT TO SCALE | REVISION # 0 | | | |
| July 2014 | | TOWN OF CARROLL | CHAUTAUQUA COUNTY | NEW YORK |

The following activities will be performed at the pre-construction meeting:

- Provide each involved entity with all relevant CQA/CQC documents and supporting information and address their role relative to the construction tasks and the CQA/CQC Program, especially highlighting the design criteria, the construction plans, and the Technical Specifications;
- Review the responsibilities, authorities, and line of communication for each of the involved entities;
- Review the established procedures for observation and testing, including sampling strategies identified in the CQA/CQC Plan;
- Review the acceptance and rejection criteria as specified in the CQA/CQC Plan and the Technical Specifications, along with the anticipated methods and means for decision making and/or resolution of issues;
- Review methods for documenting and reporting all inspection data and findings;
- Discuss the procedures for storage and protection of construction materials on the site; and,
- Conduct a site tour to review the project site layout and construction material and equipment storage locations.

Before earthwork construction or installation of the geosynthetics begins, and at least weekly thereafter until construction is completed, or more often if determined necessary by the CQA Manager, project coordination meetings will be held with the designated representative of the Earthwork Contractor, Geosynthetics Contractor, Design Engineer, Project Engineer, and Owner in attendance. NYSDEC staff will be made aware of the time and place for routine project meetings in advance in the event Department staff wish to attend.

The following topics, at a minimum, will be discussed during the routine meetings:

- Progress of the work, especially over the past week, problems encountered and corrective measures undertaken;
- Adherence to the Specifications;

- Summary of QA and QC test results – in summary;
- Adherence to the Quality Control Program, including the timely submission of the pertinent forms and submittals; and,
- Planned work and methods for the ensuing week, including estimate of time remaining to complete the work.

The minutes of the meeting will be recorded by the CQA Manager, and will be distributed to the attendees within one week after the meeting.

In the event a post construction meeting is determined to be appropriate, one will be convened. NYSDEC staff will be made aware of the time and place for any post construction meeting in advance, in the event Department staff wish to attend.

## 2.3 CQA/CQC STAFF

### 2.3.1 Project Engineer

The Project Engineer will be employed independently from Sealand (the Owner) and will have overall responsibility for the implementation of the CQA/CQC Plan. The Project Engineer is responsible for independently certifying to the Owner and NYSDEC that, in his or her professional judgment and belief, based on the information acquired by the CQA/CQC staff and inspections performed, the facility has been constructed in accordance with the plans and specifications approved by the NYSDEC.

### 2.3.2 CQA Manager

The CQA Manager will be employed independently from Sealand, and will report directly to the Project Engineer. The CQA Manager or a qualified designate of the Project Engineer, will be present on site at all times during construction activities. The CQA Manager will be responsible for auditing the activities of, and the supervision and management of the CQA Data Manager, Geotechnical and Geosynthetic Construction Observers, QA Surveyors, Geotechnical and Geosynthetic QA Laboratories.

### 2.3.3 CQA Data Manager

The CQA Data Manager will be employed independently from Sealand, and will report directly to the CQA Manager. The CQA Data Manager will be responsible for compiling field and laboratory data into the project related electronic format, primarily using spreadsheet, word processing, and computer aided design and drafting software approved by the Project Engineer. The CQA Data Manager will be responsible for checking that the tracking spreadsheets are complete and accurately reflect the field and laboratory data provided. The CQA Data Manager will be responsible for producing the necessary field forms for use by the field personnel, and will produce summary data tracking forms to be reviewed by the CQA Manager.

### 2.3.4 Construction Observers

The Geosynthetic and Geotechnical Construction Observers may be employed or retained directly by the Project Engineer, or may be retained independently from the Project Engineer as a subcontractor by Sealand, and will report directly to the CQA Manager. The Geosynthetic and Geotechnical Construction Observers will be responsible for observing, testing, and documenting construction activities on a daily basis in accordance with this CQA/CQC Plan.

### 2.3.5 QA Surveyor

The QA Surveyor may be subcontracted by the Project Engineer or may be retained or provided independently from the Project Engineer by Sealand and will report directly to the CQA Manager. The QA Surveyor will be responsible for measuring the constructed dimensions of the facility components as described in this CQA/CQC Plan and as directed by the CQA Manager.

## 2.4 CQA/CQC Laboratories

### 2.4.1 Geotechnical Quality Control Laboratory

The Geotechnical QC laboratory will be responsible for performing all soil related QC testing, as required by this plan or as directed by the Earthwork Contractor or the Project Engineer. The services of the Geotechnical QC Laboratory, which must meet the requirements set forth in this CQA/CQC Plan, may be secured by the Earthwork Contractor or the Project Engineer to complete the testing requirements presented in this plan.

### 2.4.2 Geosynthetic Quality Control Laboratory

The Geosynthetic QC laboratory will be responsible for performing all geosynthetic related QC testing, as required by this plan or as directed by the Geosynthetic Contractor or the Project Engineer. The services of the Geosynthetic CQC Laboratory, which must meet the requirements set forth in this CQA/CQC plan, will be secured by the geosynthetic material manufacturers or the Geosynthetic Contractor to complete the testing requirements presented in this plan. The Geosynthetic QC laboratories may be affiliated with the Geosynthetic Contractor or the material supplier; alternatively, the laboratory may be secured by the Project Engineer to complete the testing requirements presented in this plan.

### 2.4.3 Geotechnical and Geosynthetic Quality Assurance Laboratories

The services of Geotechnical and Geosynthetic Construction Quality Assurance Laboratories will be secured by the Project Engineer to complete the QA testing requirements presented in this CQA/CQC Plan. The selection of the QA laboratories shall be based on a review of the laboratory's quality assurance manual that describes: operating procedures, training requirements, calibration and maintenance procedures, corrective measure protocols and personnel resumes.

The QA laboratories may be affiliated with the Project Engineer or may be subcontracted by the Project Engineer. If the services of the Geotechnical QA laboratory are subcontracted, the laboratory will be independent of Sealand, the Contractor, Subcontractor, or material suppliers. If the services of the Geosynthetic QA laboratory are subcontracted, the laboratory will be independent of Sealand, the manufacturer, fabricator, or installer of geosynthetics at the site.

The Geotechnical and Geosynthetic QA laboratories will complete the required testing as directed by the Project Engineer.

# 3 PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

The pertinent qualifications, experience requirements and responsibilities of each member of the CQA/CQC group are presented below. Resumes for all CQA and CQC staff will include the name and size of all projects that satisfy the experience requirements as outlined by this Plan. All QA and QC laboratories must provide evidence of the required certifications and equipment calibrations to the Project Engineer for review and approval.

## 3.1 PROJECT ENGINEER

### 3.1.1 Qualifications and Experience

The Project Engineer must be a Professional Engineer registered in the State of New York. The Project Engineer must demonstrate past experience in a position of significant responsibility for at least five 10-acre landfill construction projects of similar or greater complexity to the Carroll Landfill project. The Project Engineer must be knowledgeable of the project requirements and objectives, and must be familiar with the Construction Plans, the CQA/CQC Plan, and the Technical Specifications. The Project Engineer will be capable of operating independently and without influence from the construction contractors and the facility owner.

### 3.1.2 Responsibilities

The Project Engineer will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Ultimate responsibility for the implementation of the CQA/CQC Plan;
- Ensure that appropriate technical review is completed by qualified representatives of the Project Engineer for the Construction Plans, Technical Specifications, any modifications to the Plans and Specifications, and the Construction Certification Report;
- Review all design documentation, including the Construction Plans and Technical Specifications;
- Assist the CQA Manager in the review and interpretation of shop drawings and other submittals, field sampling and test results, and laboratory test results on a routine basis;

- Complete periodic site visits to review job quality, progress and CQA/CQC activities; and,
- Together with the CQA Manager, prepare the Construction Certification Report, and endorse it by affixing his/her NYS Professional Engineer stamp or seal to the document.

## 3.2 CQA MANAGER

### 3.2.1 Qualifications and Experience

The CQA Manager shall be employed or retained by the Project Engineer and must have previous experience on at least three 10-acre landfill construction projects of similar or greater complexity to the Carroll Landfill project or previous experience on at least one 10-acre landfill construction project combined with similar experience in managing other quality assurance programs for civil construction projects as approved by the NYSDEC. The CQA Manager must have an engineering technology degree or be certified by the Geosynthetic Certification Institutes – Inspector Certification Program (GCI-ICP), and must have a working knowledge of the quality assurance and quality control testing procedures included in this CQA/CQC Plan. The CQA Manager must have a thorough familiarity with the project, the Construction Plans, the CQA/CQC Plan, and the Technical Specifications.

### 3.2.2 Responsibilities

The CQA Manager will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Serve as the primary contact person for the Project Engineer. Maintain contact with Sealand, the Contractors, and Subcontractors regarding conformance with the requirements of this Plan;
- Review of shop drawings and other submittals from Contractors and Subcontractors for conformance with the Construction Drawings and the Technical Specifications, taking appropriate actions based on that review;
- Forward requests for any proposed modifications of the Construction Drawings, Technical Specifications, and/or CQA/CQC Plan requirements to the Project Engineer;

- Be onsite at times the Geotechnical or Geosynthetic Construction Observers are required to coordinate activities, review progress and monitor procedures; or, coordinate with the Project Engineer to ensure that in the CQA Manager's absence, a qualified designate of the Project Engineer will be present on site[1];
- Be on site for all construction activities;
- Provide coordination of the activities of the Geotechnical and Geosynthetic Construction Observers and overall supervision of construction observers at all times;
- Monitor delivery of appropriate samples to the CQA laboratories for quality assurance testing;
- Coordinate with the Project Engineer to establish sampling procedures including proper sample location, sample size, sample collection protocol and sample numbering system;
- Provide assistance to the Geotechnical and Geosynthetic Construction Observers in the review and interpretation of field and CQA/CQC laboratory testing results on a routine basis. Receive and organize all quality assurance and quality control sampling and test results and check for compliance with specifications. Review test results with Project Engineer to make determination of areas to be reworked or repaired and notify the Contractor and Construction Observers of results;
- Ensure the Construction Observers are informed of any noted deficiencies in quality assurance testing results or procedures so that corrective actions can be taken;
- Review all Daily Construction Reports prepared by the Construction Observers;
- Forward requests for any proposed design modifications to the Design Engineer;
- Organize all field quality assurance and quality control data for the purposes of preparing a weekly data summary as described in this CQA/CQC Plan; and,
- Compile the Construction Certification Report with the assistance of the Geotechnical and Geosynthetic Construction Observers.

[1] This will likely be either the lead Geotechnical and/or lead Geosynthetic Construction Observer

## 3.3 CQA DATA MANAGER

### 3.3.1 Qualifications and Experience

The CQA Data Manager shall be employed or retained by the Project Engineer and have a working knowledge of the quality assurance and quality control testing procedures included in this CQA/CQC Plan and the software used to manage the site data. The CQA Data Manager must have a thorough familiarity with the project, the Construction Plans, the CQA/CQC Plan, and the Technical Specifications.

### 3.3.2 Responsibilities

The CQA Data Manager will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Obtain all field and laboratory data sheets from the CQA Manager after they are reviewed and approved;
- Populate all project related tracking sheets for use by the CQA Manager in documenting the accumulating quality assurance and quality control data;
- Ensure the Construction Observers have a sufficient supply of field forms at the beginning of each day;
- Assist in the shipping and management of samples to the CQA laboratories;
- Assist the CQA Manager in preparing the weekly data summary;
- In the event all the above activities are completed, assist the Construction Observers in completing their work activities; and,
- Work both on and offsite as directed by the CQA Manager.

## 3.4 GEOTECHNICAL CONSTRUCTION OBSERVER

### 3.4.1 Qualifications and Experience

The Geotechnical Construction Observers may be subcontractors retained by Sealand directly, or may be employed by the Project Engineer, and will report directly to the CQA Manager. The

experience levels of the Geotechnical Construction Observers must be approved by the Project Engineer. Through a combination of formal education, training, and experience, the Geotechnical Construction Observer must have at a minimum; demonstrated knowledge of earthwork construction including compacted fine grained structural soil fills, installation of granular fills, aggregates, low permeability soil liners, and applicable testing methods. The Geotechnical Construction Observer must also have a demonstrated knowledge of the installation of manholes, pumping, and piping systems.

The Geotechnical Construction Observers must be familiar with, and trained in, the use and application of Shelby tube sampling methods and nuclear moisture density meters if they are required to obtain undisturbed soil samples or operate a nuclear moisture density meter. Any Geotechnical Construction Observer that operates a nuclear moisture-density gauge must be certified to operate that equipment.

### 3.4.2 Responsibilities

The Geotechnical Construction Observers will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Visually observe construction materials such as soils and piping delivered to the site to determine and document conformance with material specifications;
- Observe and record procedures used for site preparation clearing and grubbing;
- Observe and record procedures used for excavation and filling of subgrade to required elevations;
- Observe and record procedures for placement of structural fill, barrier protection layer soil, drainage layer soils and low permeability soil, including:
    - Lift thickness
    - Method of moisture adjustment (if applicable)
    - Compaction procedures (if applicable)
    - Proof-rolling (if applicable)

- Fine grading

- Perform soil moisture and density testing, as established in the CQA/CQC Plan;
- Assign locations and obtain samples of low permeability soil liners for quality assurance testing;
- Assign locations and collect samples of other soils and aggregates for quality assurance testing;
- Provide for delivery of quality assurance samples to the CQA laboratory or the CQA Manager;
- Record any onsite activities that could result in damage to any earthwork or site improvements, such as compacted subgrade, low permeability soils, or geosynthetic reinforcement, and report these activities to the Contractor, Subcontractor and the CQA Manager; and;
- Prepare daily construction reports as described in this CQA/CQC Plan.

## 3.5 GEOSYNTHETIC CONSTRUCTION OBSERVER

### 3.5.1 Qualifications and Experience

The Geosynthetic Construction Observers may be subcontractors retained by Sealand directly, or may be employed by the Project Engineer, and will report directly to the CQA Manager. The experience levels of the Geosynthetic Construction Observers must be approved by the Project Engineer. Through a combination of formal education and experience, the Geosynthetic Construction Observer must have at a minimum; demonstrated knowledge of environmental construction projects including manufacturing, installation, and testing methods for geosynthetics.

### 3.5.2 Responsibilities

The Geosynthetic Construction Observers will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Visually observe construction materials such as geomembranes, geotextiles, geosynthetic clay liners, geocomposite drainage layer, geogrid, and open mesh geosynthetic delivered to the site to determine and document conformance with the material specifications;
- Observe and record condition of subgrade prior to placement of all geomembranes;
- Observe and record procedures for stockpiling, storage, and handling of geosynthetic materials delivered to the site;
- Observe and record procedures used for installation of geomembranes;
- Visually observe all geosynthetics after installation for compliance with the requirements of this CQA/CQC Plan;
- Observe and record procedures used for installation of all liner penetrations;
- Conduct final inspection of geomembranes immediately prior to placement of cover materials;
- Observe that panel placement is in accordance with the approved panel plan;
- Observe that permanent and temporary anchoring procedures are followed;
- Observe and record procedures used for seaming. Observe and record that the area of seam is clean, supported, and overlap and seam widths are in accordance with this CQA/CQC Plan;
- Observe and record that all required field-seaming tests are performed. Observe and record that all areas with deficient seams are marked for repair;
- Observe and record procedures used for all repairs;
- Assign locations and obtain samples for quality assurance testing;
- Provide for delivery of quality assurance samples to the CQA laboratory or the CQA Manager;

- Record any onsite activities that could result in damage to geomembranes or other geosynthetics, and report these activities to the Contractor, Subcontractor, and the CQA Manager; and,
- Prepare daily construction reports as described in this CQA/CQC Plan.

## 3.6 GEOSYNTHETICS CONTRACTOR

### 3.6.1 Qualifications and Experience

The Geosynthetics Contractor must have previous experience in the installation of geosynthetic liner systems. The field crew foreman must have a documented minimum qualification of successful installation experience on at least 50 acres of landfill or comparable geosynthetic system construction from a minimum of five different projects. Geomembrane seaming personnel must have a documented minimum qualification of successful installation experience on at least 30 acres of landfill or comparable geomembrane liner system construction.

## 3.7 EARTHWORK CONTRACTOR

### 3.7.1 Qualifications and Experience

The Earthwork Contractor may be Sealand's own construction group, or may be subcontracted by Sealand and must have previous experience in the placement of low permeability soil liners, structural fills, and drainage systems. The Earthwork Contractor's field supervisor must have as a minimum, successful experience on at least 50 acres of landfill or comparable low permeability soil liner system construction, including the installation of manholes, pumping, and piping systems.

### 3.7.2 Responsibilities

The Earthwork Contractor will have the following responsibilities in the implementation of the CQA/CQC Plan:

- Receive and stockpile all materials required for the project prior to construction;

- Site preparation including but not limited to; excavation, grubbing and clearing, grading, compaction of soils and proof-rolling;
- Managing stormwater; trenching, installing piping and pumping systems as well as manholes;
- Communicating closely with CQA Manager and Geosynthetic Contractor to ensure that construction is in accordance with this CQA/CQC Manual and all technical specifications.

# 4 CQA/CQC LABORATORIES

## 4.1 GEOTECHNICAL CQA/CQC LABORATORIES

The Geotechnical CQA/CQC Laboratories must have experience in testing low permeability soil, granular fills and aggregates, and be familiar with ASTM test standards and Army Corps of Engineers test procedures for permeability, as required in this CQA/CQC Plan. The Geotechnical CQA/CQC Laboratories must be capable of providing permeability test results within 48 hours of receipt of any sample. The Geotechnical CQA/CQC laboratories must submit an acceptable Quality Assurance Plan to the Project Engineer to demonstrate that the laboratory has the capability to complete the quality control testing required in this CQC/CQC Plan. The Quality Assurance Plan shall include certification and calibration information pertaining to equipment to be utilized in the testing.

The Geotechnical CQA/CQC Laboratories are responsible for performing all tests and formally submitting results to the Project Engineer as required in this CQA/CQC Plan.

## 4.2 GEOSYNTHETIC CQA/CQC LABORATORIES

The Geosynthetic CQA/CQC Laboratories must have experience in testing geosynthetics, and must conform to ASTM, GRI and other applicable test standards. The Geosynthetic CQA/CQC laboratories must submit an acceptable Quality Assurance Plan to the Project Engineer to demonstrate that the laboratory has the capability to complete the testing required in this CQA/CQC Plan. The Quality Assurance Plan shall include certification and calibration information pertaining to equipment to be utilized in the testing.

The Geosynthetic CQA/CQC Laboratories are responsible for performing all test procedures in accordance with this CQA/CQC Plan and formally submitting results to the Project Engineer.

# 5 CQA/CQC PROTOCOLS

## 5.1 GENERAL

The testing protocols to be used during construction of the landfill and related facilities are presented on the following pages. The protocols address the following elements of construction:

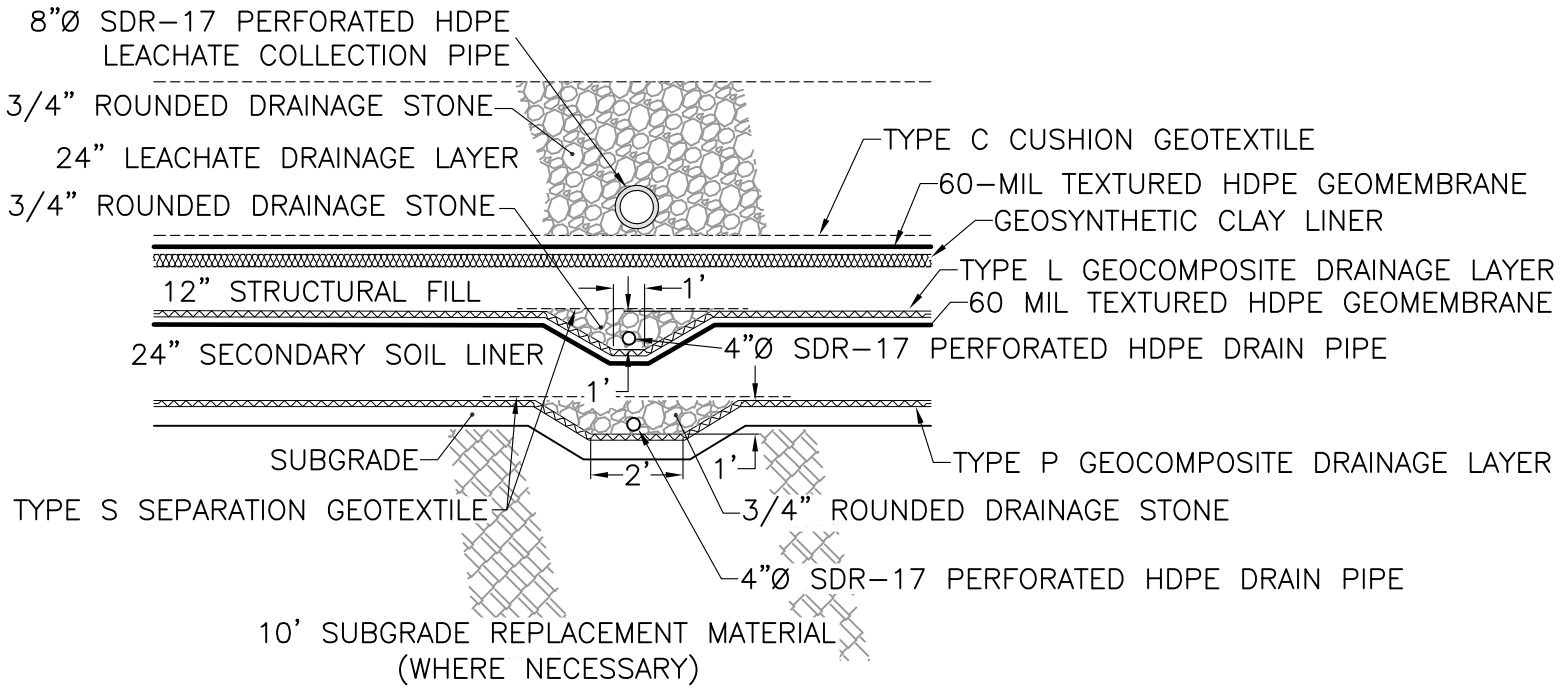
- Earthwork;
- Geosynthetics; and,
- Piping.

When applicable, the protocols describe the following testing requirements for each of the elements of construction:

- Field testing procedures to be used;
- Field testing equipment to be used;
- Frequency of field testing;
- Sampling procedures to be used;
- Sampling equipment to be used;
- Frequency of sampling for laboratory testing; and,
- Acceptable limits for field and laboratory testing results.

A majority of the requirements presented herein address the construction of the baseliner system, and the final cover system. The baseliner system, as shown on Figures 5-1 and 5-2 consists of the following components in ascending order:

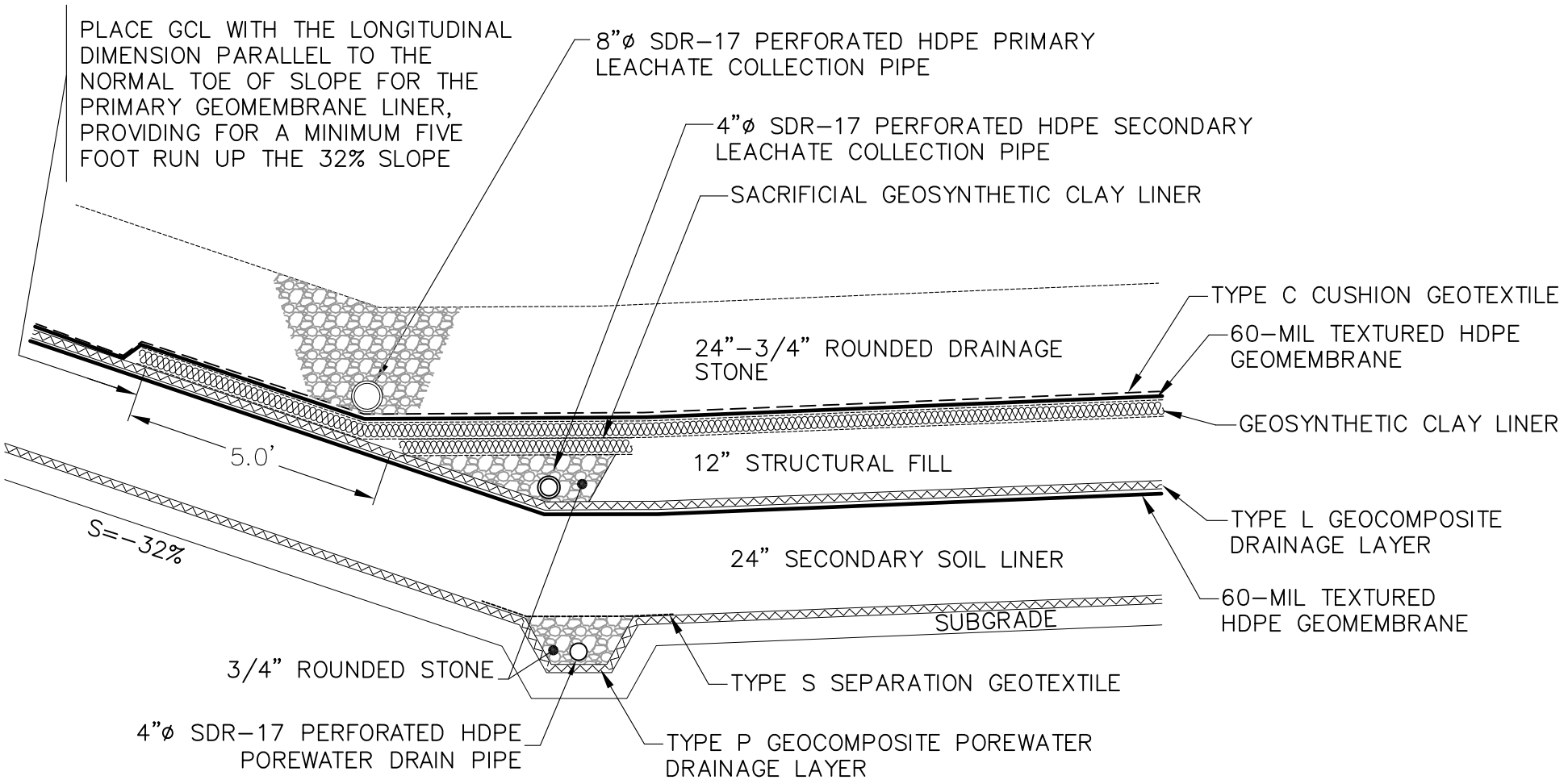
- Prepared subgrade;
- 48-inch minimum Subgrade Replacement Material (where shown on the applicable Construction Drawings);
- Geocomposite porewater drain (where shown on the applicable Construction Drawings);






DAIGLER ENGINEERING, P.C.
CIVIL & GEO-ENVIRONMENTAL ENGINEERING
2620 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072

| | | | | |
|---|---|---|---|---|
| SEALAND WASTE, LLC | | DOUBLE COMPOSITE LINER SYSTEM DETAIL<br>CARROLL LANDFILL EXPANSION APPLICATION | | FIGURE 5-1 |
| SCALE: NOT TO SCALE | REVISION # 1 | | | |
| February 2015 | | TOWN OF CARROLL | CHAUTAUQUA COUNTY | NEW YORK |



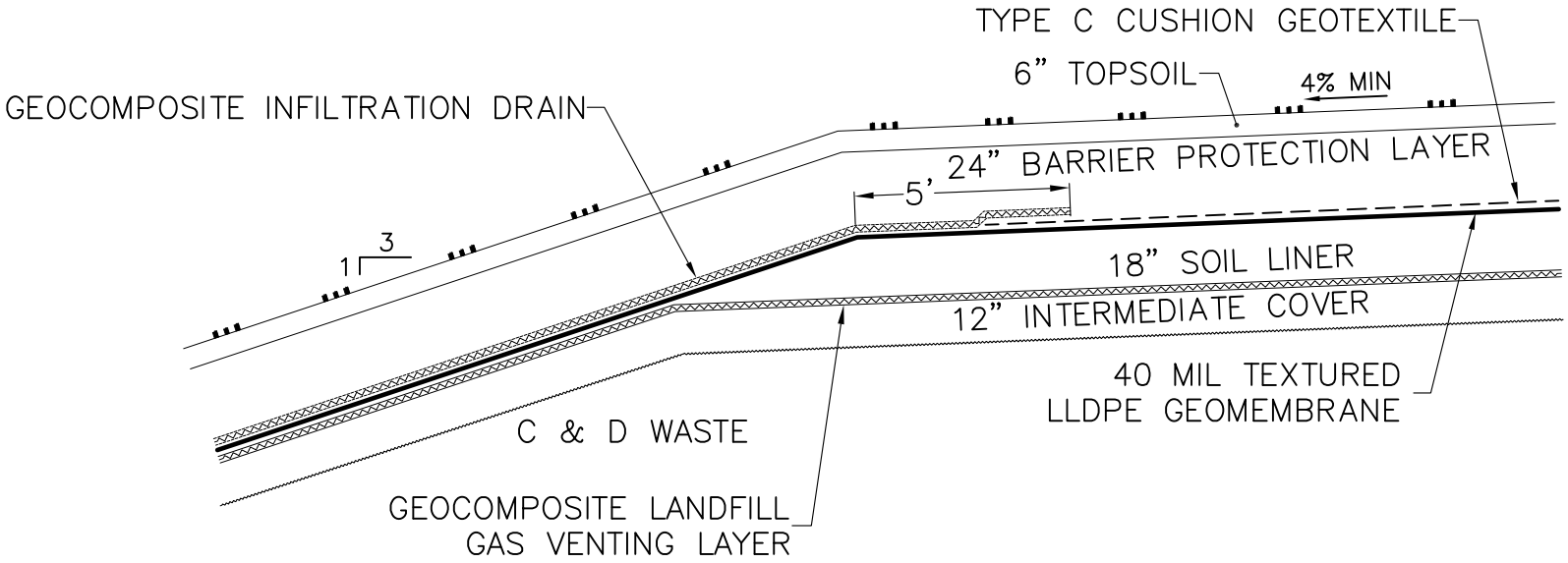

DAIGLER ENGINEERING, P.C.
CIVIL & GEO-ENVIRONMENTAL ENGINEERING
1711 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072

| | | | | |
|---|---|---|---|---|
| SEALAND WASTE, LLC | | DOUBLE COMPOSITE LINER AT TOE OF SLOPE<br>CARROLL LANDFILL EXPANSION APPLICATION | | FIGURE 5-2 |
| SCALE: NOT TO SCALE | REVISION # 0 | | | |
| February 2015 | | TOWN OF CARROLL | CHAUTAUQUA COUNTY | NEW YORK |

- 4-inch SDR-17 perforated HDPE subgrade surface drain pipe within a one-foot by two-foot, separation geotextile wrapped, ¾" drainage stone envelope (where shown on the applicable Construction Drawings);
- 24-inch (minimum) low permeability secondary soil liner;
- 60-mil textured High Density Polyethylene (HDPE) secondary geomembrane liner;
- Geocomposite drainage layer with embedded 4-inch diameter SDR-17 perforated HDPE secondary leachate collection pipe, backfilled with ¾" rounded drainage stone, covered by a separation geotextile;
- 12-inch minimum structural fill layer (only on slopes of 25% or less);
- Geosynthetic Clay Liner (only on slopes of 25% or less);
- 60-mil textured HDPE primary geomembrane liner;
- Cushion geotextile;
- 8-inch diameter SDR-17 perforated HDPE primary leachate collection pipe network, and;
- 24-inch (minimum) ¾-inch rounded drainage stone layer.

The proposed final cover system, as shown on Figure 5-3, consists of the following components in ascending order:

- 12-inch intermediate cover layer;
- Geocomposite landfill gas venting layer;
- 18-inch (minimum) low permeability soil liner (only on slopes less than 25%);
- 40-mil textured LLDPE geomembrane liner;
- Geocomposite infiltration drain (slopes equal to greater than 25%) or cushion geotextile (slopes less than 25%);
- 24-inch (minimum) barrier protection soil layer;
- 6-inch (minimum) layer of topsoil;
- Vegetation; and,




DAIGLER ENGINEERING, P.C.
CIVIL & GEO-ENVIRONMENTAL ENGINEERING
1711 GRAND ISLAND BLVD GRAND ISLAND, NEW YORK 14072

| | | | | |
|---|---|---|---|---|
| SEALAND WASTE, LLC | | FINAL COVER SYSTEM DETAIL | | FIGURE 5-3 |
| SCALE: NOT TO SCALE | REVISION # 0 | CARROLL LANDFILL EXPANSION APPLICATION | | |
| February 2015 | TOWN OF CARROLL | CHAUTAUQUA COUNTY | NEW YORK | |

- Surface water channels and erosion controls.

## 5.2 TOLERANCES

Certain slope, elevation, and thickness tolerances will be adhered to during construction to help ensure the performance requirements of the containment systems are met. These tolerances are described in the Construction Stakeout and Record Survey Requirements summary included as Appendix B.

## 5.3 CHANGES TO APPROVED DOCUMENTS

A Field Change Log shall be maintained onsite during landfill construction to record proposed field changes. Substantive changes from the approved documents must be approved by the design engineer. Proposed changes also shall be submitted to the NYSDEC and approval by the NYSDEC must be received in writing prior to implementation. All required approvals will be incorporated into the Field Change Log. Upon completion of the project the Field Change Log will become part of the Construction Certification Report.

## 5.4 SOIL QA/QC

### 5.4.1 Test Method Reference

Test methods for all soil materials are in accordance with procedures developed by the American Society of Testing and Materials (ASTM) or the U.S. Army Corps of Engineers. Table 5-1 lists those tests that may be required in the course of this project and the accepted test method reference. Substitution of a method other than that specified in Table 5-1 for a particular test is subject to the approval of the Project Engineer. Also, the use of test methods for those tests not listed in Table 5-1 that are deemed necessary for the work are subject to the approval of the Project Engineer.

### 5.4.2 Inspection of Work

Evaluation of soil placement consists primarily of observation of the quality of workmanship and soil materials used in performance of the work, observation of lift thickness, investigations into the adequacy of layer bonding and, field sampling and testing.

All field and laboratory tests will be conducted on soils included in the actual construction product. The thickness of the soil portions of the liner systems will be checked by observing the number and compacted thickness of the lifts, a review of the record survey information and/or verification by manual exploration. The soils will be placed to the thickness indicated on the Construction Drawings, as a minimum.

Initial sampling of soil sources will include procurement of bulk samples for testing in accordance with Table 5-2. Each sample collected for laboratory analysis will be approximately 50 pounds. The portion of the sample targeted for moisture content determination will be shipped in a moisture tight container.

## TABLE 5-1: ACCEPTED REFERENCES FOR TESTING OF SOILS

| Test | Reference |
|---|---|
| Standard Test Method for Particle-Size Analysis of Soils | ASTM D-422-63 (2007) |
| Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis | ASTM D-6913-04(2009) |
| Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer | ASTM D-854-06e1 |
| Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75-m) Sieve | ASTM D-1140-00(2006) |
| Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/$ft^3$ (2,700 kN-m/$m^3$)) | ASTM D-1557-09 |
| Standard Test Method for Unconfined Compressive Strength of Cohesive Soil | ASTM D-2166-06 |
| Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock By Mass | ASTM D-2216-05 |
| Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading | ASTM D-2435-04 |
| Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils | ASTM D-4767-04 |
| Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) | ASTM D-2487-06e1 |
| Standard Test Method for Unconsolidated- Undrained Triaxial Compression Test on Cohesive Soils | ASTM D-2850-03a(2007) |
| Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) | ASTM D-6938-08a |
| Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions | ASTM D-3080-04 |
| Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils | ASTM D-4318-05 |
| Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter | ASTM D-5084-03 |
| Constant Head Permeability Test (in Triaxial Cell with Back Pressure Saturation – Low Permeability Soils) | EM-1110-2-1906 |
| Standard Test Method for Permeability of Granular Soils (Constant Head) | ASTM 2434-68 (2006) |

**TABLE 5-2: TESTING FOR QUALITY EVALUATION OF SOILS**

| Test | Minimum Frequency |
|---|---|
| **A. Subgrade Replacement Material** | |
| 1. Modified Proctor moisture-density relationship | 1 per 5,000 ccy[(1)] of material in-place or every change in source |
| 2. Moisture content | 1 per 1,000 ccy of material in-place or every change in source |
| 3. Grain size distribution | 1 per 2,500 ccy of material in-place or every change in source |
| 4. Liquid and plastic limits | 1 per 1,000 ccy of material in-place or every change in source |
| 5. Laboratory recompacted permeability | 1 per 5,000 ccy of material in-place or every change in source |
| 6. Moisture-density permeability relations | 1 per 5,000 ccy of material in-place or every change in source |
| 7. Moisture-density with nuclear densometer | 9 per acre per lift |
| 8. Laboratory permeability on undisturbed sample from SRM | 1 per acre per lift |

| **B. Soil Liner** | Pre-Use | During Construction |
|---|---|---|
| 1. Grain size distribution | 1 per 5,000 ccy | 1 per 5,000 ccy |
| 2. Liquid and plastic limits | 1 per 2,000 ccy | 1 per 2,000 ccy |
| 3. Laboratory recompacted permeability | 1 per 5,000 ccy | when material change occurs |
| 4. Modified Proctor moisture-density relationship | 1 per 5,000 ccy | when material change occurs |
| 5. Moisture content | 1 per 2,000 ccy | 1 per 2,000 ccy |
| 6 Moisture-density permeability relations | 1 per 5,000 ccy | when material change occurs |
| 7. Moisture-density with nuclear densometer | ---- | 9 per acre per lift |
| 8. Laboratory permeability on undisturbed sample from soil liner | ---- | 1 per acre per lift |

| Test | Minimum Frequency | |
|---|---|---|
| **C. Primary Leachate Drainage Stone** | | |
| | Pre-Use | During Construction |
| 1. Particle-Size Analysis | 1 per 2,000 cy | 1 per 2,000 cy |
| 2. Laboratory Permeability | 1 per 5,000 cy | 1 per 5,000 cy |
| **D. Structural Fill and Barrier Protection Soil** | | |
| 1. Modified Proctor Moisture-Density Relationship | 1 per 5,000 ccy of material in-place or every change in source | |
| 2. Moisture Content | 1 per 1,000 ccy of material in-place or every change in source | |
| 3. Grain Size Distribution | 1 per 2,500 ccy of material in-place or every change in source | |
| 4. Atterberg Limits | 1 per 1,000 ccy of material in-place or every change in source | |
| 5. Moisture-Density with Nuclear Densometer | 9 per acre per lift for liner structural fill and 1 per 75 feet of embankment structural fill | |
| 6. Direct Shear or Consolidated Drained Triaxial Shear (MSE Embankment Structural Fill only) | 1 per 15,000 ccy of material in-place or every change in source | |

(1) ccy is a compacted cubic yard placed in the work

All pre-construction testing data will be obtained by testing soils from stockpiles or sources to be utilized in the construction. The pre-construction testing data will be reviewed and approved by the Project Engineer, who will also develop the moisture-density-permeability relationships for distribution to the CQA Manager, Sealand, and the NYSDEC prior to the commencement of low permeability soil construction activities. When obvious changes in soil character are observed, the variation in soil properties must be determined by additional testing.

Inspection of the work will include some or all of the following depending on the level of testing required for each specific soil layer.

- Measurement of the moisture content and dry density of the compacted soil by nuclear density/moisture gauge per the requirements for each soil type;
- Collection of undisturbed soil samples at a frequency of one per acre per lift from low permeability soil liner and Subgrade Replacement Material for confirmatory laboratory permeability testing;
- Measurements of the thickness of lifts, as loosely placed and compacted at a frequency of at least three per acre per lift;
- Observation of the effects of the compaction and heavy hauling equipment on the previously placed lifts (pumping, cracking, etc.);
- Randomly observing the number of passes by compaction equipment used to compact soil lifts;
- Obtaining measurements of slope and finish grades to ensure tolerance and design requirements are met;
- Observing the intermediate cover to ensure that waste materials, organic and other undesirable soils are removed prior to placement of the geocomposite landfill gas venting layer;
- Noting any changes in color, texture or moisture content of soils;
- Checking for desiccation cracks prior to placement of subsequent soil layers or geosynthetics;

- Inspecting the soils for the presence of roots, stumps, and large rocks; and,
- Observation and documentation of the Earthwork Contractor's operation.

## 5.4.3 Subgrade Preparation

### 5.4.3.1 Construction

The Earthwork Contractor is responsible for subgrade preparation which consists of grading and proof-rolling the subgrade surface, and removing any unsuitable material as required (Section 02222 of the Technical Specifications). Once the CQA Manager confirms that the Earthwork Contractor has prepared the subgrade to within the elevation and slope tolerance limits (Appendix B), a Geotechnical Construction Observer will inspect and record the soil conditions.

A Geotechnical Construction Observer will observe and document proof rolling of the subgrade surface, using a compactor in static mode, for the purpose of detecting unsuitable materials. Unsuitable materials are defined as excessively wet or soft soils that inhibit successful compaction of the overlying soil lifts or placement of geosynthetics. The reaction of the proof rolled surface will be observed as the compacter passes over the subgrade at walking speed. Permanent ruts or indentations that result in a breaking apart or significant cracking of the soil surface, or, that based on the judgment of the CQA Manager or Project Engineer, may prevent the proper placement of overlying layers, will identify a failing area. The Geotechnical Construction Observer will establish the aerial extent of any unsuitable material, and will determine the probable cause of the failing proof rolling results. The appropriate remedial actions will be taken; including but not necessarily limited to:

- Moisture adjustment (drying);
- Additional compaction;
- Surface water drainage or relief of excessive pore pressure by the extension of the subgrade surface drain system; or,
- Removal and replacement of unsuitable soils.

In the event unsuitable materials are removed, they will be excavated to a maximum depth of two feet and replaced with Structural Fill placed in accordance with Section 02224 of the Technical Specifications.

#### 5.4.3.2 Acceptance

The dry density and moisture content of the subgrade soil will be measured at a minimum frequency of nine tests per acre. The soil moisture and density measurements will be obtained using a nuclear densometer at a probe depth of 12 inches, unless otherwise approved by the Project Engineer. The results of the in-place soil moisture and density testing will be documented and summarized in the Certification Report.

Before placing any material over the subgrade, record survey measurements will be obtained to confirm the slope and elevation tolerances required by the construction stakeout and record survey requirements in Appendix B have been met. The record survey will also be used to help control the grade and thickness of overlying liner system components. The lead Geosynthetics Construction Observer and the Geosynthetic Contractor must certify all subgrade surfaces covered by a geosynthetic have met the project requirements by signing a subgrade acceptance form, an example of which is provided as Figure 5-4.

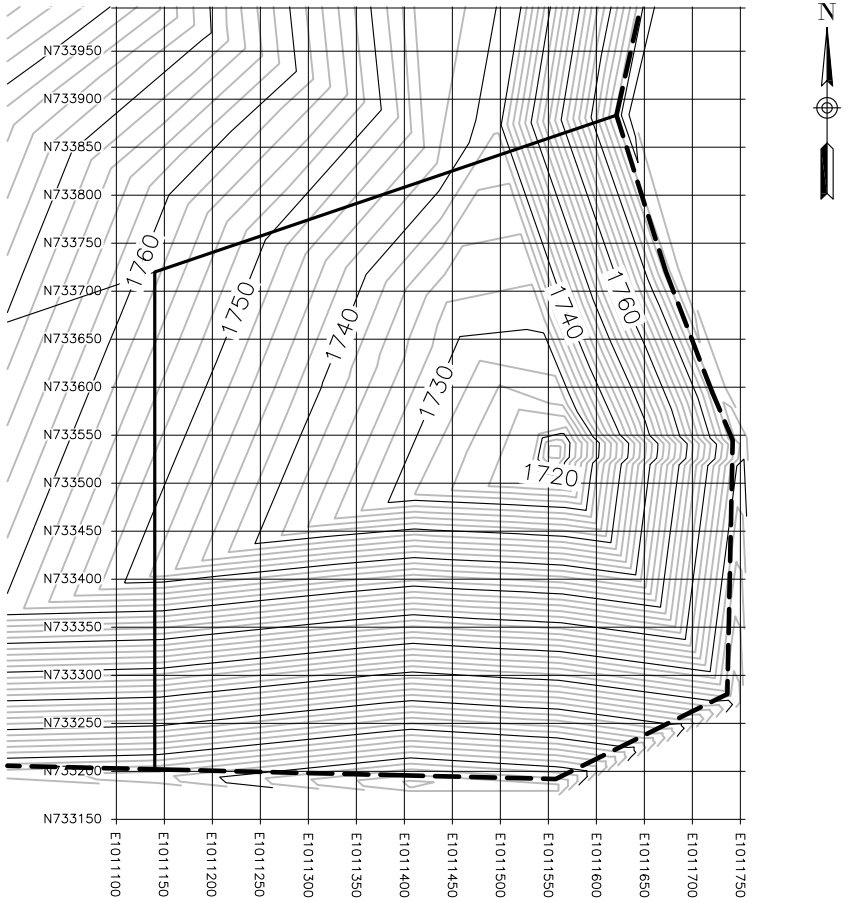
### 5.4.4 Low Permeability Soils

#### 5.4.4.1 General

Low permeability soil includes the Subgrade Replacement Material (SRM), required to achieve a permeability no greater than $5 \times 10^{-6}$ cm/sec, the secondary soil liner in the baseliner system, as well as the soil liner in the final cover system, both required to achieve a permeability no greater than $1 \times 10^{-7}$ cm/sec, and the containment pad of the Composting and C & D Processing Operation Facilities. The SRM will be placed in areas where the design subgrade surface lies within four feet of the highly weathered shale (HWS) as shown in the Construction Drawings. The minimum compacted thickness of the SRM layer shall be 48 inches. The 24-inch secondary soil liner in the baseliner system will be placed immediately below the 60-mil textured HDPE secondary geomembrane liner. The 18-inch soil liner in the final cover system will be placed immediately below the 40-mil textured LLDPE geomembrane liner. The 12-inch minimum

GEOMEMBRANE SUBGRADE ACCEPTANCE CERTIFICATION

I HEREBY CERTIFY THAT I HAVE INSPECTED THE GEOMEMBRANE SUBGRADE IN THE AREA OUTLINED ON THIS FORM, AND FIND THE CONDITION OF THIS GEOMEMBRANE SUBGRADE TO BE ACCEPTABLE AT THE TIME OF ITS PLACEMENT.
I ALSO CERTIFY THAT THE SURFACE COVERED BY THE _____ IS FREE OF EXCESS MOISTURE, AND SUBSTANTIALLY CLEARED OF LOOSE SOIL, SHARP OBJECTS, STONES, STICKS, OR ANY MATERIALS THAT MAY CONTRIBUTE TO PUNCTURES, SHEARING, RUPTURING OR TEARING OF THE MATERIAL.
THE _____ GEOMEMBRANE SUBGRADE HAS A SMOOTH, FINISHED SURFACE, FREE FROM POCKETS, HOLES, RUTS, AND DISCONTINUITIES THAT WILL CAUSE BRIDGING OF THE MATERIAL




| | |
|---|---|
| GEOSYNTHETIC CONTRACTOR NAME: | GEOMEMBRANE SUBGRADE ACCEPTANCE FORM<br>SEALAND WASTE, LLC.<br>CARROLL LANDFILL EXPANSION |
| GEOSYNTHETIC CONTRACTOR SIGNATURE: | |
| GEOSYNTHETIC CONSTRUCTION OBSERVER NAME: | CQA/CQC PLAN |
| GEOSYNTHETIC CONSTRUCTION OBSERVER SIGNATURE: | ACTIVITY: _____GEOMEMBRANE PLACEMENT |
| DATE: | |

FIGURE 5-4

thickness of recompacted, low-permeability soil of the containment pad will be overlain by a 12 to 18-inch thick layer of 1 to 3-inch aggregate material, and will make up the un-loading, loading and storage areas of the composting and recycling facilities. Initial sampling of low permeability soil sources will include procurement of bulk samples for testing in accordance with Table 5-2.

#### 5.4.4.2 Test Pad Requirements

For any soil and equipment type combination that has not previously been used successfully at the site, one test pad shall be completed by the Earthwork Contractor for the purpose of confirming acceptable construction procedures. The test pad will be constructed on a slope representative of the average bottom slope of the low permeability soil; and if 3H:1V slopes are included in the construction, a second test pad shall be constructed on the 3H:1V grade to simulate soil construction on those steeper slopes.

The test pad shall be constructed with the same equipment to be used to construct the low permeability soil, and shall be at least 30 feet wide and 80 feet long, or as required to allow equipment to reach normal operating speed. The thickness of the lifts shall be the maximum lift thickness to be placed and compacted during low permeability soil installation. The CQA Manager and the Geotechnical Construction Observer shall observe test pad construction, obtain the required data, assess the acceptability of construction procedures and prepare a report to document the findings as detailed in Section 02277 of the Technical Specifications. The required data obtained from the test pad are detailed in Paragraph 4.2.B of the Test Pad Technical Specification (Section 02277), including laboratory testing for liquid and plastic limit, modified Proctor moisture-density relationship, grain-size distribution, and permeability; as well as, field measurements of soil moisture and density, and a visual assessment of the effectiveness of any kneading action in the soil matrix, and soil clod destruction.

#### 5.4.4.3 Construction

Low permeability soil will be placed in lifts with a maximum compacted thickness as demonstrated to be acceptable by previous successful use of the specific soil and equipment type combination proposed for the work, or that is demonstrated to be acceptable by the test pad procedure. In no event shall the lift thickness exceed nine inches.

Compaction will be performed by properly controlling soil moisture content, lift thickness, and compaction energy/kneading action to effectively control soil clods. Clods greater than four inches, in longest dimension will be removed or broken apart prior to final compaction of material.

If the surface of a soil lift is too dry to prevent proper bonding with the next soil lift, then the surface will be scarified and moistened before the succeeding lift of soil is placed thereon. If the lift contains excessive moisture as determined by the CQA Manager, the surface will be scarified and allowed to dry to within an acceptable moisture range. Irrespective of moisture conditions, scarification of the surface of each lift will always be performed prior to placement of the succeeding soil lift to enhance lift bonding.

The upper surface of the low permeability soil will be thoroughly inspected for desiccation cracks in excess of one-half inch. The upper surface will be reworked and scarified to the depth of the desiccation cracks prior to placement of the overlying materials if such desiccation cracks are present.

#### 5.4.4.4 Acceptance

The Geotechnical Construction Observer will measure the moisture and density of the low permeability soil with a nuclear densometer. Field moisture density testing will be performed on the completed low permeability soil lifts at a rate of not less than one test for each day of placement, and at least nine tests per acre per lift overall. The dry density and moisture content values for each test will be plotted on the moisture-density-permeability acceptance window developed in the pre-qualification testing program to help confirm the low permeability soil meets the project requirements.

Additional testing for suspected non-compliance areas will be considered when:

- Soil is placed at variable moisture content;
- As directed by the Project Engineer or CQA Manager;
- Adverse weather conditions are experienced;
- Regrading of existing layers has been performed; or,

- The work area is reduced causing testing frequency to increase to assure quality of placement.

Any low permeability soil moisture and density measurement which falls outside the acceptable moisture-density-permeability window will be considered a failed test, and all failed test areas will be retested. Additional soil moisture and density measurements will be obtained to delineate unacceptable low permeability soil areas, or the reworking and retesting will extend to the nearest passing tests. Prior to retesting any area, the Geotechnical Construction Observer will determine the probable cause of the failed soil moisture and density measurements and the appropriate action will be taken; including, but not necessarily limited to:

- Moisture adjustment;
- Additional compaction; or,
- Removal and replacement of soil layers.

When either or both of the first two steps are taken, all retests will be obtained on the same lift as close as is practicable to the original test location using the same methods used to locate the original test. All retests will be performed in as close a position to the original failed test location as can be reasonably ascertained by the Geotechnical Construction Observer. When the third option is taken, all retests will be performed at a rate of nine tests per acre per lift; or, one every 4,840 square feet.

Routine in-place soil moisture and density testing will be supplemented by laboratory permeability tests on undisturbed Shelby tube samples or block samples, as appropriate. One constant head laboratory permeability test result will be obtained per acre per lift of low permeability soil. The intent of the sampling program will be to obtain specimens from the lowermost portion of each lift. The number of undisturbed samples that do not penetrate the full thickness of the low permeability soil lifts will be limited to 25% of the total number of samples; that is, if less than 75% of the samples obtained at any one time are not representative of the lowermost portion of the lift, alternate and/or more intensive sampling efforts must be implemented to achieve that rate. The Earthwork Contractor will rework, or remove and replace any material with a permeability result greater than that required by the Technical Specifications.

The in-place soil moisture and density measurements and undisturbed samples will be collected in an array that produces an even distribution of the test results across the area of construction, and from lift to lift in a fashion that does not result in "stacking" of the results (i.e., that when plotted, the sample locations from one lift to the next would not normally occur directly above or below other locations). Following permeability specimen sampling or nuclear moisture and density measurements, the resulting hole will be filled with powdered bentonite and tamped. Observational test pit excavations will be backfilled with the excavated material and compacted using the same procedures as required by the initial lift placement.

Low permeability soil layer thickness must meet the "minimum" specifications as shown on the Construction Drawings, and must be consistent with the tolerance requirements in Appendix B.

## 5.4.5 Primary Leachate Drainage Layer

### 5.4.5.1 General

The primary leachate drainage layer will consist of a 24-inch thick, hard and durable ¾-inch rounded stone. The drainage stone will have an initial minimum permeability of 10 cm/sec after final placement. The primary leachate drainage layer will be placed in a single two-foot thick lift. Dump trucks delivering stone to the cell construction will travel only on roadways constructed of a minimum of three feet of drainage stone. Drainage stone material making up these temporary roadways that is not contaminated with fines will be regraded and incorporated into the primary leachate drainage layer.

### 5.4.5.2 Acceptance

The quality control and quality assurance testing of the drainage stone will be conducted at the frequencies indicated in Table 5-2. As shown, one-half of the samples will be obtained subsequent to final placement.

The density of the specimen used in a select number of the post placement permeability tests will be recorded by the laboratory as directed by the CQA Manager. Random field density testing of the completed primary leachate drainage layer will be performed at the CQA Manager's discretion to compare against the lab density. A comparison of the results of this random field

density testing to the laboratory density will provide the CQA Manager a means to determine whether the required permeability is still available in the reworked layer.

The primary leachate drainage layer thickness must meet the "minimum" specification as shown on the Construction Drawings and as described in the Construction Stakeout and Record Survey Requirements included in Appendix B. The thickness of the primary leachate drainage layer will be checked by the record survey and random probes, auger holes or excavations at a frequency of at least three per acre. All excavations in the primary leachate drainage layer must be backfilled with in-kind material.

### 5.4.6 Structural Fill and Barrier Protection Soil

#### 5.4.6.1 General

Liner structural fill will be installed over the secondary leachate collection and removal geocomposite drainage layer in the baseliner system. Structural fill will also be used for the construction of drainage swales, embankments, and at other locations as indicated in the Construction Drawings. The 24-inch barrier protection soil layer of the final cover system will be installed over the cushion geotextile or the geocomposite infiltration drain. The structural fill and barrier protection soil layers will be free of organic materials, refuse, rubble, metal, wood, or other objectionable materials which may be compressible, degradable, or cannot be properly compacted. These soils will have physical properties such that they can be readily spread and compacted to the required density. The maximum particle size of these materials will be no larger than nine inches. The lower six inches of the barrier protection soil shall be reasonably free of stone to protect the underlying geosynthetics, if present.

#### 5.4.6.2 Acceptance

Initial sampling of structural fill and barrier protection soil sources will include procurement of bulk samples for testing in accordance with Table 5-2.

All structural fill placement shall be in accordance with the requirements of Section 02224 of the Technical Specifications. Field soil moisture and density measurements shall be performed at a

minimum frequency of at least nine tests per acre per 12-inch lift over the entire area of structural fill placement.

The barrier protection soil will be placed in lifts with a maximum compacted thickness of 12-inches by mechanical spreaders and compacted with a kneading type compactor to effectively break soil clods, and to achieve a minimum dry density as determined by the Project Engineer. Field soil moisture and density measurements shall be performed if required by the Project Engineer.

## 5.5 GEOSYNTHETIC QA/QC

### 5.5.1 Geomembrane Liners

#### 5.5.1.1 General

The textured high density polyethylene (HDPE) geomembrane in both the primary and secondary liners of the baseliner double composite system shall have a nominal thickness of 60-mil. A textured 40-mil (nominal) linear low density polyethylene (LLDPE) geomembrane liner shall be installed as part of the final cover system. The geomembrane liners will be installed to the lines and grades, as indicated on the approved Construction Drawings. The final cover system must extend beyond the limit of waste, as determined in the field.

#### 5.5.1.2 Materials

The properties of the geomembranes will meet the requirements indicated in Tables 5-3 and 5-4, per GRI GM-13 and GRI GM-17 respectively, as demonstrated by the results of tests performed on samples of material included in the work.

The HDPE geomembrane and welding rod or pellets shall be manufactured from a pure virgin polyethylene resin, having a density between 0.932 and 0.939 grams per cubic centimeter. The LLDPE geomembrane and welding rod or pellets shall be manufactured from a pure virgin polyethylene resin having a density of less than 0.926 grams per cubic centimeter. The virgin resins shall be mixed with two to three percent carbon black. The carbon black is to be pre - blended according to specifications of the geomembrane manufacturer.

Extruded sheets will be at least 20 feet in width (or greater depending on standard widths available from manufacturer). Geomembrane will be continuously inspected by the manufacturer for uniformity, damage, imperfections, holes, cracks, thin spots, and foreign materials.

#### 5.5.1.3 Material Acceptance

Prior to the delivery of geomembrane and welding rod or pellets to the site, the Geosynthetic Contractor will be required to provide the Project Engineer with a written certification that the product to be delivered has been extruded from the approved resin. Certification shall be provided for each resin lot, or at the rate normally performed by the resin manufacturer. The parameters necessary for certification of the geomembrane are listed in the Geomembrane MQA/MQC Tables in Paragraph 2.3.B of the Technical Specification Sections 02597 and 02598. The HDPE sheet manufacturer shall supply all standard chemical compatibility test data on the specified geomembrane using leachate representative of that anticipated to be generated at the site.

The Project Engineer will arrange for conformance test samples to be obtained either at the location of manufacture, or at the project site as requested by the Owner. Samples will be obtained at the frequencies listed in Tables 5-3 and 5-4, and the samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties required by this CQA/CQC Plan. The parameters for conformance testing shown in Table 5-3 and 5-4 are required for all membrane rolls that arrive onsite. Conformance sampling and testing of the welding rod and/or pellets will be performed with a testing frequency of three tests per welding project.

## TABLE 5-3: 60 MIL HDPE GEOMEMBRANE CONFORMANCE TESTING – MINIMUM FREQUENCY REQUIREMENTS

| PROPERTY | TEST METHOD | TEXTURED SHEET VALUE | CONFORMANCE TESTING FREQUENCY (sq. ft.) |
|---|---|---|---|
| Core Thickness, mil | ASTM D5994 | 60, nominal (-5%) | 150,000 |
| Asperity Height, mil (min. avg.) | ASTM D7466 | 16 | 150,000 |
| Density, g/cm$^3$ (min. avg.) | ASTM D1505/D792 | 0.94 | 150,000 |
| Tensile Properties (min. avg.) (both directions) | ASTM D6693 | | 150,000 |
| Yield strength, lb./in. | | 126 | |
| Break strength, lb./in. | | 90 | |
| Yield elongation, % | | 12 | |
| Break elongation, % | | 100 | |
| Carbon Black Content, % (min. avg.) | ASTM D1603/D4218 | 2.0 - 3.0 | 150,000 |
| Carbon Black Dispersion | ASTM D5596 | Note (1) | 150,000 |
| Standard Oxidative Induction Time, minutes (min.) | ASTM D3895 | 100 | 1,200,000 |
| Tear Resistance, lb (min. avg.) | ASTM D1004 | 42 | 150,000 |
| Puncture Resistance, lb (min. avg.) | ASTM D4833 | 90 | 150,000 |

Notes:

1) Carbon Black dispersion for 10 different views, with at least nine in Categories 1 or 2; one (max.) in Category 3.

**TABLE 5-4: 40 MIL LLDPE GEOMEMBRANE CONFORMANCE TESTING – MINIMUM FREQUENCY REQUIREMENTS**

| PROPERTY | TEST METHOD | TEXTURED SHEET VALUE | CONFORMANCE TESTING FREQUENCY (sq. ft.) |
|---|---|---|---|
| Core Thickness, mils | ASTM D5994 | 40 mil, nominal (-5%) | 150,000 |
| Asperity Height, mils (min. avg.) | ASTM D7466 | 16 | 150,000 |
| Density, g/cm$^3$ (max.) | ASTM D1505/D792 | 0.939 | 150,000 |
| Tensile Properties (min. avg.) (both directions)<br>Break strength, lb./in.<br>Break elongation, % | ASTM D6693 | <br>60<br>250 | 150,000 |
| Carbon Black Content, % (min. avg.) | ASTM D1603/D4218 | 2.0 - 3.0 | 150,000 |
| Carbon Black Dispersion | ASTM D5596 | Note (1) | 150,000 |
| Standard Oxidative Induction Time, minutes (min.) | ASTM D3895 | 100 | 1,200,000 |
| Tear Resistance, lb (min. avg.) | ASTM D1004 | 22 | 150,000 |
| Puncture Resistance, lb (min. avg.) | ASTM D4833 | 44 | 150,000 |

Notes:

1) Carbon Black dispersion for 10 different views, with at least nine in Categories 1 or 2; one (max.) in Category 3.

In addition to the conformance testing, minimum interface shear strength shall be tested upon installation per ASTM D6243 and must meet the requirements shown on the Construction Drawings. The Geosynthetic QA/QC Laboratory will complete interface shear testing of the liner system components under saturated conditions and normal stresses as will be encountered in the landfill area under construction. Peak, residual, and large strain (minimum of three inches) shear strength will be reported by the Laboratory. A change in material will require additional testing. The interface shear strength testing shall be conducted at a rate of one per material combination per construction season.

Upon delivery, the Geosynthetic Construction Observer will visually inspect all material to be included in the work for transport damage and uniformity, and will compare roll identification numbers with those identified by the manufacturer for delivery, or itemized on the certification provided by the manufacturer to assure delivery of the appropriate material. The Project Engineer will review the data and the Geosynthetic Construction Observers reports for final material acceptance. The Geosynthetic Construction Observer will obtain archive samples that are a minimum of three feet long by three feet wide.

#### 5.5.1.4 Installation

For the geomembrane components of the liner systems, field seams will be one of two weld types; dual-track fusion or extrusion, as specified in Technical Specification Sections 02597 and 02598. The Geosynthetic Contractor must provide all of the necessary information with respect to proposed seaming method(s) to permit the Project Engineer to evaluate the intended technique. No deviation from the approved seaming methods will be permitted.

Prior to delivery of the geomembrane to the site, the Geosynthetic Contractor must provide the Project Engineer a panel diagram indicating the proposed geomembrane panel layout for his approval. This diagram must be in sufficient detail to provide an accurate representation of the field seaming that will be performed. The proposed layout of panels shall assure efficiency of material, minimization of welds and proper placement of welds. Any revision to the panel diagram that may be proposed by the Geosynthetic Contractor must be submitted to the Project Engineer in writing for approval prior to installation operations that may conflict with the previously approved diagram.

Installation shall conform to the requirements of appropriate Technical Specification (Section 02597 or 02598). Any deviations from the Technical Specification will require previous approval by the Project Engineer.

Geomembrane shall not be placed on an unsuitable surface. Geomembrane will not be installed when sheet temperatures are below 32°F or exceed 158°F, when ambient air temperature is less than 32°F or exceeds 120ºF, during precipitation or when winds exceed 20 mile per hour unless

appropriate measures are taken such as use of shelters, heaters, or windscreens, as previously approved by the Project Engineer.

Based on the approved geomembrane panel installation diagram and material certifications, the installed panels will be numbered and seams will be identified by using the panel numbers that create the seam. Writing on panels will be done using two different colors; one color for CQA personnel, and a different color for the Geosynthetic Contractor.

No ATVs will be allowed on the geomembrane.

#### 5.5.1.5 Acceptance

The Geosynthetic Contractor and Geosynthetic Construction Observer will approve the underlying layer before the installation of the geomembranes, and both will be required to sign a Geomembrane Subgrade Surface Acceptance Form as shown in Figure 5-4. Acceptance of the surface for installation of each panel or series of panels placed must occur on a daily basis. The following conditions will be minimal for the surface acceptance:

- No significant amounts of loose soil or stones, no stones greater than one-inch in any dimension, and no sharp objects shall be present on the surface to be lined;
- The surface will have a smooth finished surface. There shall be no loose soil or stone beneath the geomembrane. The surface should not be pebbly or tracked and rutted by equipment. Any rutting in excess of one inch must be repaired. The surface shall be free from pockets, holes, and discontinuities which will cause bridging which would, in the judgment of the Geosynthetic Construction Observer, overstress the liner;
- The surface shall not be excessively wet or in any condition which will impede proper installation. Under no condition shall the geomembrane be placed over standing water; and,
- No membrane shall be placed on areas where desiccation cracks exist or the soil has softened due to precipitation.

The Geosynthetics Contractor will be required to conduct both destructive and non-destructive testing during the geomembrane installation as part of the CQA/CQC program. The required

tests and pass/fail criteria are discussed in the Technical Specifications (Sections 02597 and 02598).

Trial seam procedures and testing must be observed by the Geosynthetic Construction Observer, and the pass/fail criteria shall be as required by the Technical Specifications. The entire sample will be considered a failed sample if one or more of the shear or peel test specimens do not meet the requirements. The field tensiometer used to complete the peel and shear testing shall be capable of maintaining a constant grip separation rate and shall be adjustable to operate in the ranges identified in the Technical Specifications. A Certificate of Calibration for the field tensiometer that is less than six months old must be provided to the CQA Manager.

The Geosynthetic Construction Observer must observe and document the proper setup of the equipment prior to completing trial seams. For hot wedge welders, this shall include:

1. The hot wedge, or "anvil," should be inspected to see that it is symmetrically balanced and gradually tapered. It is imperative that the wedge has no sharp edges on any surface that contacts the geomembrane during the welding process;

2. The chain drive powering any portion of the welder should be synchronized, properly lubricated, and physically sound;

4. Contour roller heights are adjustable to allow for varying geomembrane thickness. Normal adjustments are made while the welder is at ambient temperature. The procedure is as follows:

    - Insert two material samples into the nip drive rollers;

    - Place two other material samples above and below the wedge;

    - Lock the wedge into its operating position by shifting the wedge forward, into the clutch of the upper and lower nip rollers;

    - Adjust the contour rollers until they are snug against the liners, which sandwich the wedge to assure proper roller pressure;

- Set the maximum distance that the wedge can move into the nip rollers (unsecured, the wedge might make direct contact with the nip rollers when the machine has no geomembrane material running through it and damage the machine);

- The forward face of the welding machine should be inspected for sharp corners and irregular details which may damage the geomembrane as it advances during the seaming process; and,

- Temperature controllers on the wedge device should be set according to geomembrane thickness, ambient temperature, and seaming rate. Temperature gauges should be checked for accuracy and repeatability.

For extrusion welders:

- Ensure the proper shoe is attached to the gun, and it is in a clean condition;
- Check and record pre-heat air temperature;
- Check and record extrusion screw temperature;
- Purge gun to remove old material from chamber; and,
- Warm Teflon shoe by running unit along scrap material prior to trial welding.

The Geosynthetic Construction Observer will observe all geomembrane seaming and all seam testing on a real time basis. Seaming equipment, seaming conditions, site conditions, and seaming and inspection personnel will be documented. The machine and operator for each seam will be documented.

The Geosynthetics Contractor will be required to complete non-destructive testing of all seams along the entire length in the manner approved prior to installation, in the presence of the Geosynthetic Construction Observer. One of three recommended test methods; pressurized air channel, vacuum box, or spark, must be used as detailed in the Technical Specifications. All seams made by dual-track fusion welding must employ the pressurized air channel test. Vacuum box testing is to be used on extrusion welded seams. Spark testing may be used on short, detail extrusion welds that cannot be tested by vacuum box.

Destructive seam samples shall be obtained from the installed liner system at a frequency of one sample per 500 linear feet of seam. In the case where extrusion seaming equipment is started solely for patching, a destructive sample of the in-place welds will only be obtained if more than 250 feet of seaming is accomplished in one day, or at the discretion of the CQA Manager. Any seam that is reconstructed must be sampled destructively as well. The Geosynthetic Construction Observer will be responsible for determining the location of any destructive seam sample. The resulting hole in the installed liner shall be covered with an oval cornered patch overlapping the edge of the hole by a minimum of six inches, and seamed in accordance with the requirements for extrusion welding.

Specimens that will be subject to peel and shear testing shall be selected alternately from the sample. All peel tests shall be performed on the upper weld track for dual track fusion welds. The laboratory shall report the locus of break code for each specimen according to ASTM D6392. The test results will be reported in "ppi" (pounds-per-inch of width). The pass/fail criteria for the tests will be as stated in Paragraph 4.2 of Section 02597 or 02598 of the Technical Specifications and the entire sample will be considered a failed sample if one or more of the shear or peel test specimens do not meet the requirements.

All inadequate seams or portions thereof, as demonstrated by failing non-destructive or destructive tests, will be corrected in accordance with the Technical Specifications. Reconstructed seams must be destructively tested at a frequency of one test per 500 feet of reconstructed seam.

## 5.5.2 Geocomposites

### 5.5.2.1 General

The current landfill design incorporates four geocomposite layers. The geocomposites will be placed above the subgrade where a porewater drain is required, on top of the 60-mil textured HDPE secondary geomembrane of the baseliner system, immediately beneath the 40-mil LLDPE textured geomembrane or soil liner in the final cover system to act as a landfill gas venting layer, and on top of the 40-mil textured LLDPE geomembrane liner in the final cover system on slopes greater than 25% to control infiltration.

The geocomposites will consist of an HDPE geonet with non-woven geotextiles heat-bonded to each side of the geonet. The material properties, conformance testing requirements, and installation methods will be the same for all four geocomposite layers.

#### 5.5.2.2 Materials

The geocomposite panels will be manufactured from first quality virgin materials. The material properties of the geocomposite will meet the requirements indicated in Tables 5-5, as demonstrated by the results of tests performed on samples of material included in the work.

**TABLE 5-5: GEOCOMPOSITE CONFORMANCE TESTING – MINIMUM FREQUENCY REQUIREMENTS**

| TYPE | PROPERTY | TEST METHOD | VALUE | CONFORMANCE TESTING MIN FREQUENCY (sq. ft.) |
|---|---|---|---|---|
| GEONET | Density, g/cm$^3$ (min. avg.) | ASTM D1505/D792 | 0.940 | 100,000 |
| | Carbon Black Content, % (min. avg.) | ASTM D1603-3/D4218 | 2.0 - 3.0 | 100,000 |
| | Thickness | ASTM D5199 | 270±15 | 100,000 |
| GEOTEXTILE | Mass per Area, oz/sq. yd. (min. avg.) | ASTM D5261 | 6.0 | 100,000 |
| | Puncture Resistance, lbs (min. avg.) | ASTM D4833 | 95 | 400,000 |
| | UV Resistance, % Strength/hrs (min. avg.) | ASTM D4355 | 70/500 | See Note 2 |
| | AOS, mm (max. avg.) | ASTM D4751 | 0.212 | 540,000 |
| | Grab Tensile Strength, lbs (min. avg.) | ASTM D4632 | 160 | 100,000 |
| | Grab Elongation, % (min. avg.) | ASTM D4632 | 50 | 100,000 |
| | Permittivity, sec$^{-1}$ (min. avg.) | ASTM D4491 | See Note 1 | 540,000 |
| | Mullen Burst Strength, psi (min. avg.) | ASTM D3786 | 330 | 400,000 |
| | Trapezoidal Tear Strength, lbs (min. avg.) | ASTM D4533 | 65 | 400,000 |
| GEOCOMPOSITE | Ply Adhesion, lb/in (min. avg.) | ASTM D413 | 0.5 | 150,000 |

Notes:

1) The minimum permittivity must be equivalent to a permeability two orders of magnitude greater than the adjacent soil material.
2) The Manufacturer shall provide evidence of any representative UV Resistance testing on the polymer used in the manufacture of the geotextile that is satisfactory to the Project Engineer.

In addition to the conformance testing, performance testing to include minimum interface shear strength and transmissivity shall be completed upon installation per ASTM D6243 and D4716, respectively, and must meet the requirements shown on the Construction Drawings. The Geosynthetic QA/QC Laboratory will complete these tests of the liner system components under saturated conditions and normal stresses as will be encountered in the landfill area under

construction. Peak and large strain (minimum of three inches) shear strength will be reported by the Laboratory. A change in material will require additional testing. The interface shear strength and transmissivity testing shall be conducted at a rate of one per material combination per construction season.

The Project Engineer will arrange for conformance test samples to be obtained either at the location of manufacture, or at the project site as requested by the Owner. Conformance samples will be obtained at the frequency listed in Table 5-5 and the samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties required by this CQA/CQC Plan.

The geocomposite manufacturer will identify all material delivered to the site with a weatherproof label located on the outside end of the wrapping material. This label will include all information required by Section 02599 of the Technical Specifications. Each roll of product will include any additional information required to allow the CQA Manager to relate that roll with the manufacturing quality control and raw material quality control documentation.

Upon delivery, the Geosynthetic Construction Observer will examine the rolls of geocomposite and obtain archive samples; and if not already obtained, conformance test samples. The Geosynthetic Contractor will be required to provide the CQA Manager with the manufacturer's written certification that the geocomposite delivered to the site meets or exceeds the minimum properties required for the project. This certification must be supported by the MQA/MQC test documentation developed during the manufacture of the delivered material. The CQA Manager will examine all results from laboratory testing. Geocomposite material will be rejected if it does not meet the minimum property requirements or if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the Geosynthetic Construction Observer.

#### 5.5.2.3 Installation

The Geosynthetics Contractor will be responsible for the condition and acceptability of the underlying surface prior to placement of the geocomposite layer. The geocomposite layers will be installed to the lines and grades shown on the Construction Drawings in accordance with the requirements of the Technical Specifications. Adjacent geocomposite panels shall be joined as

required by Section 02599 of the Technical Specifications. No geocomposite material will be permitted to remain exposed directly to sunlight for more than 30 days.

Tracked equipment or any other equipment that may pose a risk of puncturing, tearing, or otherwise damaging the installed work will not be permitted to operate on the geocomposite. There must be three feet of separation provided before any equipment with wheels is allowed to pass over the geocomposite.

All cover materials will be placed in such a manner to ensure:

- Soil does not accumulate in the geonet portion of the geocomposite;
- The geocomposite and underlying liner materials, where present, are not damaged;
- Minimal slippage of the geocomposite on underlying layers; and,
- No excess tensile stresses develop in the geocomposite.

## 5.5.3 Geotextiles

### 5.5.3.1 General

Geotextiles will address three different functions in construction of the baseliner and final cover systems. A separation geotextile will be used to wrap the subgrade surface drain and placed between the ¾" drainage stone of the porewater drainage trench and the secondary soil liner. A separation geotextile will also be placed between the ¾" drainage stone of the secondary leachate collection and removal trench and the structural fill. Finally, a cushion geotextile will be used to protect the HDPE primary geomembrane liner from the leachate drainage layer stone and the LLDPE geomembrane liner from the barrier protection soil. Each geotextile will be of the same type, a 10 oz non-woven needle-punched product, as described in Section 02595 of the Technical Specifications.

### 5.5.3.2 Materials

The geotextile will be manufactured from first quality virgin materials. Material requirements for the geotextiles are as listed in Table 5-6. The Project Engineer will arrange for conformance

test samples to be obtained either at the location of manufacture, or at the project site as requested by the Owner. Conformance samples will be obtained at the frequency listed in Table 5-6 and the samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties required by this CQA/CQC Plan.

The geotextile manufacturer will identify all material delivered to the site with a weatherproof label located on the outside end of the wrapping material. This label will include all information required by Section 02595 of the Technical Specifications. Each roll of product will include any additional information required to allow the CQA Manager to relate that roll with the manufacturing quality control and raw material quality control documentation.

Upon delivery, the Geosynthetic Construction Observer will examine the rolls of geotextile and obtain archive samples; and if not already obtained, conformance test samples. The Geosynthetic Contractor will be required to provide the CQA Manager with the manufacturer's written certification that the geotextile delivered to the site meets or exceeds the minimum properties required for the project. This certification must be supported by the MQA/MQC test documentation developed during the manufacture of the delivered material. The CQA Manager will examine all results from laboratory testing. Geotextile material will be rejected if it does not meet the minimum property requirements or if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the Geosynthetic Construction Observer.

**TABLE 5-6: GEOTEXTILE CONFORMANCE TESTING – MINIMUM FREQUENCY REQUIREMENTS**

| PROPERTY | TEST METHOD | VALUE | CONFORMANCE TESTING MIN FREQUENCY (sq. ft.) |
|---|---|---|---|
| Weight per Area<br>- oz/sq. yd. (min. avg.) | ASTM D5261 | 10 | 150,000 |
| Grab Tensile Strength<br>- lbs (min. avg.) | ASTM D4632 | 250 | 150,000 |
| Grab Elongation (1)<br>- % (min.avg.) | ASTM D4632 | 50 | 150,000 |
| Trapezoidal Tear Strength<br>- lbs (min. avg.) | ASTM D4533 | 100 | 150,000 |
| CBR Puncture Resistance<br>- lbs (min. avg.) | ASTM D6241 | 700 | 150,000 |
| UV Resistance<br>- % Strength/hr (min. avg.) | ASTM D4355 | 70 | N.A. |
| AOS<br>- mm (max. avg.) | ASTM D4751 | 100 | 540,000 |
| Minimum Friction with Material above and below | ASTM D5321 | See note 2 | Once per Project |
| Permittivity<br>- $sec^{-1}$ (min. avg.) | ASTM D4491 | See Note 4 | 540,000 |

Notes:

1) Geotextile shall be non-woven, needle punched.
2) The minimum interface shear strength requirements shall be as shown in the Construction Drawings.
3) The Manufacturer shall provide evidence of any representative UV Resistance testing on the polymer used in the manufacture of the geotextile that is satisfactory to the Project Engineer.
4) The minimum permittivity must be equivalent to a permeability two orders of magnitude greater than the adjacent soil material.

### 5.5.3.3 Installation

The surface to be covered by the geotextile will be cleared of sharp objects, boulders, sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The surface to be covered will be graded as smooth as is practicable. The subgrade will be inspected for unstable areas or soft spots before the geotextile is placed and additional surface preparation will be required to eliminate any unstable areas as determined by the Geosynthetic Construction Observer.

Geotextile shall be laid smooth and free of excess tension, stress, folds, wrinkles, or creases. Geotextiles shall be joined by field sewing, unless otherwise approved by the Project Engineer.

A minimum depth of 12 inches of soil will be maintained at all times between the geotextile and any low ground pressure vehicles. Three feet of soil must be in place to allow any wheeled vehicle to travel over the geotextile.

If the geotextile develops any holes or tears, they must be repaired by the appropriate method depending on the slope on which the geotextile is installed as detailed in Section 02595 of the Technical Specifications. No geotextile material will be permitted to remain exposed directly to sunlight for more than 30 days after installation.

## 5.5.4 Geosynthetic Clay Liner

### 5.5.4.1 General

A geosynthetic clay liner (GCL) will be placed directly below the 60-mil textured HDPE primary geomembrane to the lines and grades, as indicated on the approved Construction Drawings, including a minimum five foot run up the 32% slope. The GCL will consist of a factory manufactured composite of low permeability bentonite clay supported on both sides by geotextile which is held together by gluing, needling or stitching.

### 5.5.4.2 Materials

The GCL will be manufactured from first quality virgin materials. Specifications for the GCL are as listed in Table 5-7. The bentonite used in the GCL shall be a natural, granular, sodium bentonite. Powdered bentonite shall not be used in the manufacture of the GCL. At a minimum, the bentonite portion of the GCL shall be subjected to Manufacturing Quality Assurance (MQA) testing for swell index and fluid loss by the GCL manufacturer as detailed in the Technical Specification, Section 02278.

**TABLE 5-7: GEOSYNTHETIC CLAY LINER CONFORMANCE TESTING – MINIMUM FREQUENCY REQUIREMENTS**

| PROPERTY | TEST METHOD | VALUE | CONFORMANCE TESTING MIN FREQUENCY (sq. ft.) |
|---|---|---|---|
| Bentonite Mass, lbs/sq. ft. (min. avg.) | ASTM D5993 | 0.75 | 150,000 |
| Max Permeability, cm/sec (min. avg.) | ASTM D5887 | $5.0 \times 10^{-9}$ | 150,000 |
| Grab Tensile Strength, lbs (min. avg.) | ASTM D6768 | 90 | 150,000 |
| Peel Strength, lbs (min. avg.) | ASTM D6496 | 15 | 150,000 |
| Hydrated Internal Strength, lbs/sq. ft. (min.) | ASTM D6243 | 500 | 300,000 |

Note: The minimum interface shears strength requirements shall be as shown in the Construction Drawings.

The Project Engineer will arrange for conformance test samples to be obtained either at the location of manufacture, or at the project site as requested by the Owner. Conformance samples will be obtained at the frequency listed in Table 5-7 and the samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties required by this CQA/CQC Plan.

The GCL manufacturer will identify all material delivered to the site with a weatherproof label located on the outside end of the wrapping material. This label will include all information required by Section 02278 of the Technical Specifications. Each roll of product will include any additional information required to allow the CQA Manager to relate that roll with the manufacturing quality control and raw material quality control documentation.

Upon delivery, the Geosynthetic Construction Observer will examine the rolls of GCL and obtain archive samples; and if not already obtained, conformance test samples. The Geosynthetic Contractor will be required to provide the CQA Manager with the manufacturer's written certification that the GCL delivered to the site meets or exceeds the minimum properties required for the project. This certification must be supported by the MQA/MQC test documentation developed during the manufacture of the delivered material. For a needle

punched product, the manufacturer shall issue a certification demonstrating that a continuous needle detection and removal process has been applied for all GCL supplied to the project.

The CQA Manager will examine all results from laboratory testing. GCL will be rejected if it does not meet the minimum property requirements or if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the Geosynthetic Construction Observer.

#### 5.5.4.3 Installation

The surface to be covered by the GCL shall be smooth and dry, and will be cleared of sharp objects, stones, sticks, or any materials that may contribute to punctures, shearing, rupturing, or tearing of the geosynthetic materials. The GCL will be placed in the manner and at the locations shown on the Construction Drawings. When placing the GCL, adjacent sections shall be joined by overlapping the GCL a minimum of six inches or as recommended by the manufacturer and as approved by the Project Engineer. Panels installed end to end will be overlapped a minimum of 24 inches. Horizontal seams (i.e., seams shall be along, not across, the slope) will be avoided. GCL shall be laid smooth and free of excess tension, stress, folds, wrinkles, or creases.

The GCL will not be installed in standing water or during precipitation and will be dry when installed. Any GCL which becomes wet or free swells shall be removed from the work and replaced. The primary geomembrane liner shall be placed over the GCL immediately after placement of the GCL. Only those GCL panels which can be covered that same day shall be unpacked and placed in position.

## 5.6 MECHANICALLY STABILIZED EARTH EMBANKMENT QA/QC

### 5.6.1 General

A Mechanically Stabilized Earth (MSE) embankment is proposed to address the necessary grade separation in areas as required by the Construction Drawings. The MSE embankment will be a wire-formed, geogrid reinforced stone faced retaining wall system.

The testing and inspection program for the MSE embankment is designed to ensure the appropriate materials are installed properly to maximize the performance of the structure. The important observations and documentation efforts associated with MSE embankment construction are summarized as follows:

- Confirmation of geosynthetic material conformance to project specifications;
- Subgrade preparation and testing;
- Alignment and grade control; and,
- Control of structural soil and geosynthetic reinforcement placement.

Details regarding material approval requirements, subgrade inspection and testing, grid and basket placement/alignment, and grade control are provided in Sections 02222, 02224, 02600, and 02836 of the Technical Specifications. Certification survey requirements are as described in Appendix B.

### 5.6.2 Geogrids

The reinforcements assumed in the owner provided design shown in the Permit Drawings are polyester geogrids, whose function is to reinforce and stabilize the structure and fill materials behind the slopes. Geogrids can also be provided in polyethylene or polypropylene, and Sealand will solicit bids from geogrid vendors who may propose the use of alternate materials. In that case, the vendor will be required to provide design information supporting the use of their material.

The geogrid shall be manufactured from a pure virgin resin, as approved by the Project Engineer. The long term allowable design load for the geogrid reinforcements will be computed by the material vendor and this documentation will be reviewed and approved by the Project Engineer to confirm the material can provide the required long term allowable design strength. Methodology for extrapolation of creep data for 100 year minimum design life must be provided. Reductions for creep, chemical and biodegradation and installation damage must be considered in the vendors computations. All calculations and drawings for alternate materials will be reviewed and approved by the Project Engineer.

#### 5.6.2.1 Onsite Materials Management

The geogrid manufacturer will identify all rolls delivered to the site with a weatherproof label located on the outside end of the wrapping material. This label will include the following information as a minimum:

- Manufacture's name;
- Product identification;
- Date of manufacture;
- Lot number;
- Roll number, and;
- Roll dimensions.

Each roll of product will include any additional information required to allow the CQA Manager to relate that roll with the manufacturing quality control documentation.

The Project Engineer will arrange for conformance test samples to be obtained either at the location of manufacture, or at the project site as requested by the Owner. Conformance samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties required by this CQA/CQC Plan. At least one conformance sample will be obtained for each product and the samples will be forwarded to an approved laboratory for independent testing to ensure conformance with the material properties used in the long term allowable design load calculations. Upon delivery, the Geosynthetic Construction Observer will examine the rolls of geogrid to obtain archive samples; and, if not already obtained, conformance test samples. Archive samples will be a minimum of three feet long by three feet wide. The CQA Manager will examine all results from laboratory testing. No non-conforming material will be used in the work.

### 5.6.3 Subgrade Acceptance

The subgrade must be approved before proceeding with the placement of the fill materials, geosynthetic reinforcements and wall facing. Once the CQA Manager confirms that the Earthwork Contractor has excavated the subgrade surface to the design limits, a Geotechnical

Construction Observer will observe and document the physical appearance of the subgrade soils. The Geotechnical Construction Observer will establish the aerial extent of any unsuitable material, by observation. The appropriate remedial action for unsuitable MSE Embankment subgrade will be to remove and replace the soils to a maximum depth of two feet with MSE Embankment Structural Fill (Section-02224 of the Technical Specifications). Record survey measurements of the limit of excavations and the final subgrade surface will be obtained before placement of overlying MSE Embankment Structural Fill materials as described in Appendix B.

### 5.6.4 Wire Baskets

The wire baskets that will form the face of the wall are galvanized welded steel wire mesh forms bent at 90 degrees at the long centerline. The baskets will be filled with stone acting as a free drainage wall face as shown in the Permit Drawings. The legs of the baskets are typically 18 inches wide, and the basket is normally ten feet long. The vertical and horizontal wires of the wire mesh facing forms and wire struts must be of a minimum diameter as specified on the Construction Drawings. Baskets are placed level from end to end and front to back and adjacent baskets are overlapped and joined using stainless steel hog rings. Certification survey requirements as described in Appendix B.

The placement of the baskets will define the slope and alignment of the embankment as well as the beginning position of the geogrid reinforcement; accordingly, the most critical quality assurance requirement will be that the Construction Observers check the horizontal and vertical position of each row, independently of the final position of the underlying course of the facing forms. Material specifications and additional information regarding the alignment, placement and joining of the baskets is found in Section 02836 of the Technical Specifications.

MSE basket fill materials will consist of a 4 to 8 inch stone facing, a No. 4 stone filter and a No.1 stone fill. The 4 to 8 inch stone facing will be carefully placed and arranged to provide an aesthetically pleasing appearance. All No. 4 and No.1 stone fill shall be in accordance with the requirements of Section 02233 of the Technical Specifications.

### 5.6.5 MSE Embankment Structural Fill

The quality assurance and quality control sampling and testing of the MSE Embankment Structural Fill materials will be conducted at the frequencies indicated in Table 5-2. The surface of the subgrade will be scarified or, both moistened and scarified before the MSE Embankment Structural Fill is placed to help ensure proper bonding. MSE Embankment Structural Fill and placement requirements shall be in accordance with Section 02224 and Section 02600 of the Technical Specifications.

The MSE Embankment Structural Fill shall be placed in maximum nine-inch compacted lifts where heavy compaction equipment is used. The MSE Embankment Structural Fill shall be placed in maximum three-inch compacted lifts where hand tamping equipment is used. A walk-behind or similar vibrating plate compactor shall be used to compact the granular fill.

Self propelled construction equipment such as compactors, dump trucks or non-low pressure bulldozers shall not travel or operate within four feet of the face of the embankment. Tracked construction equipment shall not be operated directly upon the geosynthetic reinforcement. A minimum fill thickness of nine inches is required prior to operation of tracked vehicles over the geosynthetic reinforcement. If approved by the Project Engineer, rubber tired equipment may pass over the geosynthetic reinforcement at speeds less than five miles per hour. Sudden braking and sharp turning shall be avoided.

The backfill shall be placed near the wall face first and then proceed toward the geogrid tails. Backfill shall be placed, spread, and compacted in such a manner to eliminate wrinkles and minimize displacement of the geosynthetic reinforcement. Backfill shall be graded away from the slope crest and rolled at the end of each work day to prevent ponding of water on surface of the reinforced soil mass.

### 5.6.6 Alignment and Grade Control

It is determined critically important that the position of each course of the wall facing units and each layer of geogrid reinforcement be measured and checked against the design to document and confirm the proper location. Prior to subgrade excavation a permanent, visible control baseline will be established in the field by the surveyor in such a location that the CQA

personnel can reference this line to check the vertical and horizontal position of each geogrid layer and course of wire forms. This control baseline can and will most likely consist of a line of fixed survey hubs, from which an offset string line can readily be established by CQA personnel. Initially, the vertical and horizontal limits of subgrade excavation for the MSE Embankment must be established in the field by ground survey to ensure the subgrade excavation is positioned in a manner that will accommodate the proper positioning of the overlying structure. Certification survey requirements as described in Appendix B.

The facing elements and geogrid reinforcement shall be installed on level grade. The method used to confirm the proper location of the reinforcement and facing units must be independent of the final position of the underlying elements. The Geotechnical Construction Observer will utilize a level or other suitable instrument or technology to confirm and document the grade on which the facing forms and geogrid reinforcement is placed. The Geotechnical Construction Observer shall confirm that the constructed slope face conforms to the geometry shown on the Construction Drawings. The finished construction shall meet the geometric tolerances and Certification survey requirements as described in Appendix B.

## 5.7 PIPING SYSTEMS

### 5.7.1 General

The landfill design contains five piping systems, the subgrade surface drain, the groundwater trench drain, the primary and secondary leachate collection and removal systems, the leachate transfer system, and the landfill gas recovery system. The piping and/or piping systems will be installed or subcontracted by the Earthwork Contractor. The piping will be installed in accordance with the approved Construction Drawings and the Technical Specifications. All piping and piping systems will be installed to the lines and grades specified on the Construction Drawings.

The subgrade surface drain pipe will be four-inch diameter SDR-17 perforated HDPE. Stone filled collection trenches will direct perched groundwater to the subgrade surface drain header. The header will in turn discharge to a four-inch diameter SDR-17 perforated HDPE subsurface level spreader which will feed a natural wetland area.

The groundwater trench drain will be a six-inch diameter, SDR-17 perforated HDPE pipe. This drain system will be placed at the toe of the subgrade slope in the southern and eastern edges of the landfill as shown in the Construction Drawings. Groundwater in the trench will drain to a central sump where a two or three inch submersible pump will be located. The discharge hose from this pump will be positioned inside a 12-in diameter, SDR-17 HDPE sideriser pipe, conveying the pumped groundwater to Sediment Basin 2.

The secondary leachate collection piping network will use perforated, four-inch diameter, SDR-17 HDPE pipe. The primary leachate collection system will employ eight-inch diameter, SDR-17 HDPE pipe. The leachate collection system will drain by gravity to a sump in the southeast corner of the landfill. Leachate within the SLCRS will be pumped to the surface through a 24-inch diameter, SDR-17 HDPE sideriser pipe. The leachate will be metered and sampled, and then returned to the primary leachate drainage layer. Leachate within the PLCRS will be pumped from the sump to the surface through a 36-inch diameter, SDR-17 HDPE sideriser pipe. All mechanical components of the pumping systems will be installed as specified and as shown on the Construction Drawings.

The leachate transmission lines from the sump to the leachate storage facility that are outside of the double lined landfill cells will be comprised of a double-contained HDPE piping system. The carrier and containment pipe sizes will be as shown on the Construction Drawings.

The landfill gas recovery system will consist of main headers, subheaders, condensate drains, PLCRS collectors, horizontal collectors, and vertical collectors. The main header will be 24-inch diameter, solid SDR-17 HDPE pipe located within the clay plug inside the liner system atop the berm surrounding the landfill. The main header will be connected to a blower, and will serve to convey a vacuum to be distributed throughout the system.

The subheaders are eight-inch diameter, solid SDR-17 HDPE pipe that carry vacuum upslope from the main header to the horizontal and vertical collectors above the elevation of the perimeter berm, and downslope to the horizontal collectors below the elevation of the perimeter berm. Horizontal collection pipes will use both perforated and non-perforated six-inch diameter SDR-17 HDPE pipe. They will be located in three foot by three foot horizontal trenches excavated approximately eight feet deep in the waste and backfilled with No. 2 stone and

recompacted waste. Trenches will be parallel to each other at a 200-foot horizontal spacing and 40-foot vertical spacing. The horizontal collection piping will be sloped a minimum 3% grade downward toward the perimeter of the landfill.

Vertical collector pipes installed in the final cover system will be six-inch diameter SDR-17 HDPE installed inside a two-foot diameter borehole augered into the waste. The borehole will be advanced to either no closer than ten feet above the liner system, or no deeper than 65-feet into the waste, whichever is higher in elevation. The lower portion of the pipe within the waste will be perforated and embedded in a gravel pack. The upper end of the gas recovery pipe will be non-perforated. A soil and bentonite plug will be installed in the uppermost 18 feet of the waste profile to limit the potential for air intrusion. The vertical collectors will be strategically spaced 250 feet apart.

The landfill gas collection system's main header will be connected to the PLCRS cleanout risers and sideslope laterals that will be connected to supplemental collectors that will be located around the PLCRS system. This will place a vacuum on the PLCRS system in order to remove landfill gas from this layer.

Condensate drains, wellheads, and valves used in construction of the LFG collection system will be as specified and as shown on the Construction Drawings. The LFG collection system will convey all LFG to the Sulfatreat System and enclosed flare for treatment before being vented to the atmosphere.

The material, installation, and testing of all HDPE pipe is as described in Section 02660 of the Technical Specifications.

### 5.7.2 Materials

All pipe and pipe fittings shall be of the same type and from the same manufacturer unless otherwise specified or approved, and all polyethylene fittings shall have a pressure rating equal to or higher than the design pressure rating. Prior to shipment to the site, the Earthwork Contractor will provide the CQA Manager with all information received from the manufacturer, which as a minimum must identify that the materials meet the project requirements and the minimum industry standards for the specified pipe and fittings.

All shipments will be inspected upon arrival. The Earthwork Contractor will be responsible for verification that all materials listed on the packing list have been received. A visual inspection will be performed by the Earthwork Contractor or the Geotechnical Construction Observer to identify any apparent damage to the pipe during shipment. The Geotechnical Construction Observer will verify and document that the proper pipe has been received by recording the pipe designations marked on the pipe and by spot measuring the pipe ID and OD.

Damaged pipe or fittings must be inspected and evaluated to determine if the damage impairs serviceability according to the guidelines found in the Technical Specifications. If any defective or excessively damaged pipe is discovered pre or post installation replacement with a sound pipe will be required.

### 5.7.3 Installation

The HDPE pipes will be butt-fusion welded following the procedures and requirements included in Section 02660 of the Technical Specifications. Electrofusion welds can be made on approval of the Project Engineer in cases where butt-fusion welds are impractical. The Earthwork Contractor will be responsible for providing personnel experienced with the operation of the butt-fusion and electrofusion seaming apparatus. The fusion equipment operator must be proficient in tool and equipment use and operation, and trained and certified in fusion procedures. Sample joint testing will be required as described in Section 02660, paragraph 3.3.D.1 of the Technical Specifications. The Geotechnical or Geosynthetic Construction Observer will verify and document that all approved welding procedures are followed, and will visually inspect the welds for completeness and uniformity.

The pipe will be placed on the minimum select stone bedding type and thickness as required by the Construction Drawings. The select stone backfill will then be placed to the spring line of the pipe and consolidated in-place. The pipe will be covered with select stone backfill for a total minimum thickness above the top of the pipe as shown on the Drawings. Where appropriate, the remainder of the backfill will consist of the specified soil shown on the Construction Drawings, and compacted in accordance with the Technical Specifications.

The Geotechnical Construction Observer will verify and document the following:

- All foreign objects are removed from the pipe interior prior to the pipe being placed in its final position;
- No damaged pipe has been installed;
- The pipe has been installed to the proper lines and grades as identified on the Drawings;
- The pipe has been properly bedded, haunched, and backfilled in accordance with the Technical Specifications; and,
- The pipe is not damaged or moved during backfilling operations.

For Record Drawing purposes, the installed grade of the pipes will be surveyed every 20 feet and at grade changes, valves, special fittings, or at changes in direction. The tolerance of the leachate pipe slope will be as identified in Appendix B.

The Earthwork Contractor will be responsible for performing hydrostatic or pneumatic leak testing of the carrier and containment pipe and fittings for the leachate transfer piping. The Geotechnical or Geosynthetic Construction Observer will monitor and document the leak testing procedure as described in Section 02660 of the Technical Specifications.

# 6 POST-CONSTRUCTION CARE PROCEDURES

Section 360-2.8 requires the CQA/CQC Plan to "contain the procedures to ensure that the post construction care requirements will be maintained prior to initial operation".

To protect the constructed baseliner system, a policy will be adopted which will restrict uncontrolled access to unfilled areas of the baseliner coupled with a maintenance and inspection program. The maintenance and inspection program will include requirements that casual traffic shall not be allowed directly above the leachate drainage layer. All primary leachate collection pipes will be rodded, jetted or otherwise inspected to confirm the integrity of the primary pipe network, and the results of this exercise will be documented for inclusion in the Certification Report.

Any work directly on the completed baseliner system shall be carried out in a manner consistent with that required for initial construction activities, and this will include oversight by a spotter to reduce the potential for overstressing the liner system. Inspection of the liner system in the unfilled areas shall be a routine part of landfill operations. This will include visual inspections and observations during the placement of the five-foot thick layer of select waste to preclude objects that may damage the liner system.

The drainage layer and geotextile fabric will be protected from water-borne sediments by grading the top of the perimeter berm in such a way that runoff from outside the landfill area will be diverted away from the constructed landfill cell. Dust control measures will be performed at the site by watering of the site access roads using a water truck. Similar operational practices will be performed to minimize wind-borne sedimentation on the drainage layer.

# 7 DOCUMENTATION AND RECORDKEEPING

Records of construction progress and quality assurance/quality control activities will be maintained throughout the construction of the landfill and related facilities. The following reports will be prepared:

- Daily Construction Report;
- Weekly Construction Data Summary Report;
- Construction Certification Report for the baseliner system; and,
- Construction Certification Report for the final cover system.

## 7.1 DAILY CONSTRUCTION REPORT

Daily construction reports will be prepared by the Geotechnical Construction Observers and the Geosynthetic Construction Observers at the conclusion of every day construction activities occur at the site.

The daily construction reports will include the following:

- Date;
- Weather conditions, including daily high and low temperature, wind conditions, and precipitation, if any;
- General description of work activities at the site;
- List of personnel and equipment operating on site, number of hours worked, number of hours on standby, and work activities completed. Include names of key CQA/CQC and construction personnel;
- Description of work completed for the day, referencing stationing and grid coordinates;
- Identification of areas worked including lift number, panel number, and seam number;
- Drawings, sketches, and maps showing work completed;
- Summary of CQA/CQC procedures used for the day;

- Results of all field testing performed;
- Drawings, sketches, and maps showing all field testing areas. Passing and failing areas of the soil liner, geomembrane panels and seams will be recorded;
- Reworked and repair areas will be recorded with all testing results;
- Identification of all samples collected for testing at the CQA/CQC laboratories, including sample number, location, and testing to be performed;
- Identify any field modifications; and,
- Documentation of discussions, decisions or recommendations involving the Contractor, Subcontractor, Sealand, NYSDEC, the Project Engineer and/or representatives thereof.

The Daily Construction Report will be submitted to the CQA Manager for review and inclusion in the project file.

## 7.2 WEEKLY CONSTRUCTION DATA SUMMARY REPORT

- Weekly construction data summary reports will be prepared by the CQA Manager at the end of every working week, and will include the following:

- General description of work activities completed at the site for the week;
- Specific description of work completed for the week, referencing stationing, and grid coordinates;
- Identification of areas worked for the week, including lift number, panel number, and seam number;
- Drawings, sketches, and maps showing work completed for the week;
- Summary of CQA/CQC procedures used for the week;
- Summary of testing results for the week;
- Summary of reworked areas and repairs completed for the week;
- Identification of problems and corrective measures undertaken;

- Summary of shop drawings and submittals received from the Contractor and Subcontractors during the week, and disposition of same;
- Summary of results received from the geotechnical and geosynthetic CQA/CQC laboratories during the week;
- Summary of field modifications; and,
- A copy of the minutes of routine construction meetings for the week documenting the discussions and decisions; including any decisions and recommendations as a result of discussions with the Contractor, Subcontractors, Sealand, NYSDEC, the Project Engineer, and/or representatives thereof.

The Weekly Construction Data Summary Report will be submitted to the NYSDEC and will be included in the project file.

## 7.3 CONSTRUCTION CERTIFICATION REPORTS

### 7.3.1 Final Cover Construction Certification Report

Upon completion of final cover construction activities and a final site inspection, the Project Engineer will prepare a Construction Certification Report. The report will be prepared under the direction of, and will be endorsed by, the Project Engineer who will be licensed to practice engineering in the State of New York. The report will be submitted to NYSDEC within 45 days after the completion of construction.

The Certification Report will document construction in accordance with Construction Drawings and Technical Specifications, with any exceptions noted. The Certification Report will include the following:

- Narrative description of the construction completed at the site;
- Description of deviations from Construction Drawings and Technical Specifications and reasons for such changes;
- Description of testing procedures;
- Summary of test data;

- Drawings showing test locations;
- Descriptions of procedures used to correct deficiencies;
- As appropriate, raw data sheets and worksheets related to testing;
- Daily construction reports prepared by the CQA/CQC personnel;
- CQA/CQC Plans submitted to the Project Engineer by the Geotechnical and Geosynthetic CQA/CQC laboratories;
- Record Drawings of the completed construction;
- Certification statement of completion of construction in accordance with the intent of the Construction Plans and Specifications;
- Typed or printed results of all testing (including failed test results and retesting results) and plots of the distribution of moisture/density measurements and permeability results (if applicable); and,
- A representative set of color photographs of the major project stages and features.

### 7.3.2 Baseliner Construction Certification Report

Upon completion of the baseliner construction activities and a final site inspection, the Project Engineer will prepare a Construction Certification Report. The report will be prepared under the direction of, and will be endorsed by, the Project Engineer who will be licensed to practice engineering in the State of New York. The report will be submitted to NYSDEC within 45 days after the completion of construction.

The Baseliner Certification Report will document construction in accordance with Construction Drawings and Technical Specifications, with items listed in Section 7.3.1, as well as the following:

- Certification of the initial jetting of the primary leachate collection pipe network;
- Certification of the leak testing of any leachate transfer forcemain installed; and,

- A minimum of 30 consecutive days of secondary leachate collection and removal system flow data.

## 7.4 RECORD DRAWINGS

As part of the final cover construction certification effort, record survey measurements will be obtained to generate the following record drawings:

- Top of the intermediate cover layer;
- Limit of the geocomposite landfill gas venting layer;
- Top of the soil liner;
- 40-mil textured LLDPE geomembrane liner panels and sample locations; and,
- Top of final cover system including locations of drainage features such as swales, downchutes and culverts, etc.

Record survey measurements obtained during baseliner construction will be used to generate the following record drawings:

- Limit of excavation/top of subgrade (including the subgrade surface drains, the trench drain and the porewater drain system);
- Top of secondary soil liner;
- 60-mil textured HDPE secondary geomembrane liner panels and sample locations;
- Secondary leachate collection pipe network;
- Top of structural fill;
- 60-mil textured HDPE primary geomembrane liner panels and sample locations;
- Top of leachate drainage layer stone, including primary leachate collection pipe network; and,
- The location of the leachate forcemain and associated manholes, valves, etc.

The Record Drawings developed for the geomembrane liner systems will identify all panels and panel numbers. The drawings will identify the limits of the liner system, and will illustrate the location of:

- All geomembrane seams;
- All destructive samples; and,
- All patched repairs (i.e. repairs other than extruded beads).

The primary goal for the record survey effort is to obtain an optimum number of measurements and to ensure the design grades of the facility are obtained and plotted on a continuing basis. All survey requirements shall be in accordance with the Construction Stakeout and Record Survey Requirements detailed in Appendix B. This information will be plotted on a continuous basis as time allows during the course of the work.

In the event the Project Engineer utilizes Sealand's in-house survey crew for the purpose of obtaining record survey measurements, written and clear procedures that comply with the requirements of the NYS Board of Engineering and Land Surveying must be provided to the surveyor by the Project Engineer prior to beginning the survey. The written procedures provided by the Project Engineer must be included as an attachment to the Certification Report. Before any record survey work begins, the Earthwork or Geosynthetic Contractor must confirm that the prepared work is ready for the record survey, and must formally request in writing that record survey measurements be obtained.

The Project Engineer will be responsible to ensure that the record survey measurements are checked against the project requirements, and will be responsible for the accurate preparation of the Record Drawings. The Project Engineer may review and utilize as appropriate QC survey data obtained by the construction survey crew in preparing the Record Drawings. The Project Engineer will be responsible to evaluate the QC survey data, verify its accuracy and to certify the integrity of all data used in the preparation of the Record Drawings. The Project Engineer will be responsible to sign and stamp the Record Drawings for inclusion with the Certification Report.

# APPENDIX A

# Technical Specifications

**Carroll Landfill**
**Technical Specifications – October 2015**

# TABLE OF CONTENTS

## Division 2 – Site Work

# SECTION 02222

# SUBGRADE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of subgrade preparation, including grading, proof-rolling, removal of unsuitable material (see Article 3.3 below for the definition of unsuitable material) as required and replacement with Structural Fill as specified in this Section and Section 02224.

B. The CONTRACTOR shall complete other related and incidental work within the designated area as required for the construction of work placed above the subgrade as shown, specified or required by other related Sections.

### 1.2 RELATED SECTIONS

A. Section 02224 - Structural Fill

B. Section 02227 – Subgrade Replacement Material

C. Section 02276 – Soil Liner

D. Section 02595 - Geotextiles

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D2487-06e1 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

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

B. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Subgrade preparation shall consist of grading the surface as shown on the Drawings, proof-rolling the subgrade surface and removing any unsuitable material as required by the Specifications.

B. Structural fill placement shall consist of furnishing material and placing and compacting material where designated on the Drawings or as required by the Specifications.

## 1.5 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

# PART 2 PRODUCTS

## 2.1 MATERIALS GENERAL

A. Subgrade soils may consist of in-situ soils at the limit of excavation or structural fill as appropriate.

B. All structural fill materials shall conform to Section 02224 - Structural Fill. The structural fill material shall meet the approval of the PROJECT ENGINEER.

C. The maximum particle (stone) size shall be no larger than nine inches, or as restricted by Section 02595 in the case of geotextile installation.

D. All subgrade and structural fill soil materials shall be substantially free from organic matter, wood, trash, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall not contain blocks, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted to the density required for the specified item. Snow, ice, and frozen soil shall not be permitted.

## 2.2 TESTING

A. The PROJECT ENGINEER shall obtain information on in-situ subgrade soils as required by Articles 3.2 and 3.3 of this Section.

B. The CONTRACTOR shall not proceed with placement of structural fill within subgrade over excavations until the PROJECT ENGINEER has approved the proposed material in accordance with Section 02224.

# PART 3 EXECUTION

## 3.1 PRECAUTIONS

A. Structural Fill placement shall not:

1. Be performed with or placed on frozen materials.

2. Be placed on snow that has a thickness greater than one tenth of an inch.

3. Be placed on ice. Ice shall be defined as frozen water on the surface of in situ soils or previously placed material.

B. Where the subgrade surface is to be covered by a geosynthetic layer, the subgrade must have a smooth surface to minimize the potential for damage to the adjacent geosynthetic layer, as described in the Section of the Technical Specifications addressing the subject geosynthetic (e.g. Section 02595 - Geotextiles).

## 3.2 FILLING AND COMPACTION OF SUBGRADE OVER EXCAVATIONS

**A.** Prior to placement of overlying soil or geosynthetic materials, the subgrade shall be proof-rolled to confirm the subgrade is suitable. Once the CQA Manager confirms that the Earthwork Contractor has graded the Subgrade surface to within the tolerance limits (Appendix B), a Geotechnical Construction Observer will inspect and record the soil conditions at the limit of the design. A Geotechnical Construction Observer will observe and document proof rolling of the Subgrade surface, using a compactor in static mode, for the purpose of detecting unsuitable materials. Excessively wet or soft soils will be determined present when permanent ruts or indentations in excess of one inch are observed, and the soils in that area will be considered unsuitable. Unsuitable soils that cannot be repaired to meet the project requirements shall be over-excavated and replaced with structural fill.

It is recommended that the excavation be far enough in advance of the overlying liner construction such that a stiff crust can be developed through weathering/drying and adequate compaction of the soil liner can be achieved.

B. Structural fill shall be brought uniformly to grade throughout the over-excavation area and compacted. The compacted thickness of each structural fill lift shall not exceed 1 foot, unless otherwise approved by the PROJECT ENGINEER. The moisture content of the structural fill material shall be such that proper compaction as defined by Section 02224 is readily obtained. The soils shall be placed and compacted in a manner that eliminates lift interfaces and prevents the formation of observable voids in the completed lifts as determined by the PROJECT ENGINEER.

C. Hand-operated plate type vibratory tampers or other suitable equipment as proposed by the CONTRACTOR and approved by the PROJECT ENGINEER must be used in areas not accessible to larger compactors.

## 3.3 FIELD QUALITY ASSURANCE/QUALITY CONTROL

A. The CONTRACTOR shall complete, and the PROJECT ENGINEER shall observe and document, proof-rolling of the subgrade for the purpose of detecting unsuitable material. Unsuitable materials are defined as: ASTM D2487 classification PT, OH, OL; or excessively wet or soft soils which inhibit compaction. Excessively wet or soft soils will be determined present when permanent ruts or indentations in excess of one inch are observed, All unsuitable materials in the subgrade that cannot be repaired to meet the project requirements shall be removed and replaced with structural fill materials as required by Section 02224 of the Technical Specifications.

B. The slope of the subgrade shall be no less than the minimum and no greater than the maximum slope requirements as specified in Appendix B, and as measured on a 50-foot grid.

C. The PROJECT ENGINEER shall perform onsite field moisture and density testing at an overall frequency of nine tests per acre per lift over the entire subgrade area, including in-situ soils, and all areas of structural fill placement. The soil moisture and density measurements shall be performed using a nuclear densometer at a probe depth of 12 inches, unless otherwise approved by the PROJECT ENGINEER.

D. No minimum/maximum density or moisture content will be established for the in-place soil moisture and density testing of the in-situ subgrade soils. This data will be recorded and reviewed together with the results of proof rolling to assist the PROJECT ENGINEER in evaluating the suitability of the subgrade.

E. In-place soil moisture and density testing within structural fill will be compared to the moisture-density relationship for the soil at a frequency determined by the PROJECT ENGINEER, but not less than nine tests per acre lift of soil placed. The CONTRACTOR shall rework, or remove and replace as directed by the PROJECT ENGINEER, any structural fill material that does not meet the requirements of Section 02224.

F. On trench subgrade, field density and field moisture testing shall be performed at a frequency determined by the PROJECT ENGINEER

G. In areas where the degree of compaction is questionable, or the uniformity of materials is not maintained, additional tests will be made as directed by the PROJECT ENGINEER.

END OF SECTION

# SECTION 02223

# COMMON TRENCH BACKFILL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of placing and consolidating common trench backfill as shown, specified, or required.

### 1.2 RELATED SECTIONS

A. Section 02222 – Subgrade

B. Section 02224 - Structural Fill

C. Section 02233 - Bedding and Backfill

### 1.3 DEFINITIONS

A. Common trench backfill shall consist of furnishing material, if necessary, and placing and consolidating material within excavated trenches. If the trenches are for pipes, the common trench backfill is placed above the select granular backfill.

### 1.4 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

## PART 2 PRODUCTS

### 2.1 MATERIALS GENERAL

A. All common trench backfill materials shall consist of approved fill material as described in Section 02224 - Structural Fill.

B. The common trench backfill shall be consolidated in 12 to 18 inch thick lifts. However, the maximum lift thickness shall be 12 inches when common trench backfill is placed within the landfill liner footprint, and this backfill shall be placed as structural fill in accordance with Section 02224.

C. All required fill materials shall be substantially free from organic materials, wood, trash, and other objectionable materials which may be compressible or which cannot be properly densified by common earthwork equipment. It shall not contain granite blocks, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and consolidated. Snow, ice, and frozen soil shall not be permitted.

# PART 3 EXECUTION

## 3.1 PRECAUTIONS

A. Common trench backfill placement shall not:

1. Be performed with or placed on frozen materials;

2. Be placed on snow that has a thickness greater than one tenth of an inch; or,

3. Be placed on ice. Ice shall be defined as frozen water on the surface of in situ soils or previously placed material.

## 3.2 BACKFILLING

A. Common trench backfill shall not be placed until the pipeline or other construction component has been inspected in-place and approved by the PROJECT ENGINEER. If the trench contains pipes, the common trench backfill is placed after the select granular backfill has been placed and approved by the PROJECT ENGINEER. The extent of trench left open shall be kept to a minimum.

B. Unless otherwise directed, excavations shall be backfilled as soon as possible after pipes are laid and the work is inspected, tested as required, and accepted by the PROJECT ENGINEER. Immediately prior to backfilling, all rubbish, debris, forms, and similar materials shall be removed from the excavations.

C. Where sheeting is withdrawn, all cavities left thereby shall be filled with common trench backfill, tamped in place so as to fill all voids thoroughly.

D. Common trench backfill shall be brought to grade uniformly throughout the area. The thickness of each layer shall not exceed 18 inches or unless otherwise specified by the PROJECT ENGINEER.

E. All common trench backfill is to be consolidated to the satisfaction of the PROJECT ENGINEER. After the material is placed in a lift, it is consolidated to eliminate excessive voids through use of hand-operated plate type vibratory tampers or other suitable equipment.

## 3.3 FIELD QUALITY CONTROL

A. The PROJECT ENGINEER shall perform onsite visual inspection of the CONTRACTOR'S compaction efforts on common trench backfill outside the limits of the landfill liner system to determine if it is satisfactory.

B. All common trench backfill placed inside the limits of the landfill liner system shall be subject to inspections and soil moisture and density testing as required for structural fill and defined in Section 02224.

END OF SECTION

# SECTION 02224

# STRUCTURAL FILL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, equipment, tools and appurtenances required to complete the work of structural fill placement, grading, and other related and incidental work within the work area and as required for the construction of Plain Embankment Structural Fill, MSE Embankment Structural Fill, Liner System Structural Fill, and subgrade as shown, specified, or required by the Drawings and Specifications.

### 1.2 RELATED SECTIONS

A. Section 02222 – Subgrade

B. Section 02223 – Common Trench Backfill

C. Section 02227 – Subgrade Replacement Material

D. Section 02277 – Test Pad

E. Section 02278 – Geosynthetic Clay Liner

F. Section 02599 – Geocomposites

G. Section 02600 - Geogrids

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D422-63 Standard Test Method for Particle-Size Analysis of Soils
2. D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$))
3. D2216-05 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock By Mass
4. D3080-04 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions

5. D4318-05 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index Of Soils
6. D4767-04 Standard Test Method for Consolidated Undrained Triaxial Compression Test For Cohesive Soils
7. D6938-08a Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 DEFINITIONS

A. Structural fill for liner system and embankments shall consist of placing and compacting material where designated on the Drawings, by these specifications, or by the PROJECT ENGINEER.

B. Plain embankments are those embankments without geosynthetic or other reinforcement materials.

### 1.5 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

## PART 2 PRODUCTS

### 2.1 MATERIALS GENERAL

A. All structural fill materials shall be substantially free from organic materials, wood, trash, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall have physical properties such that it can be readily spread and compacted to the specified density. Snow, ice, and frozen soil shall not be permitted.

B. The maximum particle (stone) size shall be no larger than nine inches for Plain Embankment Structural Fill and Liner System Structural Fill. The maximum particle (stone) size shall be no larger than six-inches for MSE Embankment Structural Fill

### 2.2 STRUCTURAL FILL MATERIALS

A. Materials used as structural fill shall be obtained from a suitable source. The CONTRACTOR shall not place structural fill prior to the availability of geotechnical testing, and only after approval of the soil source by the PROJECT ENGINEER. Soil from a new source location shall not be included in the work prior to the written acceptance of testing by the PROJECT ENGINEER. Should unstable soils be encountered in the work, no further material shall be placed in the area in question without the approval of the PROJECT ENGINEER.

B. The soil material used for structural fill as shown in the Drawings shall be placed at a minimum dry density and maximum moisture content as determined by the pre-construction testing to achieve the minimum shear strength specified by the design.

C. The OWNER may complete initial testing of the soil types within the limits of excavation or elsewhere that may be used for structural fill, and submit the results to the PROJECT ENGINEER for review. This information would consist of the following:

| | |
|---|---|
| 1. Moisture Content | ASTM D2216 |
| 2. Grain Size | ASTM D422 |
| 3. Atterberg Limits | ASTM D4318 |
| 4. Modified Proctor | ASTM D1557 |
| 5. Consolidated Drained Triaxial Shear | ASTM D4767 |
| 6. Direct Shear | ASTM D3080 |

# PART 3 EXECUTION

## 3.1 PRECAUTIONS

A. Structural fill placement and compaction shall not:

1. Be performed with or placed on materials that are frozen;

2. Be performed on snow that has a thickness greater than one tenth of an inch; or,

3. Be performed on ice. Ice shall be defined as frozen water on the surface of in situ soils or previously placed material.

## 3.2 PLACEMENT AND COMPACTION OF STRUCTURAL FILL

A. The subgrade area for structural fill placement shall be cleared of any topsoil, roots, garbage, or other deleterious materials. The subgrade for Structural Fill shall be inspected by the PROJECT ENGINEER and be proof rolled as required by Section 02222 of the Technical Specifications. Unsuitable soils in the subgrade shall be excavated as directed by the PROJECT ENGINEER. For plain embankments and liner systems, any over excavation of the subgrade shall be backfilled with structural fill in accordance with the requirements of Plain Embankment Structural Fill and Liner Structural Fill. For the MSE Embankment, any over excavation of the subgrade shall be backfilled in accordance with the requirements for MSE Embankment Structural Fill.

B. Prior to placement of the initial lift of structural fill, the prepared subgrade shall be scarified to a depth of two (2) inches.

C. The CONTRACTOR is encouraged to excavate and deliver the structural fill soils to the point of use in such a manner as to minimize the mixing of the various strata within the source area. Soil stratum is typically sampled as unmixed sources for the purpose of compaction control and testing. In the event the CONTRACTOR wishes to employ active soil stratum mixing to address site conditions, the CONTRACTOR shall propose a method of soil mixing to the PROJECT ENGINEER such that representative sampling strategies can be employed.

D. The CONTRACTOR shall place and compact structural fill in lifts to form a uniform upper surface to the lines and grades as shown on the Drawings. In the case of Plain Embankment Structural Fill and MSE Embankment Structural Fill, the upper surface of each lift shall be scarified in order to provide proper adhesion to subsequently placed lifts of structural fill. Each lift shall be cleared of any roots, garbage or other deleterious materials prior to compaction. For Plain Embankment Structural Fill and Liner Structural Fill, each lift shall be a maximum of twelve (12) inches thick after the lift is compacted, unless otherwise approved by the PROJECT ENGINEER based on the results of a test pad program. For MSE Embankment Structural Fill, each lift shall be a maximum of nine (9) inches thick after the lift is compacted.

E. At the discretion of the CONTRACTOR prior to commencement of structural fill construction that may differ from any requirements of this Specification, the CONTRACTOR may complete a test pad utilizing the soils, equipment, and placement techniques proposed for use in the project (see Section 02277). The PROJECT ENGINEER shall observe, measure, sample, and evaluate the test pad construction as required to establish the appropriate means and methods, including lift thickness, that are required to obtain the proper engineering properties of the structural fill soils.

F. Structural fill shall be placed in well-drained "horizontal" lifts. The contractor is responsible for maintaining the surface of the structural fill to prevent ponding or other conditions that will lead to degradation of materials. The CONTRACTOR shall drain areas of completed lifts that accumulate standing water, scarify, and dry as necessary for re-compaction. Fill materials that become soft or overly moist will not be incorporated within the final embankment, liner system, or subgrade.

G. All structural fill is to be compacted. The density and moisture content of all structural fill shall be consistent with the requirements established by the PROJECT ENGINEER based on his review of the pre-construction geotechnical test results. Unless otherwise approved by the PROJECT ENGINEER, the minimum dry density for Plain Embankment Structural Fill and Liner System Structural Fill shall be 90% of the modified Proctor maximum dry density. For MSE Embankment Structural Fill the soil shall be placed at a moisture content between plus 1% and minus 3% of the modified Proctor optimum moisture content, and the dry density shall be at least 90% of the modified Proctor maximum dry density.

H. Compaction equipment used shall be a sheepsfoot type, or have segmented pad feet. Hauling and spreading equipment shall not be considered as compaction equipment. Hand-operated plate type vibratory tampers or other suitable equipment must be used in areas not accessible to larger compactors, using a smaller lift thickness approved by the PROJECT ENGINEER. The PROJECT ENGINEER shall complete in-place soil moisture and density testing on areas where hand-operated plate type vibratory tampers or other manual compaction efforts have been performed, to ensure adequate compaction.

I. The CONTRACTOR is responsible for achieving the appropriate in-situ dry density and moisture content. The CONTRACTOR is responsible for staging and/or manipulation of the excavation and structural fill placement that will allow the soils to reach the moisture content required to meet the specifications.

## 3.3 FIELD QUALITY CONTROL/QUALITY ASSURANCE

A. The engineering properties for the structural fill shall be established and confirmed throughout the project work by laboratory testing. Quality assurance laboratory testing for Structural Fill built within the landfill liner system shall be performed at a minimum frequency of one moisture density relationship, one grain size distribution (without hydrometer) and one Atterberg (liquid and plastic) limits test per 5,000 compacted cubic yards (ccy) of material placed in the work. Quality assurance laboratory testing for Structural Fill used outside of the liner system, such as MSE Embankment Structural Fill, shall be performed at a minimum frequency of one moisture density relationship, one grain size distribution (without hydrometer), one Atterberg (liquid and plastic) limits test, and one direct shear test per 25,000 ccy. Additional tests may be performed at the discretion of the PROJECT ENGINEER. The specified test program must be completed on any soils that are not representative of the available test results.

B. The PROJECT ENGINEER is to perform onsite field moisture and density testing at a minimum frequency of at least nine tests per acre per 12-inch lift over the entire area of Liner System Structural Fill placement. The field density and field moisture test coverage shall include at a minimum, at least one test for every 75 linear feet of embankment for every lift of Plain Embankment Structural Fill and MSE Embankment Structural Fill. The field density and moisture test shall be D6938. The field test will be performed using a probe depth of 12 inches for Plain Embankment Structural Fill and nine-inches for Liner System Structural Fill and MSE Embankment Structural Fill, unless otherwise stated or approved by the PROJECT ENGINEER.

C. Structural fill moisture and density tests are required to exhibit a minimum dry density and moisture content range as specified in Paragraph 3.2 G of this Section.

D. Any areas not meeting the specified moisture content and dry density will receive additional compaction; or be reworked and re-compacted; or be removed, replaced and re-compacted; and retested until a passing determination is achieved. All retests will be performed in as close a position to the original failed test location as can be reasonably ascertained by the Geotechnical Construction Observer.

END OF SECTION

# SECTION 02226

# LOW PERMEABILITY BACKFILL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of low permeability backfill placement, grading, and consolidation.

### 1.2 RELATED SECTIONS

A. Section 02222 - Subgrade

B. Section 02223 - Common Trench Backfill

C. Section 02224 - Structural Fill

D. Section 02276 - Soil Liner

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D422-63 Standard Test Method for Particle-Size Analysis of Soils

2. D4318-10 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils

3. D2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soils and Rock by Mass

B. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 DEFINITIONS

A. Low permeability backfill shall consist of furnishing source material, placing and compacting the material where designated on the Drawings, or by the ENGINEER.

B. Low permeability backfill is to be used at the limit of waste above the geosynthetics, or at the edge of waste placed near the temporary liner terminations, as shown in the Construction

Drawings. In particular, any geosynthetic anchor trenches used in the construction will typically be shown to be backfilled or covered with low permeability backfill.

# PART 2 PRODUCTS

## 2.1 MATERIALS GENERAL

A. All low permeability backfill materials shall consist of fine grained soils having clay-like properties. The material shall be substantially free from organic matter, wood, trash, and other objectionable substances which may be compressible or which cannot be properly consolidated. It shall have physical properties such that it can be readily spread and consolidated. Snow, ice, and frozen soil shall not be permitted.

B. The maximum particle (stone and/or soil clod) size shall be no larger than four inches, or no larger than 75% of the lift thickness, whichever is less.

## 2.2 SOIL

A. Soil to be used for low permeability backfill shall be approved for such use by the ENGINEER. Available test data shall be supplied by the CONTRACTOR to the ENGINEER for grain size distribution and liquid and plastic limits. The plasticity index shall be at least 6. The recompacted permeability shall be a maximum of $1 \times 10^{-5}$ cm/sec.

B. The CONTRACTOR shall not place low permeability backfill prior to the ENGINEERS review and approval of the available test data. Depending on the test results, the ENGINEER shall accept or reject the soil, or require further testing.

## 2.3 TESTING

A. The CONTRACTOR shall submit to the ENGINEER for approval suitable evidence that the soils proposed for low permeability backfill are appropriate. This information is to be provided for each individual low permeability backfill source, or when in the opinion of the ENGINEER, the material is different in any way from the originally tested and approved material. This evidence shall include, but not necessarily be limited to, the following testing.

| | |
|---|---|
| 1. Grain Size | ASTM D422 |
| 2. Atterberg (liquid and plastic) Limits | ASTM D4318 |
| 3. Moisture Content | ASTM D2216 |

A. If in the opinion of the ENGINEER based on his review of the available data, the CONTRACTOR'S soil is unsuitable for the proposed application, the CONTRACTOR shall submit the above evidence for soil of another type or from another source for consideration by the ENGINEER.

# PART 3 EXECUTION

## 3.1 PRECAUTIONS

A. Low permeability backfill placement shall not:

1. Be performed with or placed on frozen materials.

2. Be placed on snow that has a thickness greater than a tenth of an inch.

3. Be placed on ice or in standing water. Ice shall be defined as frozen water on the surface of in situ soils or previously placed material.

## 3.2 PLACEMENT OF LOW PERMEABILITY BACKFILL

A. Low permeability backfill shall be brought to grade uniformly throughout the area and consolidated using a smooth drum roller to achieve the quality of low permeability soil described in 3.2 C. Hand-operated plate type vibratory tampers or other suitable equipment must be used in areas not accessible to larger compactors.

B. The thickness of each consolidated lift shall not exceed 1 foot, unless otherwise specified by the ENGINEER.

C. The low permeability backfill shall be placed in a manner that isolates soil clods, eliminates lift interfaces and prevents the formation of observable voids in the completed lifts.

## 3.3 FIELD QUALITY ASSURANCE/QUALITYCONTROL

A. The ENGINEER shall observe and document the placement procedures to be utilized by the CONTRACTOR in construction of the low permeability backfill. The ENGINEER shall perform in-place shovel testing on select lifts at a rate sufficient to document that proper consolidation procedures are being employed to achieve the requirements of Paragraph 3.2 C. All shovel tests shall be performed throughout the full thickness of the lift(s).

B. The ENGINEER shall observe that the soil has been consolidated such that soil clods in excess of four inches have been eliminated, and that the consolidated soil includes no observable lift interfaces or voids.

C. Field moisture-density testing shall be performed at a rate of not less than one test for each day of low permeability soil placement, and as directed by the Project Engineer. Test locations must be proportionately distributed throughout the soil placement.

D. Routine in-place soil moisture and density testing will be confirmed by laboratory permeability tests on undisturbed Shelby tube samples or block samples. The samples shall be taken in the locations and at frequencies selected by the PROJECT ENGINEER to ensure a representative and proportionate distribution of test results for the soil fill. The CONTRACTOR shall rework,

or remove and replace as directed by the PROJECT ENGINEER, any material with a permeability greater than $1 \times 10^{-5}$ cm/sec, as determined by the PROJECT ENGINEER based on his review of the permeability test data, field observations, and confirmation of soil conditions (that may include additional soil moisture-density measurements and/or undisturbed sampling and laboratory testing activities).

E. Any areas not meeting the specified consolidation or uniformity requirements will receive additional consolidation; or be reworked and reconsolidated; or be removed, replaced and reconsolidated; and retested until acceptable results are achieved throughout the backfill. All retests will be performed within two feet of the original failed test location.

END OF SECTION

# SECTION 02227

# SUBGRADE REPLACEMENT MATERIAL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of supplying, placing, and compacting material for the subgrade replacement material as shown, specified, or required.

### 1.2 RELATED SECTIONS

A. Section 02222 – Subgrade

B. Section 02224 – Structural Fill

C. Section 02276 – Soil Liner

D. Section 02277 – Test Pad

### 1.3 REFERENCES

A. American Society For Testing and Materials (ASTM)

1. D422-63 Standard Test Method for Particle-Size Analysis of Soils

2. D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2700 kN-m/m$^3$))

3. D2216-05 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock By Mass

4. D4318-05 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

5. D5084-03 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

B. United States Army Corps of Engineers (USACE)

1. EM 1110-2-1906 30 Nov 70 (20 Aug 86) Laboratory Soils Testing – Appendix VII – Permeability Tests

C. The most current version of the specified test method shall be followed by the, EARTHWORK CONTRACTOR or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Subgrade replacement material preparation shall consist of grading the surface as shown on the Drawings, proof-rolling the subgrade replacement material surface, and removing any unsuitable material as required by the Specifications.

B. Structural fill placement shall consist of furnishing material and placing and compacting material where designated on the Drawings or as required by the Specifications.

## 1.5 SUBMITTALS

A. Target Head Data

B. Refer to Section 02277 – Test Pad

## 1.6 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

## 1.7 TOLERANCES

A. The minimum completed, compacted thickness of the subgrade replacement material shall be 10.0 feet. The thickness tolerance for the subgrade replacement material, and Certification Survey Requirements, is as described in Appendix B.

B. The slope of the subgrade replacement material shall be as specified in the Construction Drawings. The slope tolerance for the subgrade replacement material, and Certification Survey Requirements, is as described in Appendix B This slope shall be as measured between any two points at least 50 feet distant.

C. The maximum acceptable compacted subgrade replacement material lift thickness shall be as determined by Test Pad construction as specified in Section 02277, with the exception of the first lift of any subgrade replacement material directly overlying geosynthetics and/or soft soils to be left in-place at the direction of the Project Engineer, in which case the default maximum lift thickness shall be 12 inches.

### 1.8 DELIVERY, STORAGE, AND HANDLING

A. All soil designated for use as subgrade replacement material shall be delivered, stored, and handled in a manner that will prevent contamination by other soils or deleterious materials.

## PART 2 PRODUCTS

### 2.1 SOIL

A. The subgrade replacement material shall be constructed with natural clayey soils obtained onsite. Natural clayey soil means a fine-grained soil containing sufficient plastic fines such that the soil acts as a clayey material, and will readily achieve the specified maximum permeability requirements. However, the governing characteristic shall be that the soil is capable of achieving and maintaining the required permeability.

B. All subgrade replacement material shall be free from organic matter, wood, trash, and other objectionable substances which may be compressible or which cannot be properly compacted. It shall not contain blocks, broken concrete, masonry rubble or other similar materials. It shall have physical properties such that it can be readily spread and compacted to achieve the specified permeability. Snow, ice, and frozen soil shall not be permitted.

C. The maximum particle (stone) size for the lowermost portion of the subgrade replacement material shall be one-half the lift thickness.

## PART 3 EXECUTION

### 3.1 SOIL PLACEMENT

A. The permeability of the lowermost eight feet of the subgrade replacement material shall not exceed $1 \times 10^{-5}$ cm/sec. The permeability of the uppermost two feet of the subgrade replacement material shall not exceed $1 \times 10^{-7}$ cm/sec.

B. Subgrade replacement material shall be graded and compacted to a uniform lift thickness no greater than the maximum lift thickness approved by the PROJECT ENGINEER based on the results of the test pad specified by Section 02277. All subgrade replacement material lifts shall be placed, and compaction shall be performed, in a manner that properly controls moisture content, lift thickness, compactive/kneading action to effectively control soil clod size and eliminate lift interfaces. Soil clods, if found, must not exceed either one-half the lift thickness or a maximum of four-inches, in maximum dimension, and must be isolated within

the matrix of the subgrade replacement material so as not to create a void. Hauling and spreading equipment will not be considered as compaction equipment.

C. The CONTRACTOR shall continue to place and compact lifts of subgrade replacement material to form a uniform upper surface to the requirements of the grading plan. The upper surface of each lift shall be scarified, dried or hydrated as required to provide proper adhesion and bonding to subsequently placed lifts of subgrade replacement material as determined by the PROJECT ENGINEER.

D. The subgrade replacement material shall be placed so as to minimize ponding of rainfall and runoff. Where ponding has occurred, the CONTRACTOR shall remove the excess water prior to continuing operations in those areas. Any soil material that has become too wet for proper placement and compaction, as determined by a failure to meet the requirements of Article 3.2H, shall be removed or dried prior to placement of additional material.

E. The top lift of subgrade replacement material shall be placed and finished to a smooth, uniform appearance reasonably free of cracks or other openings that would promote drying of underlying layers. Desiccation cracks with a depth or width in excess of one-half inch on any lower lifts shall be reworked and moisture/density field tests will be performed and/or Shelby tube/block samples obtained at the discretion of the PROJECT ENGINEER. Desiccation cracks on the top lift that exceed one-half inch shall be remediated. Excessive desiccation of an area of subgrade replacement material shall be prevented by covering the completed area of subgrade replacement material as soon as practical after acceptance of the subgrade area as a whole by the PROJECT ENGINEER.

F. The CONTRACTOR shall restrict vehicular traffic or equipment operation on finished subgrade replacement material areas except as required for redressing or placement of overlying liner system components. Those areas, which are completed and approved by the PROJECT ENGINEER, shall be identified and marked along the perimeters by suitable means. The PROJECT ENGINEER will maintain documentation identifying completed areas.

G. No subgrade replacement material shall be placed in a frozen state, or on any material that has become frozen. All frozen material shall be completely removed prior to placement of additional subgrade replacement material.

H. In-place subgrade replacement material which fails to meet the specified thickness, density, moisture content, or permeability requirements, or exhibits excessive cracking, drying, or other damage prior to covering by the overlying material shall be reworked, or removed and replaced by the CONTRACTOR according to the Specifications.

## 3.2 QUALITY CONTROL/QUALITY ASSURANCE

A. The PROJECT ENGINEER shall maintain a construction control grid having defined positions across the liner system construction area. All aspects of construction shall be referenced to the control grid, including but not limited to, moisture-density test locations, Shelby tube (or other) sample locations, soil placement areas, and tops/toes of slope. The

construction control grid shall be established in rectangular coordinates and lie in the same orientation as the New York State Plane West grid.

B. The CONTRACTOR shall submit to the PROJECT ENGINEER, for his approval, evidence that the proposed subgrade replacement material meets the requirements of this Specification. This evidence shall include, but not necessarily be limited to, the following test results performed on at least one sample from the proposed borrow source:

| | |
|---|---|
| Atterberg Limits | ASTM D4318 |
| Grain Size Distribution | ASTM D422 |
| Moisture Content | ASTM D2216 |
| Modified Proctor | ASTM D1557 |
| Permeability | USACE EM 1110-2-1906<br>or, ASTM D5084 |

If the test data indicates the proposed soil may not be suitable for use in constructing the subgrade replacement materials, the CONTRACTOR shall submit information as noted above for soil from an alternative borrow source.

C. Upon approval of the CONTRACTOR's Quality Control soil test data, the PROJECT ENGINEER shall obtain additional samples for conformance testing. The number of conformance samples collected shall be specified by the project CQA/CQC Plan. Upon receipt of the initial conformance test data, the PROJECT ENGINEER shall prepare a moisture-density-permeability relationship and acceptance window to be used for moisture-density pass/fail criteria during subgrade replacement material construction.

D. If the PROJECT ENGINEER determines that soil delivered to the project varies significantly from the soil approved for use, or material is obtained from an alternate source, additional sampling and testing shall be performed on that source as defined above.

E. During the course of construction, the PROJECT ENGINEER shall modify the acceptance window as appropriate. The changes shall be based on the moisture, density, and permeability QA data obtained during subgrade replacement material placement.

F. Prior to subgrade replacement material construction, test pad(s) shall be completed by the CONTRACTOR for the purpose of confirming acceptable construction procedures for soil source and equipment combinations that have not previously been used successfully on the project. The test pad(s) shall be completed in accordance with Section 02277, on a slope(s) representative of the average bottom slope of the subgrade replacement material. This could include slopes between approximately 2% and 10%, and slopes between 10% and 33% to simulate soil construction on an embankment slopes. The test pad(s) shall be constructed with the same equipment to be used to construct the subgrade replacement material. The thickness of the lifts shall be the maximum lift thickness to be placed and compacted during subgrade replacement material installation. The PROJECT ENGINEER shall observe test pad construction, obtain the required data, assess the acceptability of construction procedures and prepare a report to document the findings. To replicate design boundary conditions, the test pad

will be installed over installed geosynthetic materials to simulate the final construction. Alternatively, a layer of the proposed boundary material shall be placed below the test pad to model design conditions.

G. Prior to the start of any subgrade replacement material construction operations, the PROJECT ENGINEER will review the subgrade QA information, including record survey data and/or drawing(s) showing the elevations and slopes of the underlying subgrade surface. The PROJECT ENGINEER shall check the subgrade for conformance with the requirements of Section 02222, and the grades as required by the design. Subgrade replacement material placement shall not begin prior to approval of the subgrade by the PROJECT ENGINEER. The CONTRACTOR shall note any discrepancies and shall plan his operations so that upon completion of the liner, the finish grades conform to the specified slope requirements.

H. Field moisture-density testing shall be performed at a rate of not less than one test for each day of subgrade replacement material placement, and at least nine tests per acre per lift. Test locations must be proportionately distributed throughout the subgrade replacement material. Prior to leaving the test area, each test location shall be determined by the Construction Observer to within two feet of its actual location and plotted on a plan of the work area illustrating the construction control grid. The Construction Observer shall also plot the dry density and moisture content values on the moisture-density-permeability acceptance window. Failing test results are those that plot outside the acceptance window, and shall not be accepted by the PROJECT ENGINEER.

I. The subgrade replacement material area determined to have unacceptable moisture or density test results shall be defined by the PROJECT ENGINEER based on a series of soil moisture-density tests designed to delineate the failing area. Once defined by the PROJECT ENGINEER, the failed area shall be reworked (further compact and/or hydrate), or removed and replaced by the CONTRACTOR.

J. Moisture-density tests shall be taken through the full depth of the lift.

K. The Construction Observer shall measure the height of the dozer blade above the previous layer or lift to verify the setting on the GPS and the thickness of the layer to be placed that day. In addition, if there is a change in the lift thickness during the day, the Construction Observer shall remeasure the height of the dozer blade above the previous layer or lift. The thickness of each soil lift may be checked by the Construction Observer with random, manual auger holes through the lift. If auger holes are used to determine lift thickness, the location of the lift thickness measurements shall be plotted by the Construction Observer on a plan of the work area illustrating the construction control grid. The final thickness of the subgrade replacement material shall be checked by the Construction Observer with random, manual auger holes through the entire subgrade replacement material, at locations selected by the PROJECT ENGINEER and/or using surfaces generated in three-dimensional modeling software.

L. Routine in-place soil moisture and density testing will be confirmed by laboratory permeability tests on undisturbed Shelby tube samples or block samples. One constant-head, laboratory permeability test result shall be obtained per acre per lift of subgrade replacement material. The

samples shall be taken in the locations selected by the PROJECT ENGINEER to ensure a representative and proportionate distribution of test results for the completed subgrade replacement material. The CONTRACTOR shall rework, or remove and replace as directed by the PROJECT ENGINEER, any material with a permeability greater than $1 \times 10^{-5}$ cm/sec in the lower eight-feet, or greater than $1 \times 10^{-7}$ cm/sec in the uppermost two-feet, as determined by the PROJECT ENGINEER based on his review of the permeability test data, field observations, and confirmation of subgrade replacement material conditions (that may include additional soil moisture-density measurements and/or undisturbed sampling and laboratory testing activities).

M. The CONTRACTOR shall provide the heavy equipment required for Shelby tube and/or block sampling; including but not limited to, a bulldozer and operator and shall assist and cooperate with the PROJECT ENGINEER for all sampling and testing activities. If required, the CONTRACTOR shall restrict operations in designated areas to allow for additional sampling and testing (moisture-density and permeability).

N. All penetrations of the subgrade replacement material resulting from nuclear moisture-density testing and Shelby tube sampling shall be sealed using bentonite approved by the PROJECT ENGINEER. The bentonite shall be rodded into the open hole. The CONTRACTOR shall backfill block sample excavations with subgrade replacement material, and compact the soil using the same procedures required during initial placement.

O. All subgrade replacement material that, after placement and prior to covering, is determined by the PROJECT ENGINEER to be unsuitable (i.e., too wet, too dry, excessive cracking or otherwise compromised), shall be repaired by the CONTRACTOR to the satisfaction of the PROJECT ENGINEER and in conformance with the provisions of these Specifications.

END OF SECTION

# SECTION 02232

# COARSE SAND

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the placement of coarse sand as shown in the Construction Drawings, or elsewhere as specified or required.

### 1.2 RELATED SECTIONS

A. Section 02650 – Polyvinyl Chloride (PVC) Pipe

B. Section 02660 – High Density Polyethylene Pipe

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D422 Standard Test Method for Particle-Size Analysis of Soils

B. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

## PART 2 PRODUCTS

### 2.1 MATERIALS GENERAL

A. All coarse sand materials, unless otherwise specified, shall come from offsite sources and shall be approved by the ENGINEER prior to placement.

B. All coarse sand materials shall be free from organic matter, wood, trash, and other objectionable materials which may be compressible or which may result in damage to any adjacent geosynthetics, to the satisfaction of the ENGINEER. Snow, ice, and frozen material shall not be permitted.

C. The typical gradation requirements for coarse sand are as follows:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| No. 4 | 80-100 |
| No. 16 | 30-70 |
| No. 100 | 0-10 |

### 2.2 TESTING

A. The CONTRACTOR shall submit to the ENGINEER for approval, evidence the proposed materials are appropriate, including but not necessarily limited to grain size analysis (ASTM D422). This information is to be provided for each individual source of coarse sand, or when in the opinion of the ENGINEER, the material is different in any way from the originally tested and approved material

B. The CONTRACTOR shall not proceed with placement of coarse sand until the ENGINEER has approved the proposed material.

C. If in the opinion of the ENGINEER the CONTRACTOR'S proposed material is unsuitable for the proposed application, the CONTRACTOR shall submit the above evidence for material of another type or from another source for consideration by the ENGINEER.

## PART 3 EXECUTION

### 3.1 PLACEMENT

A. Coarse sand shall not be placed until the ENGINEER has approved the installation of the underlying geomembrane liner/subgrade.

B. The CONTRACTOR shall use extreme care in placing other coarse sand.

END OF SECTION

# SECTION 02233

# BEDDING AND BACKFILL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the placement of bedding and backfill, including grading, as shown, specified or required.

### 1.2 RELATED SECTIONS

A. Section 02223 – Common Trench Backfill

B. Section 02224 – Structural Fill

C. Section 02650 – Polyvinyl Chloride (PVC) Pipe

D. Section 02660 – Polyethylene Pipe

E. Section 02836 – MSE Baskets

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D422-63 Standard Test Method for Particle-Size Analysis of Soils

B. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 PROTECTION OF PEOPLE AND PROPERTY

A. The Contractor shall ensure protection of people and property during construction activities.

# PART 2 PRODUCTS

## 2.1 MATERIALS GENERAL

A. All bedding and backfill materials, unless otherwise specified, shall consist of clean, sound, durable granular material from approved offsite sources and shall meet the approval of the PROJECT ENGINEER. All materials shall meet NYSDOT specifications for soundness and hardness in accordance with NYSDOT Standard Specification and the proper ASTM procedures, as demonstrated by the suppliers standard QC test data.

B. All bedding and backfill materials shall be substantially free from organic materials, wood, trash, slag, and other objectionable materials which may be compressible or which cannot be properly compacted. It shall not contain blocks, broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted to the required density. Snow, ice, and frozen material shall not be permitted.

## 2.2 TYPE 2

A. Type 2 granular material shall be used as shown on the Drawings for select soil bedding and backfill, for bedding and backfilling structures and for pipe bedding and backfill unless otherwise stated in the Drawings or as directed by the PROJECT ENGINEER.

B. Soils used as Type 2 material shall be provided by the CONTRACTOR from an approved offsite source. Materials shall be a well-graded, clean, sound, durable, stone and shall not contain slag, organics, or other deleterious materials.

C. The CONTRACTOR shall not place Type 2 material without the approval of the PROJECT ENGINEER.

D. The material shall generally exhibit the following gradation requirements:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| 2 inch | 100 |
| ¼-inch | 25-60 |
| No. 40 | 5-40 |
| No. 200 | 0-10 |

## 2.3 TYPE 1

A. Type 1 material shall be used as shown on the Drawings as select soil bedding and backfill, for bedding and backfilling structures, and for pipe bedding and backfill unless otherwise stated in the Drawings or as directed by the PROJECT ENGINEER.

B. Soils used as Type 1 material shall be provided by the CONTRACTOR from an approved source. Materials shall be a well-graded, clean, sound, durable, stone and shall not contain slag, organics or other deleterious materials.

C. The CONTRACTOR shall not place Type 1 material without the approval of the PROJECT ENGINEER.

D. The material shall generally exhibit the following gradation requirements:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| 2 inch | 90-100 |
| ¼-inch | 30-65 |
| No. 40 | 5-40 |
| No. 200 | 0-10 |

## 2.4 NUMBER 4 STONE

A. Number 4 stone shall be used as shown on the Drawings as backfill inside the front face of the MSE Baskets for the MSE Embankment.

B. Materials used as Number 4 stone shall be provided by the CONTRACTOR from an approved offsite source. Materials shall be clean, sound, durable stone and shall not contain slag, organics, or other deleterious materials.

C. The CONTRACTOR shall not place Number 4 stone without the approval of the PROJECT ENGINEER.

D. The material shall generally exhibit the following gradation requirements:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| 4-inch | 100 |
| 3-inch | 90-100 |
| 2-inch | 0-15 |

## 2.5 NUMBER 2 STONE

A. Number 2 stone shall be used as shown on the Drawings as select soil bedding and backfill, for bedding, and backfilling structures and for pipe bedding and backfill unless otherwise stated in the Drawings or as directed by the PROJECT ENGINEER.

B. Materials used as Number 2 stone shall be provided by the CONTRACTOR from an approved offsite source. Materials shall be clean, sound, durable stone and shall not contain slag, organics, or other deleterious materials.

C. The CONTRACTOR shall not place Number 2 stone without the approval of the PROJECT ENGINEER.

D. The material shall generally exhibit the following gradation requirements:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| 1 ½-inch | 100 |
| 1-inch | 90-100 |
| ½-inch | 0-25 |
| No. 200 | 0-5.0 |

## 2.6 NUMBER 1 STONE

A. Number 1 stone shall be used as shown on the Drawings as select soil bedding and backfill, for bedding and backfilling structures, for pipe bedding and backfill and as MSE Embankment backfill inside the Number 4 stone placed in the MSE Baskets unless otherwise stated in the Drawings or as directed by the PROJECT ENGINEER. A washed Number 1 stone shall be used for tank bedding and backfill.

B. Materials used as Number 1 stone shall be provided by the CONTRACTOR from an approved offsite source. Materials shall be clean, sound, durable stone and shall not contain slag, organics, or other deleterious materials.

C. The CONTRACTOR shall not place Number 1 stone without the approval of the PROJECT ENGINEER.

D. The material shall generally exhibit the following gradation requirements:

| Sieve Size Designation | Percent Passing by Weight |
|---|---|
| 1-inch | 100 |
| ½-inch | 90-100 |
| ¼-inch | 0-15 |
| No. 200 | 0-1.0 |

## 2.7 TESTING

A. The CONTRACTOR shall submit to the PROJECT ENGINEER for approval suitable evidence that any materials proposed for bedding and backfill are appropriate. This information is to be provided for each individual type and source of material or when in the opinion of the PROJECT ENGINEER the material is different in any way from the originally tested and approved material. This evidence shall include, but not necessarily be limited to a grain size

analysis (ASTM D422). The CONTRACTOR shall furnish a 50-pound sample of each proposed soil type (i.e. Type 2, Type 1, Number 4 stone, Number 2 stone, or Number 1 stone) to the PROJECT ENGINEER.

B. The CONTRACTOR shall not proceed with placement of bedding and backfill until the PROJECT ENGINEER has approved the proposed material.

C. Sampling and testing of the bedding and backfill materials for determination of minimum and maximum density values may be performed at the PROJECT ENGINEER's discretion.

D. If in the opinion of the PROJECT ENGINEER the CONTRACTOR'S proposed material is unsuitable for the intended application, the CONTRACTOR shall submit the above evidence for material of another type or from another source for consideration by the PROJECT ENGINEER.

# PART 3 EXECUTION

## 3.1 PRECAUTIONS

A. Bedding and backfill placement shall not:

1. Be performed with or placed on frozen materials;

2. Be placed on snow that has a thickness greater than one tenth of an inch; or,

3. Be placed on ice. Ice shall be defined as frozen water on the surface of in situ soils or previously placed material.

## 3.2 BEDDING AND BACKFILLING

A. All excavations shall be made to such depth as required and of the width shown on the Drawings to provide suitable room for building the structure or laying the pipe(s) they are to contain and for sheeting, shoring, pumping and draining, as necessary, and for removing peat, silt, or any other materials the PROJECT ENGINEER deems unsuitable.

B. The bottom of trenches and excavations shall be accurately graded to provide a uniform layer of bedding material as required for the structure or each section of pipe. The CONTRACTOR shall trim and shape the bottom of trenches or excavations and leave them free of irregularities, lumps and projections.

C. If, in the opinion of the PROJECT ENGINEER, existing material below the excavation or trench grade is unsuitable for properly placing bedding material and installing the structure or

pipe, the CONTRACTOR shall excavate and remove the unsuitable material and replace the same with an approved material properly compacted in place.

D. The side slopes of excavations shall comply with all applicable codes and regulations. The CONTRACTOR shall shore, brace, or slope the excavation or trench as required to maintain the excavation or trench in a safe condition until the completion of backfilling.

E. Removal of materials beyond the indicated elevations, without authorization by the PROJECT ENGINEER, shall be remedied by replacing the same with an approved material properly compacted in place. This work shall be performed by the CONTRACTOR at no additional cost to the OWNER.

F. The CONTRACTOR shall remove all excess water from the excavation or trench promptly throughout the progress of the work and shall keep the excavation or trench stable at all times until the structure or pipe to be constructed therein is completed and backfilled, or have sufficient weight to resist uplift pressures. No structure or pipe is to be laid on loose or softened soils or in water, and water shall not be allowed to rise or flow over any pipe or structure until such time as approved by the PROJECT ENGINEER. Precautions shall be taken to protect uncompleted work from flooding during storms or other causes. All pipe lines or structures not stable against uplift during construction prior to completion shall be thoroughly braced or otherwise protected.

G. Bedding and backfill shall not be placed until the excavation or trench has been inspected in place and approved. The extent of any excavation or trench left open shall be kept to a minimum. Immediately prior to material placement, all rubbish, debris, forms, and similar materials shall be removed from the excavations.

H. Bedding and backfilling shall be accomplished in three stages unless otherwise proposed by the CONTRACTOR and approved by the PROJECT ENGINEER. The first stage shall involve the placement of the bedding material as a layer of select material as shown on the Drawings or as approved by the PROJECT ENGINEER to support the pipe or structure. This material shall be compacted as required by the PROJECT ENGINEER or as specified on the Drawings. In the case of pipe installations, the second stage shall consist of "haunching" which shall be placed to the springline of the pipe and consolidated in-place as directed by the PROJECT ENGINEER. In the case of other structures, the second stage shall consist of the first lift of backfill placed in a lift not to exceed 12 inches and shall be consolidated in-place as approved by the PROJECT ENGINEER. The third stage involves the placement of select backfill lifts not to exceed 12 inches in thickness that shall be placed and consolidated in-place as approved by the PROJECT ENGINEER. The remainder of the trench or excavation shall be brought to grade using materials as shown on the Drawings using methods to be approved by the PROJECT ENGINEER.

I. Any pipe or structure that is damaged or moved out of alignment shall be replaced or realigned at no additional cost to the OWNER.

J. Tank bedding and backfill shall be performed as per the tank manufacturer’s recommendations.

K. Number 4 and Number 1 backfill used in MSE Embankment Construction shall be placed as required by the CQA/CQC Plan.

## 3.3 FIELD QUALITY ASSURANCE/QUALITY CONTROL

A. The CONTRACTOR shall notify the PROJECT ENGINEER at least one working day in advance of all phases of excavation and backfilling operations.

B. The PROJECT ENGINEER shall typically perform onsite visual inspection of the CONTRACTOR'S placement effort to determine if it is satisfactory.

C. The PROJECT ENGINEER may direct additional tests to establish gradation, maximum density and in-place density as required by the Drawings or field conditions.

END OF SECTION

# SECTION 02235

# TOPSOIL

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, equipment, and incidentals necessary to perform all fill and grading required to complete the placement of topsoil in all areas shown on the Drawings or as directed by the ENGINEER. The work shall include, but not necessarily be limited to, the earthwork required for placement of topsoil and all related work.

### 1.2 RELATED SECTIONS

A. Section 02936 – Seeding

### 1.3 DEFINITIONS

A. Topsoil is defined as soil suitable for vegetative growth.

## PART 2 PRODUCTS

### 2.1 TOPSOIL

A. Topsoil used for surface restoration will be provided by the OWNER from onsite sources, resulting from the excavation of the landfill, the stripping of embankment subgrade areas, or other construction activity onsite, or from offsite source, as necessary.

B. Topsoil shall have at least two percent by weight of fine textured stable organic material, and no greater than six percent, or as approved by the ENGINEER.

C. Topsoil shall have not less than 20 percent fine textured material (passing the No. 200 sieve) and not more than 15 percent clay, or as approved by the ENGINEER.

D. Topsoil that was treated with soil sterilants or herbicides shall be so identified by the OWNER.

E. Topsoil shall have a pH between 6.0 and 8.0, or as approved by the ENGINEER.

F. Topsoil shall be relatively free of stones over 1½ inches in diameter, trash, noxious weeds, such as nut sedge and quackgrass, and will have less than 10 percent gravel by volume, or as approved by the ENGINEER.

G. Topsoil that contains soluble salts greater than 500 ppm shall not be used, or as approved by the ENGINEER.

### 2.2 TESTING

A. The OWNER may submit, to the ENGINEER for approval, evidence that the material proposed for use as topsoil is adequate for the proposed application.

B. The topsoil shall be analyzed by the ENGINEER's designated laboratory to determine the percentage of nitrogen, phosphorus, potash soluble salt content, organic matter content, and pH.

C. No material shall be placed unless approved by the ENGINEER.

D. If, in the opinion of the ENGINEER, the soil is unsuitable for the proposed application then the OWNER may submit to the ENGINEER the required information specified in (B) above for soil from a different source.

## PART 3 EXECUTION

### 3.1 INSTALLATION

A. This item shall consist of the placement of topsoil in all areas shown on the Drawings or as directed by the ENGINEER. The CONTRACTOR shall provide all the required labor and equipment to perform the work in accordance with these Specifications.

B. The CONTRACTOR shall install and maintain erosion control devices such as diversions, channels, sediment traps, and stabilizing measures, as needed, to preserve the soil layer until vegetation is established.

C. After the ENGINEER has approved the grades and subsoil, CONTRACTOR shall scarify all compact, slowly permeable, medium and fine textured subsoil areas. The CONTRACTOR shall scarify at approximately right angles to the slope direction in areas that are steeper than five percent.

D. Topsoil shall be installed in a single, minimum three-inch lift in all areas except the final cover system. Soil shall not be placed when it is partly frozen, muddy, or on frozen slopes or over ice, snow, or standing water. Minimum final thickness shall be six inches when used on the landfill final cover system.

E. The CONTRACTOR shall take care to ensure that underlying soil remains intact and does not become mixed with the topsoil during installation.

END OF SECTION

# SECTION 02240

# LEACHATE DRAINAGE LAYER

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of furnishing, placing, and grading the leachate drainage layer material as shown, specified, or required.

### 1.2 RELATED SECTIONS

A. Section 02233 – Bedding and Backfill

B. Section 02595 - Geotextile

C. Section 02597 – HDPE Geomembrane

D. Section 02660 – High Density Polyethylene Pipe

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. C136-06 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

2. D422-63 Standard Test Method for Particle-Size Analysis of Soils

3. D2434-68 Standard Test Method for Permeability of Granular Soils (Constant Head)

C. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 TOLERANCES

A. The total thickness of the leachate drainage layer shall be no less than the minimum thickness shown on the Drawings. The slope and thickness tolerance for the Leachate Drainage Layer, and Certification Survey Requirements, is as described in Appendix B.

# PART 2 PRODUCTS

## 2.1 MATERIALS

A. The minimum initial permeability for the leachate drainage stone shall be 10 cm/sec.

B. As illustrated on the Drawings, the leachate drainage layer design consists of a minimum 24-inch thick ¾ inch nominal stone drainage layer.

C. The ¾ inch nominal stone leachate drainage layer shall be free of organic material and comprised of clean, sound, durable stone and shall be free of slag or any other materials capable of damaging the geomembrane liner. The ¾ inch nominal stone material used shall be in general conformance with the following gradation:

| | **Percent Passing** |
|---|---|
| **Sieve Size** | **By Weight** |
| 1½-inch | 100 |
| 1-inch | 85-100 |
| ½-inch | 0-30 |
| No. 200 | 0-5 |

## 2.2 TESTING

A. The CONTRACTOR will be responsible for all initial testing of the leachate drainage layer materials. The testing required shall be completed on at least one sample of the material, and will include:

1. Grain Size Analysis ASTM D422

2. Permeability ASTM D2434 (or as approved by the PROJECT ENGINEER)

B. The initial test information shall be submitted, reviewed, and approved by the PROJECT ENGINEER before the material is used in the construction. No material shall be placed unless approved by the PROJECT ENGINEER.

C. The ¾ inch nominal stone supplier shall provide one grain size analysis (ASTM D422) for each 1,000 cubic yard block of material delivered and installed, for review by the PROJECT ENGINEER. Additional sampling and testing shall be taken from delivered, stockpiled, and installed materials as required by the project CQA/CQC Plan.

# PART 3 EXECUTION

## 3.1 INSTALLATION - LEACHATE COLLECTION SYSTEM BLANKET DRAIN

A. This item shall consist of the placement of the leachate drainage layer over the cushion geotextile and geomembrane liner. The CONTRACTOR shall provide all the required materials, labor, and equipment to perform the work in accordance with these Specifications.

B. The leachate drainage layer shall be installed as shown by the details in the Drawings. The primary drainage layer shall cover the base of the lined area as illustrated in the Drawings.

C. No material shall be placed until the PROJECT ENGINEER has approved the installation of the underlying cushion geotextile and geomembrane liner materials.

D. The leachate drainage layer shall be placed directly above the cushion geotextile covering the geomembrane liner in 12-inch minimum lifts.

E. The CONTRACTOR shall use extreme care in the placing of the leachate drainage layer over the geotextile and geomembrane liner. The material shall be placed in a manner that will maintain a minimum thickness of 1 foot of material between the geomembrane liner and the spreading equipment. Only tracked equipment shall be allowed on the 1 foot thick aggregate layers. Access roads used to deliver aggregate materials over previously constructed liner shall have a minimum thickness of 3 feet. All equipment to be used in this operation shall be low ground pressure equipment and be approved by the PROJECT ENGINEER. All leachate drainage layer placement operations on slopes greater than 10% will proceed from the bottom of the slope to the top.

F. The CONTRACTOR shall take care to ensure that:

1. The cushion geotextile and geomembrane liner remain intact during the installation of the leachate drainage layer;

2. During installation of the stone, the maximum geomembrane wrinkle size shall not exceed three-inches or a height to width ratio of 0.5, or as deemed acceptable by the PROJECT ENGINEER. The height of the wrinkle shall be measured from the base or subgrade to the peak of the wrinkle. The width of the wrinkle shall be as measured along its base. The geomembrane wrinkle must be trapped during stone installation to prevent spreading and enlargement. The geomembrane wrinkles should not be folded over during leachate drainage layer stone installation.

3. No foreign objects or material are mixed into the leachate drainage layer, in any significant amount as determined by the PROJECT ENGINEER, which may produce clogging or restrict the ability of the layer to transmit water or leachate.

4. No vehicles shall drive on the uncovered cushion geotextile and geomembrane liner, unless previously approved in writing by the PROJECT ENGINEER.

# PART 4 QUALITY ASSURANCE/QUALITY CONTROL

## 4.1 GENERAL

A. The PROJECT ENGINEER will develop and maintain a construction control grid. The control grid shall have defined positions across the area of the proposed overfill liner. All aspects of construction shall be referenced to the control grid including, but not limited to, tops and toes of slope, leachate collection headers, laterals and cleanout risers, berms, manholes, roadways, and culverts. The construction control grid shall be established in rectangular coordinates, and lie in the same orientation to, and with an established relationship to, the New York State Plane grid.

B. The PROJECT ENGINEER shall have grain-size analyses performed on installed stone samples as specified in the project CQA/CQC Plan.

C. The thickness of the leachate drainage layer as measured perpendicular to the slope of the liner system shall be determined by random excavation of the stone layer and the tire shred layer individually, or by instrument survey. The locations of all hand excavations and/or survey points shall be determined and documented by the Geotechnical Construction Observers, and plotted on a plan area map of the landfill.

D. A laboratory permeability test shall be performed during construction at a frequency that results in a total of at least one test for every 2,500 cubic yards of stone delivered and placed, in accordance with the project CQA/CQC Plan.

END OF SECTION

# SECTION 02276

# SOIL LINER

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of supplying, placing, and compacting material for the low permeability soil liner as shown, specified, or required.

### 1.2 RELATED SECTIONS

A. Section 02277 – Test Pad

B. Section 02278 – Geosynthetic Clay Liner

C. Section 02597 – HDPE Geomembrane

D. Section 02595 - Geotextile

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D422-63 Standard Test Method for Particle-Size Analysis of Soils
2. D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$))
3. D2216-05 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock By Mass
4. D4318-05 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index Of Soils
5. D5084-03 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
6. D6938-08a Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. United States Army Corps of Engineers (USACE)

1. EM-1110-2-1906 Constant Head Permeability Test (in Triaxial Cell with Back Pressure Saturation – Low Permeability Soils)

C. The most current version of the specified test method shall be followed by the EARTHWORK CONTRACTOR or authorized testing laboratory

### 1.4 TOLERANCES

A. The minimum completed, compacted thickness of the secondary soil liner shall be 24 inches. The thickness tolerance for the soil liner, and Certification Survey requirements, is as described in Appendix B.

B. The slope of secondary soil liner shall be as specified in the Construction Drawings. The slope tolerance for the soil liner, and Certification Survey Requirements, is as described in Appendix B. This slope shall be as measured between any two points at least 50 feet distant.

C. The maximum acceptable compacted soil liner lift thickness shall be as determined by Test Pad construction as specified in Section 02277.

### 1.5 DELIVERY, STORAGE, AND HANDLING

A. All soil designated for use as low permeability soil liner shall be delivered, stored, and handled in a manner that will prevent contamination by other soils or deleterious materials.

## PART 2 PRODUCTS

### 2.1 SOIL

A. The soil liner shall be constructed with natural clayey soils obtained onsite. Natural clayey soil means a fine-grained soil containing sufficient plastic fines such that the soil acts as a clay, and will readily achieve the specified maximum permeability requirements. However, the governing characteristic shall be that the soil is capable of achieving and maintaining the required permeability.

B. All soil liner material shall be free from organic matter, wood, trash, and other objectionable substances which may be compressible or which cannot be properly compacted. It shall not contain blocks, broken concrete, masonry rubble or other similar materials. It shall have physical properties such that it can be readily spread and compacted to achieve the specified permeability. Snow, ice, and frozen soil shall not be permitted.

C. The maximum particle (stone) size for the lowermost portion of the secondary soil liner shall be three inches. The maximum particle size for soil in contact with the geomembrane shall be one inch.

# PART 3 EXECUTION

## 3.1 SOIL PLACEMENT

A. The permeability of the in-place soil liner shall not exceed 1 x $10^{-7}$ cm/sec.

B. Soil liners shall be graded and compacted to a uniform lift thickness no greater than the maximum lift thickness approved by the PROJECT ENGINEER based on the results of the test pad specified by Section 02277. All soil liner lifts shall be placed, and compaction shall be performed, in a manner that properly controls moisture content, lift thickness, compactive/kneading action to effectively control soil clod size, and eliminate lift interfaces. Soil clods, if found, must not exceed either one-half the lift thickness or a maximum of four-inches, in maximum dimension, and must be isolated within the matrix of the soil liner so as not to create a void. Hauling and spreading equipment will not be considered as compaction equipment.

C. The CONTRACTOR shall continue to place and compact lifts of soil liner to form a uniform upper surface to the requirements of the grading plan. The upper surface of each lift shall be scarified, dried, or hydrated as required to provide proper adhesion and bonding to subsequently placed lifts of soil liner as determined by the PROJECT ENGINEER.

D. The soil liner shall be placed so as to minimize ponding of rainfall and runoff. Where ponding has occurred, the CONTRACTOR shall remove the excess water prior to continuing operations in those areas. Any soil material that has become too wet for proper placement and compaction, as determined by a failure to meet the requirements of Article 3.2H, shall be removed or dried prior to placement of additional material.

E. The top lift of soil liner shall be placed and finished to a smooth, uniform appearance reasonably free of cracks or other openings that would promote drying of underlying layers. Desiccation cracks with a depth or width in excess of one-half inch on any lower lifts shall be reworked and moisture/density field tests will be performed and/or Shelby tube/block samples obtained at the discretion of the PROJECT ENGINEER. Desiccation cracks on the top lift that exceed one-half inch shall be remediated. Excessive desiccation of an area of soil liner shall be prevented by covering the completed area of soil liner as soon as practical after acceptance of the soil liner area by the PROJECT ENGINEER.

F. The CONTRACTOR shall restrict vehicular traffic or equipment operation on finished soil liner areas except as required for redressing or placement of overlying liner system components. Those areas, which are completed and approved by the PROJECT ENGINEER,

shall be identified and marked along the perimeters by suitable means. The PROJECT ENGINEER will maintain documentation identifying completed areas.

G. No soil liner material shall be placed in a frozen state, or on any material that has become frozen. All frozen material shall be completely removed prior to placement of additional soil liner.

H. In-place soil liner which fails to meet the specified thickness, density, moisture content, or permeability requirements, or exhibits excessive cracking, drying, or other damage prior to covering by the overlying material shall be reworked or removed and replaced by the CONTRACTOR according to the Specifications.

## 3.2 QUALITY CONTROL/QUALITY ASSURANCE

A. The PROJECT ENGINEER shall maintain a construction control grid having defined positions across the liner system construction area. All aspects of construction shall be referenced to the control grid, including but not limited to, moisture-density test locations, Shelby tube (or other) sample locations, soil placement areas, and tops/toes of slope. The construction control grid shall be established in rectangular coordinates and lie in the same orientation as the New York State Plane West grid.

B. The CONTRACTOR shall submit to the PROJECT ENGINEER, for his approval, evidence that the proposed soil liner material meets the requirements of this Specification. This evidence shall include, but not necessarily be limited to, the following test results performed on at least one sample from the proposed borrow source:

| | |
|---|---|
| Atterberg Limits | ASTM D4318 |
| Grain Size Distribution | ASTM D422 |
| Moisture Content | ASTM D2216 |
| Modified Proctor | ASTM D1557 |
| Permeability | USACE EM 1110-2-1906<br>or, ASTM D5084 |

If the test data indicates the proposed soil may not be suitable for use in constructing the low permeability soil liners, the CONTRACTOR shall submit information as noted above for soil from an alternative borrow source.

C. Upon approval of the CONTRACTOR's Quality Control soil test data, the PROJECT ENGINEER shall obtain additional samples for conformance testing. The number of conformance samples collected shall be specified by the project CQA/CQC Plan. Upon receipt of the initial conformance test data, the PROJECT ENGINEER shall prepare a moisture-density-permeability relationship and acceptance window to be used for moisture-density pass/fail criteria during soil liner construction.

D. If the PROJECT ENGINEER determines that soil delivered to the project varies significantly from the soil approved for use, or material is obtained from an alternate source, additional sampling and testing shall be performed on that source as defined above.

E. During the course of construction, the PROJECT ENGINEER shall modify the acceptance window as appropriate. The changes shall be based on the moisture, density, and permeability QA data obtained during soil liner placement.

F. Prior to soil liner construction, test pad(s) shall be completed by the CONTRACTOR for the purpose of confirming acceptable construction procedures for soil source and equipment combinations that have not previously been used successfully on the project. The test pad(s) shall be completed in accordance with Section 02277, on a slope(s) representative of the average bottom slope of the soil liner. This could include slopes between approximately 2% and 10%, and slopes between 10% and 33% to simulate soil construction on an embankment slopes. The test pad(s) shall be constructed with the same equipment to be used to construct the soil liner. The thickness of the lifts shall be the maximum lift thickness to be placed and compacted during soil liner installation. The PROJECT ENGINEER shall observe test pad construction, obtain the required data, assess the acceptability of construction procedures and prepare a report to document the findings. A layer of the proposed boundary material shall be placed below the test pad to model design conditions.

G. Prior to the start of any soil liner construction operations, the PROJECT ENGINEER will review the subgrade QA information, including record survey data and/or drawing(s) showing the elevations and slopes of the underlying subgrade surface. The PROJECT ENGINEER shall check the subgrade for conformance with the requirements of Section 02222, and the grades as required by the design. Soil liner placement shall not begin prior to approval of the subgrade by the PROJECT ENGINEER. The CONTRACTOR shall note any discrepancies and shall plan his operations so that upon completion of the liner, the finish grades conform to the specified slope requirements.

H. Field moisture-density testing shall be performed at a rate of not less than one test for each day of soil liner placement, and at least nine tests per acre per lift. Test locations must be proportionately distributed throughout the soil liner. Prior to leaving the test area, each test location shall be determined by the Construction Observer to within two feet of its actual location and plotted on a plan of the work area illustrating the construction control grid. The Construction Observer shall also plot the dry density and moisture content values on the moisture-density-permeability acceptance window. Failing test results are those that plot outside the acceptance window, and shall not be accepted by the PROJECT ENGINEER.

I. The soil liner area determined to have unacceptable moisture or density test results shall be defined by the PROJECT ENGINEER based on a series of soil moisture-density tests designed to delineate the failing area. Once defined by the PROJECT ENGINEER, the failed area shall be reworked (further compact and/or hydrate), or removed and replaced by the CONTRACTOR.

J. Moisture-density tests shall be taken through the full depth of the lift.

K. The Construction Observer shall measure the height of the dozer blade above the previous layer or lift to verify the setting on the GPS and the thickness of the layer to be placed that day. In addition, if there is a change in the lift thickness during the day, the Construction Observer shall remeasure the height of the dozer blade above the previous layer or lift. The thickness of each soil lift may be checked by the Construction Observer with random, manual auger holes through the lift. If auger holes are used to determine lift thickness, the location of the lift thickness measurements shall be plotted by the Construction Observer on a plan of the work area illustrating the construction control grid. The final thickness of the soil liner shall be checked by the Construction Observer with random, manual auger holes through the entire soil liner. The thickness of soil liner shall also be measured at every grade change, at locations selected by the PROJECT ENGINEER, and/or using surfaces generated in three-dimensional modeling software.

L. Routine in-place soil moisture and density testing will be confirmed by laboratory permeability tests on undisturbed Shelby tube samples or block samples. One constant head laboratory permeability test result shall be obtained per acre per lift of soil liner. The samples shall be taken in the locations selected by the PROJECT ENGINEER to ensure a representative and proportionate distribution of test results for the completed soil liner. The CONTRACTOR shall rework, or remove and replace as directed by the PROJECT ENGINEER, any material with a permeability greater than $1 \times 10^{-7}$ cm/sec, as determined by the PROJECT ENGINEER based on his review of the permeability test data, field observations, and confirmation of soil liner conditions (that may include additional soil moisture-density measurements and/or undisturbed sampling and laboratory testing activities).

M. The CONTRACTOR shall provide the heavy equipment required for Shelby tube and/or block sampling; including but not limited to, a bulldozer and operator and shall assist and cooperate with the PROJECT ENGINEER for all sampling and testing activities. If required, the CONTRACTOR shall restrict operations in designated areas to allow for additional sampling and testing (moisture-density and permeability).

N. All penetrations of the soil liner resulting from nuclear moisture-density testing and Shelby tube sampling shall be sealed using bentonite approved by the PROJECT ENGINEER. The bentonite shall be rodded into the open hole. The CONTRACTOR shall backfill block sample excavations with soil liner material, and compact the soil using the same procedures required during initial placement.

O. All soil liner that, after placement and prior to covering, is determined by the PROJECT ENGINEER to be unsuitable (i.e., too wet, too dry, excessive cracking or otherwise compromised), shall be repaired by the CONTRACTOR to the satisfaction of the PROJECT ENGINEER and in conformance with the provisions of these Specifications.

END OF SECTION

# SECTION 02277

# TEST PAD

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the work of constructing pre-soil liner installation test pad(s).

B. The purpose of the test pad(s) is to evaluate the materials, methods, and equipment proposed by the CONTRACTOR to install the soil liner or subgrade replacement material, and to document that the materials, methods, and equipment proposed by the CONTRACTOR are adequate to meet the project requirements.

### 1.2 RELATED SECTIONS

A. Section 02222 – Subgrade

B. Section 02227 – Subgrade Replacement Material

C. Section 02276 - Soil Liner

### 1.3 SUBMITTALS

A. The CONTRACTOR shall provide to the PROJECT ENGINEER the following items:

1. At least 3 days prior to test pad construction, the PROJECT ENGINEER shall be notified of when and where the test pad work will be conducted. The notification shall specify the soil source that will be used to construct the test pad(s) in accordance with the requirements of this Section.

2. At least 2 days prior to construction of the test pad(s), results of the pre-qualification material testing program required by Section 02276.

3. If the test pad is to be completed in an area of the landfill to be included in the certified construction, the PROJECT ENGINEER must prepare or be supplied with a survey showing the location and extent of the test pad subgrade such that any additional testing (e.g. proof rolling, moisture-density, etc.) and approval of the subgrade can be completed prior to test pad construction. The location shown on the drawing must be referenced to the survey control network developed for the project.

4. The NYSDEC shall be notified by the PROJECT ENGINEER of the time and place of test pad construction a minimum of 3 days in advance of the work.

## PART 2 MATERIALS

### 2.1 GENERAL

A. The CONTRACTOR shall construct the test pad(s) with the materials identified and approved by the PROJECT ENGINEER for construction of the subgrade replacement material or soil liner, as specified in Sections 02227 or 02276, respectively.

## PART 3 EXECUTION

### 3.1 SITE PREPARATION

A. The CONTRACTOR shall construct the test pad(s) on subgrade conditions that mimic those of the actual subgrade replacement material or soil liner construction, and in a location approved by the PROJECT ENGINEER. If a liner test pad is constructed in an area where it will become part of the soil liner, the subgrade shall be prepared, observed, evaluated and approved in accordance with the requirements of Section 02222.

### 3.2 INSTALLATION

A. The test pad(s) shall be constructed in a manner that is representative of the manner in which the soil liner or subgrade replacement material will be installed for the project. One test pad shall be required for each soil source/construction methodology/equipment combination. The test pad process may be used to evaluate alternate sources, methods and equipment combinations; however, the PROJECT ENGINEER must obtain separate sets of data and record individual observations for each test pad. All procedures, equipment and soil materials, that will be used in the construction of the test pad shall be consistent with the requirements of Sections 02227 or 02276.

B. The test pads shall be at least 30 feet wide and 80 feet long, or as required to allow placement and compaction equipment to reach normal operating speed before entering the area to be tested and sampled by the PROJECT ENGINEER. The test pad(s) for the soil liner shall be completed on a slope(s) representative of the average bottom slope of the soil liner. This includes two ranges of grade; the first for slopes between approximately 2% and 10%, and the second for slopes between 10% and 33% to simulate soil construction on an embankment slope.

C. The test pad shall demonstrate that the CONTRACTOR can meet the material, construction, and quality requirements of Section 02227 or 02276, as applicable. If there is a change in borrow soil, construction methodology, equipment, or construction conditions, as determined by the PROJECT ENGINEER, a new test pad shall be required.

D. The CONTRACTOR shall assist and cooperate with the PROJECT ENGINEER during all sampling and testing activities.

E. The CONTRACTOR shall protect the test pad until the soil liner material, and the method of installation, have been approved by the PROJECT ENGINEER.

## PART 4 QUALITY CONTROL

### 4.1 GENERAL

A. The testing protocol described in the applicable Sections (Section 02227 for the subgrade replacement material and Section 02276 for the Soil Liner), except as modified by this Section, shall be applied to the test pad to monitor and document the construction quality of the test pad.

### 4.2 OBSERVATIONS, SAMPLING, AND TEST REQUIREMENTS

A. The following techniques shall be followed (unless modified by the CONTRACTOR and approved by the PROJECT ENGINEER) in the construction of each test pad:

1. The borrow area loading procedure shall be developed to produce a soil material with a manageable clod size such that remaining clods can readily be destroyed during the CONTRACTOR's proposed grading and compaction process.

2. The soils shall be hauled to the test pad location and graded by multiple passes of the bulldozer to grade the soil uniformly throughout the test pad area. The soil shall be compacted in a manner that destroys soil clods, eliminates lift interfaces and prevents the formation of observable voids in the completed lifts as determined by the PROJECT ENGINEER.

3. The soil shall be graded to a lift thickness that represents the maximum lift thickness to be allowed during soil liner installation, but in no case greater than 12 inches.

4. The test pad shall consist of at least 2 lifts. The second or subsequent lift(s) shall be placed, graded and compacted in the same manner as the initial lift.

5. The upper surface of the lower lift(s) shall be scarified, and hydrated/dried as required, prior to the placement of an overlying lift, in the same manner as will be carried out during subgrade replacement material/soil liner installation.

B. The PROJECT ENGINEER shall obtain measurements and samples during test pad construction, as follows:

1. Measure and record the overall size of the test pad. Measure and record individual loose and compacted lift thickness.

2. A minimum of one bulk sample per soil type shall be obtained for laboratory testing of liquid and plastic limit, modified Proctor moisture-density relationship and grain-size distribution. Such samples and data will be used to help meet the sampling and

testing frequencies required for the installed subgrade replacement material or soil liner.

3. Soil samples shall be obtained in accordance with the requirements of the gauge manufacturer for the purpose of calculating moisture corrections for the test equipment prior to obtaining field measurements.

4. At least two soil moisture and density measurements shall be obtained from the test pad soils after each pass of the compactor. The PROJECT ENGINEER will use this information to help evaluate the effects of additional passes of the equipment on soil moisture and density. The number of passes shall be sufficient to allow the soil moisture and density measurements to plot within the initial acceptance window developed by the PROJECT ENGINEER.

5. A minimum of one Shelby tube sample per lift per test pad shall be obtained for laboratory permeability testing. The PROJECT ENGINEER shall advance the Shelby tube sampler through the entire lift such that the lowermost portion of the lift will be included in the sample recovery. In the event unacceptable sample compression occurs in the sample while advancing the tube, the PROJECT ENGINEER shall modify the sampling technique (e.g. to remove the upper portion of the lift in the sample area) to obtain a reasonably undisturbed sample for laboratory testing. The PROJECT ENGINEER shall instruct the laboratory to obtain the laboratory permeability specimen from the lowermost portion of the tube sample.

6. Two test holes shall be excavated to the entire depth of each lift to evaluate and document the effectiveness of any kneading action in the soil matrix, and soil clod destruction. Photos shall be taken to document the absence and/or presences of voids or clods remaining in the constructed test pad.

C. The PROJECT ENGINEER shall observe and document the CONTRACTOR's test pad construction procedures, as follows:

1. Complete notes and obtain photographs documenting the soil type, equipment used, placement techniques, sampling and testing procedures;

2. Document the grading technique employed and results achieved by the bulldozer (e.g. distance of grading the end dumped material, number of passes to obtain lift thickness, effectiveness in reducing clod size, etc.);

3. Record compaction equipment specifications, including model, total static weight, drum type, drum width, and foot length;

4. Document the number of passes made by the compactor to achieve the measured soil densities;

5. Observe and record borrow area soil loading method, mixing method (if any) and resulting maximum clod size;

6. Observe and record procedures for lift surface scarification and preparation, including the resulting scarification depth and distribution. Excavate exploratory holes in the pad to establish the presence or absence of seams between lifts; and,

7. Observe and record compaction equipment speed and mode (i.e. static or vibratory).

D. Information obtained from test pad construction will be assembled by the PROJECT ENGINEER into a manner suitable for submission to the NYSDEC, and shall confirm the materials, lift thickness, and construction methods for subgrade replacement material or soil liner placement are adequate to meet the requirements of Section 02227 or 02276, respectively. The test pad information shall be made available to the NYSDEC prior to subgrade replacement material or soil liner construction.

E. Additional sampling, testing and documentation will be performed as directed by the PROJECT ENGINEER. In the event the test pad is constructed within the liner area, the CONTRACTOR shall rework, or remove and replace any test pad material with a hydraulic conductivity greater than $1 \times 10^{-7}$ cm/sec.

END OF SECTION

# SECTION 02278

# GEOSYNTHETIC CLAY LINER

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The GEOSYNTHETICS CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the installation of the geosynthetic clay liner (GCL) under the leachate sump as shown on the Drawings.

### 1.2 RELATED SECTIONS

A. Section 02224 – Structural Fill

B. Section 02597 – HDPE Geomembrane

C. Section 02599 - Geocomposites

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D4354 Standard Practice for Sampling of Geosynthetics for Testing

2. D4643 Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

3. D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

4. D5084 Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

5. D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles

6. D5262 Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics

7. D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

8. D5887 Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter

9. D5888 Standard Guide for Storage and Handling of Geosynthetic Clay Liners

10. D5889 Standard Practice for Quality Control of Geosynthetic Clay Liners

11. D5890 Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners

12. D5891 Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners

13. D5993 Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners

14. D6072 Standard Practice for Obtaining Samples of Geosynthetic Clay Liners

15. D6243 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

16. D6495 Standard Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners

17. D6496 Standard Test Method for Determining Average Bonding Peel Strength between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners

18. D6766 Standard Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids

19. D6768 Standard Test Method for Tensile Strength of Geosynthetic Clay Liners

B. The most current version of the specified test method shall be followed by the MANUFACTURER, GEOSYNTHETICS CONTRACTOR, or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Minimum Value – Property value representing the lowest individual allowable value obtained when tested according to the specified test method. This applies to individual readings, such as thickness; or, where only one specimen is tested for the specified parameter.

B. Minimum Average Value – Property value representing the lowest allowable value for the average of results for the specimens tested.

C. Minimum Average Roll Value (MARV) – Property value calculated as the average test result minus two standard deviations. Statistically, this implies a 97.5 percent confidence that any specimen tested during quality assurance will exceed the value reported.

D. Nominal Value – Property value that is representative of a measurable property, determined under a set of prescribed test conditions, by which a product may be described.

E. Typical Roll Value – Property value calculated as the average or mean obtained from test data.

## 1.5 SUBMITTALS

A. The GEOSYNTHETICS CONTRACTOR shall submit to the PROJECT ENGINEER all items included in this Article. Submittals shall be provided as follows:

1. Submitted with the BID:

   a. A project reference list demonstrating the GEOSYNTHETICS CONTRACTOR'S experience on a minimum of 5 projects, totaling at least two million square feet of installed GCL.

   b. A statement of the GCL MANUFACTURER'S experience, including the manufacturing and supplying company's name, address, and employee contact.

   c. A copy of the GCL MANUFACTURER'S Manufacturing Quality Assurance/ Manufacturing Quality Control (MQA/MQC) Plan.

   d. Long term creep test (ASTM D5262) data demonstrating a maximum 4 mm displacement of the upper geotextile from lower geotextile when placed under a normal load of 500 psf, and a constant shear of 350 lbs over a 10,000 hour period.

2. Fifteen days prior to site delivery, unless stated otherwise below:

   a. Resumes of all GCL installation crew members, including Supervisor and QC Manager, summarizing prior experience in installing GCL. GCL installation staff will be subject to approval by the PROJECT ENGINEER and OWNER.

   b. Manufacturing Quality Control (MQC)/ Manufacturing Quality Assurance (MQA) test data for the material to be delivered to the site. The reports shall include the test results for samples obtained prior to and during the manufacture of the material to be delivered to the site. In the event that material is delivered prior to receipt of the manufacturer's quality control

certificates, the GCL without quality control certificates will be stored separate from material with certificates. The GCL will be rejected if it does not meet the requirements of this Specification, if it does not pass the conformance test program as defined in the project CQA/CQC Plan, or if it is found to have defects, rips, holes, flaws, deterioration, or other damage deemed unacceptable by the PROJECT ENGINEER.

c. All GCL delivered or proposed for delivery shall have conformance testing in accordance to the project CQA/CQC Plan.

d. A certification from the manufacturer that the manufacturing process used to produce the GCL includes continuous needle detection and a mechanism for removal of detected needles. The certification must include tracking forms for each roll, demonstrating that the continuous needle detection and removal process has been applied to all GCL supplied to this project.

e. Samples of the proposed GCL shall be sent to the OWNER for interface shear testing within 5 days after such request is made by the OWNER. The GCL MANUFACTURER shall coordinate the quantity and dimensions of the samples with the OWNER.

f. Shop drawings including details of overlapping, seaming, and anchoring.

3. Upon Completion

a. Summary and log of all laboratory quality control and quality assurance data obtained by the GEOSYNTHETICS CONTRACTOR.

b. Summary and log of all field quality control data and information obtained by the GEOSYNTHETICS CONTRACTOR.

c. Statement of material and installation warranties.

## 1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The GEOSYNTHETICS CONTRACTOR shall be responsible for the protection of the GCL against damage during transportation to the site and during storage at the site. The GEOSYNTHETICS CONTRACTOR shall be responsible for the protection of the GCL against damage following its installation and prior to completion and acceptance of the overlying geomembrane.

B. GCL labeling, shipment, and storage shall follow ASTM D4873 and D5888, as modified by this Specification.

C. Product labels shall be placed on the ends of the roll such that they can be seen when rolls are stacked, and shall clearly show the manufacturer or supplier name, style name, roll number, and roll dimensions.

D. If any special handling is required, it shall be so marked on the outside surface of the wrapping, i.e., "Do not stack more than three rolls high", etc.

E. The GCL shall be supplied dry (unhydrated, less than 40% moisture content) and be delivered to the site undamaged.

F. Each GCL roll shall be wrapped with a material that will protect the bentonite from moisture and the GCL from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

G. Storage areas shall be stable, dry, relatively flat, and well drained. During storage the GCL rolls shall be adequately covered and protected from the following:

1. Site construction damage;

2. Exposure to ultraviolet (UV) radiation in excess of 14 days;

3. Precipitation;

4. Chemicals that are strong acids or strong bases;

5. Flames, sparks, temperatures in excess of 49 deg C (120 deg F); and,

6. Any environmental condition that might damage the GCL.

H. The GEOSYNTHETICS CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections as well as work completed by the OWNER. Only non-damaged, sufficiently dry material (as determined by the PROJECT ENGINEER) shall be included within the construction.

I. Roll numbers on partially used rolls shall be maintained such that each GCL roll number can be readily identified just prior to deployment of the remaining portions of the roll.

J. If the PROJECT ENGINEER determines the GCL is damaged, the GEOSYNTHETICS CONTRACTOR shall make all repairs and replacements in a timely manner so as to prevent delays in the progress of the work. Any material damaged by the GEOSYNTHETICS CONTRACTOR, or damaged by others due to improper installation or protection, shall be replaced by the GEOSYNTHETICS CONTRACTOR at no additional cost to the OWNER.

## 1.7 QUALITY ASSURANCE SAMPLING, TESTING, AND ACCEPTANCE

A. The GCL delivered to the site will be sampled by the PROJECT ENGINEER, who shall forward selected samples to an approved laboratory for testing to verify conformance with this specification. Conformance testing shall be performed in accordance with the project CQA/CQC Plan.

B. The PROJECT ENGINEER shall obtain conformance samples across the entire width of the rolls. The GEOSYNTHETICS CONTRACTOR shall, at no additional cost to the OWNER, provide whatever reasonable assistance the PROJECT ENGINEER may require in obtaining the samples. Unless otherwise specified, samples shall be three feet long by the roll width, and shall not include the outer wrap. The PROJECT ENGINEER shall mark the machine direction on the samples with an arrow, and shall mark the top and bottom of the sample. Non-conforming material shall not be used in the work. In the event non-conforming results are obtained from the laboratory, the nearest numbered rolls on each side of the non-conforming roll shall be sampled and tested for the full suite of conformance tests, until the extent of non-conformance is established. The Project Engineer may reject the entire lot containing non-conforming rolls at any stage of extended sampling and testing.

C. Interface and internal shear strength testing of the GCL is the responsibility of the OWNER. All shear strength testing must be completed prior to installation of the materials. Testing for interfaces involving GCL shall be conducted according to ASTM D6243. The results must comply with the criteria required by the OWNER, as specified on the Drawings.

# PART 2 MATERIALS

## 2.1 GENERAL

A. The GCL shall consist of a reinforced, needlepunched composite of natural granular sodium bentonite clay encapsulated between two geotextiles. The bentonite and finished product requirements are described in the following Parts, including the minimum Manufacturing Quality Assurance (MQA) and Manufacturing Quality Control (MQC) testing.

B. The GEOSYNTHETICS CONTRACTOR shall provide the PROJECT ENGINEER with certified laboratory data sheets from the GCL MANUFACTURER for MQC testing described in this Part.

## 2.2 BENTONITE

A. The bentonite used in the GCL shall be a natural granular sodium bentonite. Powdered bentonite shall not be used in the manufacture of the GCL. The table presented in 2.2B represents the minimum required Manufacturing Quality Assurance (MQA) testing that

must be conducted by the GCL MANUFACTURER on the bentonite portion of the GCL.

B. The bentonite shall be tested in accordance with ASTM D5889 for "Clay" as modified by the following table. Testing shall be conducted as listed in the following table at a rate of once per 100,000 pounds and must meet the specified values:

| PROPERTY | TEST METHOD | VALUE |
|---|---|---|
| Swell Index, mL/2g (min). | ASTM D5890 | 24 |
| Fluid Loss, ml (max) | ASTM D5891 | 18 |

## 2.3 GEOSYNTHETIC CLAY LINER

A. The following table represents the minimum required MQC testing that must be conducted by the GCL MANUFACTURER on both the cap and carrier geotextile, as well as the finished GCL. The GCL shall be tested in accordance with ASTM D5889 as modified by the following table. Testing shall be conducted as listed in the following table and must meet the specified values:

| GEOTEXTILE PROPERTY | TEST METHOD | VALUE |
|---|---|---|
| Cap, Nonwoven, Mass/Unit Area, oz/yd$^2$ (MARV[3]) | ASTM D5261 | 6.0 |
| Carrier, Woven, Mass/Unit Area, oz/yd$^2$ (MARV) | ASTM D5261 | 3.0 |

| FINISHED GCL PROPERTY | TEST METHOD | VALUE |
|---|---|---|
| Clay Mass / Area, dried [1], lb/ft$^2$ (min. avg.) | ASTM D5993 | 0.75 |
| Clay Moisture Content, % (max) | ASTM D4643 | 40 |
| Grab Tensile Strength [2], lbs/in. (min. avg.) | ASTM D6768 | 22.5 |
| Index Flux, m$^3$/m$^2$/sec (max) | ASTM D5887 | $1x10^{-8}$ |
| Permeability, cm/sec (max) | ASTM D5887 | $5x10^{-9}$ |
| GCL Peel Strength, lbs/in. (min. avg.) | ASTM D6496 | 2.5 |
| GCL Hydrated Internal Shear Strength, psf (min) | ASTM D6243 or D5321 | 500 |

1. Dried bentonite is defined as 0 % moisture content.
2. Tensile testing performed in machine direction.
3. Minimum Average Roll Value

B. The manufacturing process shall include a mechanism for needle detection and needle removal. This mechanism shall be in operation throughout the production of all GCL rolls to be delivered to this site. The MANUFACTURER shall issue a certification

including a tracking form for each roll, demonstrating that the continuous needle detection and removal process has been applied to all GCL supplied to this project.

## PART 3 EXECUTION

### 3.1 SITE PREPARATION

A. The surface to be covered by the GCL shall be cleared of sharp objects, angular stones sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The GCL subgrade shall have a smooth, finished surface, free from pockets , holes, soft spots, ruts greater than 1 inch in depth, discontinuities that will cause bridging and overstress the material, and substantially free of loose soil as determined by the PROJECT ENGINEER. The GCL subgrade shall be inspected for unsuitable areas or soft spots before the GCL is placed.

### 3.2 INSTALLATION

A. The GEOSYNTHETICS CONTRACTOR shall furnish the GCL roll number to the PROJECT ENGINEER prior to the installation of each panel.

B. The GEOSYNTHETICS CONTRACTOR shall maintain the GCL in a dry state up to and including the time that the overlying geomembrane is accepted by the OWNER. The GCL must have, at a minimum, the confining load of the leachate drainage stone in place prior to hydration.

C. GCL shall not be placed on a wet subgrade. Any GCL that becomes softened prior to covering with geomembrane shall be removed and replaced by the GEOSYNTHETICS CONTRACTOR at no additional cost to the OWNER. In the event softening occurs prior to placement of the leachate drainage stone, all softened GCL must be removed and replaced with "dry" material.

D. When a textured geomembrane is installed over the GCL, a slip sheet shall be used to minimize raveling of the GCL.

E. The GEOSYNTHETICS CONTRACTOR shall install only as much GCL as can be covered and protected by the overlying geomembrane within the same working day. The GEOSYNTHETICS CONTRACTOR shall sequence placement of the overlying layer so as to prevent damage, hydration or excessive drying of the GCL. GCL deployment shall be limited during periods of impending wet weather such that a minimum of GCL is uncovered at any given time.

F. The GCL panels shall be installed free of tension and without folds or creases. Panels shall be staggered such that cross seams between panels are not continuous throughout the lined area.

G. The GCL seams shall be constructed by overlapping adjacent edges of the panels and adding granular bentonite as described in Item H below. Care shall be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. The minimum dimension of the longitudinal overlap shall be 6 inches. End-of-roll overlapped seams shall be similarly constructed, but the minimum overlap shall measure 24 inches. All overlap lengths shall be as required to ensure a continuous GCL system after potential dehydration of the GCL due to overlying geomembrane placement. Seams at the ends of the panels shall be constructed such that they are shingled in the direction of the grade such that the down slope panel is overlapped by the panel immediately upslope.

H. Bentonite enhanced seams shall be constructed between the overlapping adjacent panels described above. This bentonite enhanced seam can consist of a manufactured slice in the edges of the GCL that allows for expansion of the bentonite in the composite if not the seam area between the panels. If a manufactured slice in the edges of the GCL is not available, then a continuous bead of granular sodium bentonite shall be applied along a zone defined by the edge of the underlying panel and the 6-inch line. A similar bead of granular sodium bentonite shall be applied at the end-of-roll overlap. The granular bentonite shall be applied at a minimum rate of one quarter pound per lineal foot.

I. The GEOSYNTHETICS CONTRACTOR shall be responsible for the protection of the GCL during the installation. In no way shall any tracked equipment, or any other equipment which may pose a risk of puncturing, tearing, or otherwise damaging the GCL, be permitted to operate on the GCL.Wheeled vehicle traffic is prohibited above the GCL. Low ground pressure vehicles only will be allowed to traverse any GCL covered with a foot of soil. Three feet of soil must be in place over the GCL to permit heavy wheeled vehicles to travel across the GCL.

## 3.3 REPAIRS

A. Repairs are to be made as soon as possible after deployment.

B. Damage to the GCL shall be repaired in the following manner:

1. The damaged area shall be cleared of dirt and debris.

2. A patch of GCL shall be cut to extend a minimum of 12 inches beyond the damaged area.

3. Granular bentonite shall be placed around the perimeter of the damaged area at a rate of 0.5 pounds per linear foot.

4. The patch shall be placed over the damaged area and secured with an adhesive to keep the patch in position as the overlying geomembrane is installed. The adhesive shall be approved by the GCL MANUFACTURER and the PROJECT ENGINEER.

## PART 4 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

### 4.1 GENERAL

A. Before installation begins, and weekly thereafter, (more often if determined necessary by the PROJECT ENGINEER) project coordination meetings shall be held with the designated representative of the CONTRACTOR, GEOSYNTHETICS CONTRACTOR, PROJECT ENGINEER, and OWNER in attendance to review the following information:

1. Progress of the work;

2. Adherence to the Specifications;

3. Adherence to the Construction Quality Control Program described in this Section, including the timely submission of the pertinent forms;

4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work; and,

5. Problem resolutions to be implemented during the upcoming week.

B. All information specified and required must be submitted to the PROJECT ENGINEER in a timely fashion. No material shall be installed before the interface and internal shear strength results show that the GCL meets the Specifications.

C. Any changes in the proposed method of work, subcontractors to be utilized, manufacturing or materials must be approved in advance by the PROJECT ENGINEER. The GEOSYNTHETICS CONTRACTOR assumes all responsibility relevant to providing an acceptable product.

D. The GEOSYNTHETICS CONTRACTOR, before installation begins, shall appoint an experienced individual who will be on-site at all times during the installation, to represent him in all matters relevant to this work. This individual must have the experience level outlined in Article 1.5.A.1.a of this Section.

E. Any changes in the proposed method of work, manufacturing, or GCL material must be approved in advance by the PROJECT ENGINEER.

### 4.2 INSTALLATION QA/QC

A. The GEOSYNTHETICS CONTRACTOR and PROJECT ENGINEER shall inspect the underlying surface for unsuitable areas before the GCL is placed. Additional underlying surface preparation may be required to eliminate deleterious materials and any unsuitable areas as defined by this Section, or as determined by the PROJECT ENGINEER.

B. Damage to GCL during installation shall be repaired according to Article 3.3 of this Section. If the PROJECT ENGINEER determines that the damage is un-repairable, the damaged area will be replaced.

C. The PROJECT ENGINEER and GEOSYNTHETICS CONTRACTOR shall visually inspect all material to be included in the work, and compare roll identification numbers with those on the certification provided by the manufacturer to assure delivery of the appropriate material.

D. The GCL shall be inspected continuously by the PROJECT ENGINEER and GEOSYNTHETICS CONTRACTOR for the presence of broken needles in the GCL.

E. All panel seams shall be inspected and approved by the PROJECT ENGINEER prior to covering. The PROJECT ENGINEER shall confirm the overlap length is sufficient to prevent gaps between adjacent GCL panels after potential dehydration due to placement of the overlying geomembrane liner.

F. The PROJECT ENGINEER shall inspect the installed GCL system to ensure the requirements of this Specification have been met. In the event the requirements have not been met, the GEOSYNTHETICS CONTRACTOR shall make appropriate corrections at no additional cost to the OWNER.

## 4.3 WARRANTY

A. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the installation of GCL for a minimum period of 1 year.

B. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the GCL material for a minimum period of 5 years.

END OF SECTION

# SECTION 02595

# GEOTEXTILE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The GEOSYNTHETICS CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the installation of all geotextile material, complete with appurtenances, as shown, specified or required.

### 1.2 RELATED SECTIONS

A. Section 02222 – Subgrade

B. Section 02224 – Structural Fill

C. Section 02227 – Subgrade Replacement Material

D. Section 02240 – Leachate Drainage Layer

E. Section 02276 – Soil Liner

F. Section 02597 – HDPE Geomembrane

G. Section 02598 – LLDPE Geomembrane

H. Section 02599 - Geocomposites

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D-3786/D-3786M Standard Test Method for Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method.

2. D-4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus

3. D-4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity

4. D-4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

5. D-46328 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

6. D-4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile

7. D-4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

8. D-5034 Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

9. D-5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

10. D-5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles

11. D-5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

B. The most current version of the specified test method shall be followed by the MANUFACTURER, GEOSYNTHETICS CONTRACTOR, or authorized testing laboratory.

## 1.4 SUBMITTALS

A. The GEOSYNTHETICS CONTRACTOR shall furnish a mill certificate from the company manufacturing the geotextile attesting that the cushion (Type C) and separation (Type S) geotextile meet the chemical, physical, and manufacturing requirements specified in Part 2 of this Section. This certification shall be supported by quality control test results of samples obtained during the manufacture of the material to be delivered to the site. The PROJECT ENGINEER will reject geotextile if it does not meet the minimum property requirements or if it is found to have defects, rips, holes, flaws, deterioration, or other damage deemed unacceptable.

B. The GEOSYNTHETICS CONTRACTOR shall furnish the PROJECT ENGINEER with a list of the geotextile material identification requirements itemized in Part 2 of this Section.

C. The GEOSYNTHETICS CONTRACTOR shall furnish the PROJECT ENGINEER with documentation of the thread used to construct geotextile seams. The documentation shall certify that the thread has chemical resistance properties equal to or exceeding those of the geotextile.

### 1.5 PRODUCT HANDLING

A. The GEOSYNTHETICS CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections, as well as work completed by the OWNER.

B. The GEOSYNTHETICS CONTRACTOR shall, during all periods of shipment and storage, protect the geotextile from direct sunlight, ultraviolet rays, temperatures greater than 120 degree F, mud, dirt, dust, debris, and other deleterious materials. The geotextile shall be maintained in a dry condition and be wrapped in a heavy-duty protective covering until it is installed.

C. If the PROJECT ENGINEER determines material is damaged or has excessive sunlight exposure, the GEOSYNTHETICS CONTRACTOR shall immediately make all repairs and replacements.

## PART 2 MATERIALS

### 2.1 GENERAL

A. The geotextile shall be manufactured from first quality virgin materials. The geotextile manufacturer shall identify all rolls of geotextile delivered to the site with a weatherproof label located on the outside end of the wrapping material. This label shall include the following information as a minimum:

- Manufacturer's name;
- Product identification and Style number;
- Chemical composition of filaments;
- Date of Manufacture;
- Lot number;
- Batch number;
- Roll number; and,
- Roll dimensions.

Each roll of product shall include any additional information required to allow the PROJECT ENGINEER to relate that roll with the manufacturing quality control and raw material quality control documentation. Additionally, if any special handling is required, it shall be so marked

on the outside surface of the wrapping, i.e., "Do not stack more than five rolls high", etc. All geotextile delivered to the site shall be original factory fresh rolls.

The GEOSYNTHETICS CONTRACTOR and PROJECT ENGINEER shall have the manufacturer's quality control data prior to site delivery. Geotextile with acceptable manufacturer's quality control data shall be stored separately onsite from geotextile without quality control data and geotextile with unacceptable data to prevent placement of unacceptable material. Mislabeling or misrepresentation of materials shall be reason to reject those geotextile products.

B. Prior to and/or upon delivery, the PROJECT ENGINEER shall obtain samples to forward them to an approved laboratory for independent testing to verify conformance with the material properties required by the project CQA/CQC Plan The GEOSYNTHETICS CONTRACTOR shall assist the PROJECT ENGINEER in obtaining the conformance test samples. Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the roll width. The PROJECT ENGINEER shall mark the machine direction on the samples with an arrow.

## 2.2 GEOTEXTILE

A. The cushion, filter, and separation geotextiles to be used for this project shall be of the same non-woven, needle-punched geotextile material.

B. The GEOSYNTHETICS CONTRACTOR shall provide the PROJECT ENGINEER with the Manufacturers written certification that the geotextile delivered to the site meets or exceeds the minimum properties required for the project. A person having legal authority to bind the Manufacturer shall sign the certificate. This certification shall be supported by quality control test documentation developed during the manufacture of the delivered material to certify conformance with the following properties:

| PROPERTY | TEST METHOD | FREQUENCY | VALUE | UNITS |
|---|---|---|---|---|
| Weight per Area (min. avg.) | ASTM D5261 | 90,000 $ft^2$ | 10.0 | $oz/yd^2$ |
| Grab Tensile Strength(1) (min. avg.) | ASTM D4632 | 90,000 $ft^2$ | 250 | lbs |
| Grab Elongation(1) (min. avg.) | ASTM D4632 | 90,000 $ft^2$ | 50 | % |
| Puncture Resistance (min. avg.) | ASTM D4833 | 90,000 $ft^2$ | 160 | lbs |
| Trapezoid Tear (min. avg.) | ASTM D4533 | 90,000 $ft^2$ | 100 | lbs |
| Mullen Burst Strength (min. avg.) | ASTM D3786 | 90,000 $ft^2$ | 525 | psi |
| UV Resistance(3) | ASTM D4355 | Per formulation | 70 | % at 500 hours |
| AOS (max. avg.) | ASTM D4751 | 100,000 $ft^2$ | 100 | mm US Sieve |
| Minimum Friction with material | ASTM D5321 | 90,000 $ft^2$ | See Note 2 | degree |

| | | | | |
|---|---|---|---|---|
| above and below. | | | | |
| Permittivity (min. avg.) | ASTM D4491 | 100,000 $ft^2$ | See Note 4 | $sec^{-1}$ |

Notes:

1. Weakest Principal Direction.
2. The interface shear strength with materials above and below the geotextile must be greater than that specified in the drawings. The testing must be performed with actual materials to be used in construction and under a normal stress range approved by the PROJECT ENGINEER.
3. Representative UV Resistance test data for the polymer used in the manufacture of the geotextile that is acceptable to the Project Engineer can be supplied in lieu of specific testing of the material delivered to the site.
4. The minimum permittivity must be equivalent to a permeability two orders of magnitude greater than the adjacent soil material.

### 2.3 WIDTH OF GEOTEXTILES

A. To keep the number of overlays to a minimum, the geotextile shall be provided in sections not less than 12 feet wide. Seams, if used in roll products, shall be made at the factory and shall be tested in accordance with ASTM D5034 or ASTM D5035 as directed by the PROJECT ENGINEER. The strength shall not be less than the required tensile strength of the geotextile in any principal direction. Results of the factory fabricated seam tests shall be provided with the information required by 2.2 above.

### 2.4 GEOTEXTILE JOINING MATERIALS

A. Geotextiles shall be joined by field sewing. Geotextile joining materials and methods shall be as approved by the PROJECT ENGINEER and shall conform to the recommendations of the manufacturer.

## PART 3 EXECUTION

### 3.1 SITE PREPARATION

A. The surface to be covered by the geotextile shall be cleared of sharp objects, angular stones sticks, or any materials that may contribute to punctures, shearing, rupturing, or tearing of the geosynthetic materials. The geotextile subgrade shall have a smooth, finished surface, free from pockets, holes, soft spots, ruts greater than 1 inch in depth, discontinuities that will cause bridging and overstress the material, and substantially free of loose soil as determined by the PROJECT ENGINEER. The subgrade shall be inspected for unstable areas or soft spots before the geotextile is placed and additional surface preparation will be required to eliminate any unstable areas as determined by the PROJECT ENGINEER.

## 3.2 INSTALLATION

A. The geotextile shall be placed in the manner and at the locations shown on the Drawings. When placing the geotextile, sections shall be joined by overlapping the geotextile a minimum of four inches with field-sewn seams, or as recommended by the manufacturer and as approved by the PROJECT ENGINEER. No horizontal seams (i.e., seams perpendicular to the maximum slope) shall be placed on slopes greater than 25% unless the slope length exceeds the manufactured roll length. Geotextile shall be laid smooth and free of excess tension, stress, folds, wrinkles, or creases.

B. During backdumping and spreading of soil over the geotextile, a minimum depth of 12 inches of soil shall be maintained over the geotextile at all times between the geotextile and wheels, tracks or buckets of heavy equipment or trucks. No portion of any heavy equipment or trucks shall be in direct contact with the geotextile.

C. If geotextile on a slope less than 15 percent should be damaged during any step of installation, a piece of geotextile material shall be cut and placed over the damaged area subject to a 3 foot minimum overlap requirement or as directed by PROJECT ENGINEER. If any rip or defect occurs across more than one-third the width of the roll, that portion of the roll will be removed from the work.

D. If the geotextile on a slope greater than 15 percent develops any holes or tears, they shall be repaired by a geotextile patch sewn into place using a double sewn stitch 1/4 to 3/4 inches apart and no closer than one inch from any edge. Should any tear exceed ten percent of the width of the roll, that portion of the roll shall be removed from the slope and replaced. Care shall be taken to remove any soil or other material that may have penetrated the torn geotextile.

E. Soil shall be spread in the direction of geotextile overlap, except on slopes greater than 15 percent, at which time soil shall be placed from the bottom of slope to the top.

F. Smoking is not permitted on or near the geotextile.

G. Wheeled vehicle traffic is prohibited above the geotextile. Low ground pressure vehicles only will be allowed to traverse any geotextile covered with a foot of soil. Three feet of soil must be in place over the geotextile to permit heavy wheeled vehicles to travel across the geotextile.

## 3.3 PROTECTION

A. Any geotextile damaged during its installation shall be repaired by the GEOSYNTHETICS CONTRACTOR.

B. The work shall be scheduled so that the covering of the geotextile with a layer of the cover material is accomplished within 30 days after placement of the geotextile. Failure to comply with this requirement shall require replacement of the geotextile.

END OF SECTION

# SECTION 02597

# HDPE GEOMEMBRANE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The GEOSYNTHETIC CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the installation of all geomembrane complete with appurtenances, as shown, specified, or required by the Drawings.

### 1.2 RELATED SECTIONS

A. Section 02278 – Geosynthetic Clay Liner

B. Section 02595 – Geotextile

C. Section 02276 – Soil Liner

D. Section 02599 – Geocomposite

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D792-08 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

2. D1004-09 Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

3. D1238-04c Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

4. D1505-10 Standard Test Method for Density of Plastics by the Density-Gradient Technique

5. D1603-11 Standard Test Method for Carbon Black in Olefin Plastics

6. D3895-07 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

7. D4218-96 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

8. D4354-99 Standard Practice for Sampling of Geosynthetics for Testing

9. D4833-07 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

10. D4873-02 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

11. D5321-08 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

12. D5397-07 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

13. D5596-03 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

14. D5641-94 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

15. D5820-95 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

16. D5994-10 Standard Test Method for Measuring Core Thickness of Textured Geomembrane

17. D6243-09 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

18. D6365-99 Standard Practice for the Nondestructive Testing of Geomembrane Seams Using the Spark Test

19. D6392-08 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

20. D6497-02 Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures

21. D6693-04 Standard Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes

22. D7007-09 Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

23. D7466-10 Standard Test Method for Measuring the Asperity Height of Textured Geomembrane

B. Geosynthetic Research Institute (GRI):

1. GRI GM6 - Pressurized Air Channel Test for Dual Seamed Geomembranes

2. GRI GM9– Cold Weather Seaming of Geomembranes

3. GRI GM13 Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

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

5. GRI GM19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. The most current version of the specified test method shall be followed by the Manufacturer, GEOSYNTHETIC CONTRACTOR, or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Minimum Value – Property value representing the lowest individual allowable value obtained when tested according to the specified test method. This applies to individual readings, such as thickness; or where only one specimen is tested for the specified parameter.

B. Minimum Average Value – Property value representing the lowest allowable value for the average of results for the specimens tested.

C. Minimum Average Roll Value (MARV) – Property value calculated as the average test result minus two standard deviations. Statistically, this implies a 97.5 percent confidence that any specimen tested during quality assurance will exceed the value reported.

D. Nominal Value – Property value that is representative of a measurable property, determined under a set of prescribed test conditions, by which a product may be described.

E. Typical Roll Value – Property value calculated as the average or mean obtained from test data.

F. Unit – For the purposes of this project, a "Unit" shall be a single roll of geosynthetic material.

G. Lot - For the purposes of this project, a "Lot" will be defined as a single run of geosynthetic material from the same production facility, where the tooling and raw materials of production have not changed during manufacturing.

## 1.5 SUBMITTALS

A. The GEOSYNTHETIC CONTRACTOR shall submit to the ENGINEER all items included in this Article. Submittals shall be provided as follows:

1. With the GEOSYNTHETIC CONTRACTOR's BID:

   a. A project reference list documenting the experience of the GEOSYNTHETIC CONTRACTOR on a minimum of 5 projects consisting of at least 10 million square feet of installed textured HDPE geomembrane.

   b. A copy of the Manufacturer's Manufacturing Quality Assurance/ Manufacturing Quality Control (MQA/MQC) Plan for the complete geomembrane manufacturing process.

   c. A schedule of operations, including means and methods of installation.

   d. The width of the geomembrane panels to be used for the project and the proposed method of joining adjacent geomembrane panels.

   e. Available notched constant tensile load (NCTL) data regarding the polyethylene resin to be used to manufacture the geomembrane and welding rod/pellets.

   f. The documented historic pass/fail rate for HDPE geomembrane seam destructive tests performed on seams created by the proposed welding crew members.

2. At least 15 days prior to delivery of geomembrane to the site, unless otherwise noted below:

   a. Working drawings, including proposed panel diagram and details of proposed work, extrusion welds, pipe boots, and details of sealing around all necessary geomembrane penetrations, to be submitted at least 15 days prior to delivery of geomembrane to the site. The panel diagram must depict and/or note the planned number and orientation of panels, the minimum panel size, seam orientation and overlap direction, placement of seams in corners, treatment of tee seams and the GEOSYNTHETIC CONTRACTOR's preferred sequence of panel placement. The HDPE panels shall be orientated in a manner that minimizes seams and shall not have cross seams placed on slopes greater than 25% unless the slope length exceeds the manufactured roll length. The ENGINEER prior to geomembrane installation must approve the panel diagram. The ENGINEER, in writing, prior to altering the installation, must approve proposed revisions to the panel diagram.

b. Welding Rod - Manufacturing Quality Assurance (MQA) test data from the geomembrane Manufacturer demonstrating that the resin utilized in the production of the geomembrane and welding rod and/or pellets meets the requirements specified in Article 2.2. The packages containing the welding rod and/or pellets must contain a label identifying the resin lot utilized in their manufacture.

c. Geomembrane - Manufacturing Quality Control (MQC) data certificates for the geomembrane to be delivered to the site. The reports shall reference the resin lot used in the manufacture of the sheet, and shall include the quality control test results obtained during the manufacture of the material. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates. Material with unacceptable MQC data will be segregated from approved material and shall be marked for rejection. The geomembrane will be rejected or if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the ENGINEER.

d. Resin - Resin Manufacturer's certificate for each resin lot utilized by the geomembrane Manufacturer in the production of the geomembrane and welding rod/pellets to be delivered to the site.

e. Geomembrane Sample - Samples of the proposed geomembrane shall be sent to the ENGINEER for interface shear testing within 5 days after the ENGINEER makes such request. The GEOSYNTHETIC CONTRACTOR shall coordinate the quantity and dimensions of the samples with the ENGINEER.

3. At least 15 days prior to installation:

a. Resumes of geomembrane crew; including, Supervisor, QC Manager, Master Seamers, and all Welding Technicians. The resumes shall include prior experience in installing textured HDPE geomembrane. All individuals who will perform welding on this project shall be certified by the welding equipment manufacturer as having been trained in the use of the equipment; or, in lieu of such certification, the GEOSYNTHETIC CONTRACTOR shall provide other suitable evidence that demonstrates the proposed welding personnel possess intimate knowledge of welding equipment design, set-up, operation, and maintenance. Individual geomembrane crew members will be subject to the approval of the ENGINEER.

b. A copy of the GEOSYNTHETIC CONTRACTOR's standard operating procedure (SOP) for operating an ATV or other utility vehicle on site, particularly with respect to specific uses of such vehicles and the prevention of damage to materials.

c. Field tensiometer calibration certificate showing that the equipment to be used for shear/peel testing in the field has been calibrated by a qualified individual within the previous 6 months.

4. During Installation Submitted Daily:

a. Completed Geomembrane Subgrade Acceptance Form, as endorsed by the ENGINEER, prior to geomembrane deployment in any area.

b. Construction progress reports clearly showing geomembrane placed by date.

c. Passing and failing test results for trial seams.

d. Documentation of passing and failing destructive and non-destructive testing of installed seams.

5. Within 5 days after completion:

a. Summary and log of all field quality control work completed by the GEOSYNTHETIC CONTRACTOR.

b. Certification statement signed by the Supervisor that geomembrane installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.

c. Statement of material and installation warranties.

B. The above-noted requirements shall apply to all shop-fabricated materials and those items specified for fabrication in the field

## 1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The GEOSYNTHETIC CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections, as well as work completed by the OWNER.

B. Geomembrane labeling, shipment, and storage shall follow ASTM D4873 as modified according to this Specification.

C. Product labels shall be placed on the ends of rolls such that they can be seen when rolls are stacked, clearly showing the manufacturer or supplier name, style name, roll number, and roll dimensions.

D. Each roll of product shall include any additional information required to allow the ENGINEER to relate that roll with the manufacturing quality control and raw material quality assurance documentation. Additionally, if any special handling is required, it

shall be so marked on the outside surface of the wrapping, i.e., "Do not stack more than five rolls high," etc.

E. During storage, the geomembrane shall be placed on a stable, relatively flat, dry, well-drained surface. The geomembrane shall not be placed on skids or other objects that may cause deformation of the geomembrane rolls. Adequate space shall be left between stacked rolls, such that roll labels can be examined. The geomembrane shall be protected from the following:

1. Mud and dust.

2. Site construction damage.

3. Chemicals that are strong acids or bases.

4. Flames, sparks, or geomembrane temperatures in excess of 150° F.

5. Any environmental condition that might damage the geomembrane.

F. Roll numbers on partially used rolls must be maintained such that each roll number can be readily identified prior to deployment of the remaining portions of the roll. In the event roll numbers for partial rolls cannot be identified, such rolls will be marked for rejection.

G. If the ENGINEER determines the geomembrane is damaged, the GEOSYNTHETIC CONTRACTOR shall make all repairs and replacements in a timely manner, so as to prevent delays in the progress of the work. As determined by the ENGINEER, any material damaged by the GEOSYNTHETIC CONTRACTOR, or damaged by others due to improper delivery and/or storage, shall be replaced by the GEOSYNTHETIC CONTRACTOR at no cost to the OWNER.

# PART 2 MATERIALS

## 2.1 GENERAL

A. The geomembrane shall be manufactured from first quality; virgin high-density polyethylene (HDPE) resin with no more than 10% rework. If rework is used it must be identical to the parent materials. The HDPE resin must be blended with carbon black. The resin and finished product requirements are described in this Part, including the minimum Manufacturing Quality Assurance (MQA) and Manufacturing Quality Control (MQC) sampling and testing requirements.

B. The HDPE sheet must be textured on both surfaces, and shall have a uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

C. The geomembrane may have a white surface to minimize geomembrane surface temperatures and reduce overall wrinkling in the panels during construction. Any non-black geomembrane must be suitable for exposure during the installation process without degradation to the physical and mechanical properties required by this Specification.

D. The ENGINEER will conduct conformance testing on the geomembrane in accordance with the project CQA/CQC Plan. The GEOSYNTHETIC CONTRACTOR shall, at no additional cost to the OWNER, provide whatever reasonable assistance the ENGINEER may require in obtaining samples for conformance testing.

E. The GEOSYNTHETIC CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the GEOSYNTHETIC CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the project or cost to the OWNER.

## 2.2 RESIN

A. The textured HDPE geomembrane shall be manufactured from high quality HDPE resin with superior stress crack resistance. No post consumer resin of any type shall be added to the formulation. While more than one resin may be suitable, and will be considered, the GEOSYNTHETIC CONTRACTOR is cautioned that the ENGINEER and OWNER consider proper resin selection crucial to the successful completion of the project, and proposed resins will be most thoroughly and carefully reviewed. Once a resin has been accepted for use, all material for the project shall be manufactured from that resin unless approved by the ENGINEER. A batch of resin is defined as 200,000 lbs or one rail car whichever applies to the manufacturing process. If more than one resin batch is used for manufacture of membrane, testing will be required on all additional batches.

B. The following table represents the minimum required Manufacturing Quality Assurance (MQA) testing that must be conducted by the geomembrane Manufacturer on the resin used to produce the geomembrane:

**RESIN MQA**
**MINIMUM TESTING**

| PROPERTY | TEST METHOD | REQUIRED VALUES | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Density, g/cm$^3$ (allowable range) | ASTM D1505-10/D792-08 | 0.932 - 0.939 | 1/batch |
| Notched Constant Tensile Load (NCTL), hrs (Notes 1,2) | ASTM D5397-07, Single Point | 400 (minimum average) | 1/batch |
| Melt Flow Index, g/10 min. | ASTM D1238-00 Condition E | ≤0.5g/10min | 1/batch |

NOTES:

1. The NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces, therefore, in the case of textured geomembrane, the NCTL testing shall be conducted on representative smooth material produced from the same resin lots and formulations as the textured geomembrane supplied to this project.
2. Specimens for NCTL testing must contain carbon black. If samples used for testing are not taken from the finished product, they must be produced by a representative method, such as a lab-line or other acceptable method. Deviations from ASTM D5397 shall be noted by the geomembrane Manufacturer and approved by the ENGINEER.

## 2.3 GEOMEMBRANE

A. The sheet material shall be formulated from the appropriate polymers and compounding ingredients to form HDPE geomembrane that meets all requirements of this specification.

B. The geomembrane Manufacturer shall complete Manufacturing Quality Control (MQC) testing on the geomembrane in accordance with the requirements summarized in the following table:

**GEOMEMBRANE MQA/MQC**
**MINIMUM TESTING**

| PROPERTY | TEST METHOD | TEXTURED SHEET VALUE | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Core Thickness, mils (1) | ASTM D5994 | 60 nominal (-5%) | Each Roll |
| Asperity Height, mils (min. avg.) (2,3) | ASTM D7466 | 16 | Every 2nd Roll |
| Density, g/cm$^3$ (min. avg.) | ASTM D1505/D792 | 0.940 | 1/batch |
| Tensile Properties (min. avg.) both directions<br>• Yield strength, lb./in.<br>• Break strength, lb./in.<br>• Yield elongation, %<br>• Break elongation, % | ASTM D6693<br><br>Note (4)<br>Notes (5,6) | <br>126<br>90<br>12<br>100 | Every 2nd Roll |
| Carbon Black Content, % (min. avg.) (7,8) | ASTM D4218 | 2.0 - 3.0 | Every 2nd Roll |
| Carbon Black Dispersion | ASTM D5596 | See Note 9. | Every 6th Roll |
| Oxidative Induction Time, minutes (Standard) (minimum) | ASTM D3895 | 100 | 1/batch |

| | | | |
|---|---|---|---|
| Tear Resistance, lbs (min. avg.) | ASTM D1004 | 42 | Every 6th Roll |
| Puncture Resistance, lbs (min. avg.) | ASTM D4833 | 90 | Every 6th Roll |

NOTES:

1. The result obtained from D5994 will be an average of readings from 10 specimens per roll. The lowest allowable minimum average value shall be 57 mil, the lowest individual value for 8 out of the ten specimens shall be 54 mils, and the lowest individual value for any of the 10 specimens shall be 51 mil.
2. Of 10 readings, 8 must be ≥ 14 mils, and the lowest individual reading must be ≥ 12 mils.
3. Both sides of the double-sided textured sheet shall be measured on each roll (reference Article 2.1B).
4. Yield elongation is calculated using a gauge length of 1.3 inches.
5. Break elongation is calculated using a gauge length of 2.0 inches.
6. Break elongation shall be determined based on the average of 5 specimens in the machine direction and the average of 5 specimens in the cross machine direction (reported separately).
7. Other methods, such as D1603 (tube furnace) are acceptable if an appropriate correlation to D4218 can be established.
8. Carbon black content is only measured on the black backing of the white-surfaced geomembrane. Prior to measuring the carbon black content, the white surface shall be scrapped or ground off to avoid misrepresentative results in the final result.
9. Carbon black dispersion for 10 different views, with at least nine in Categories 1 or 2; one (max.) in Category 3.

C. Geomembrane Conformance Testing - The ENGINEER shall take samples across the entire width of the geomembrane roll for conformance testing in accordance with the project CQA/CQC Plan.

D. Non-conforming material will not be used in the work. Additional sampling required to address non-conforming test results shall be performed in accordance with the project CQA/CQC Plan. The Project Engineer may reject the entire lot containing non-conforming rolls at any stage of extended sampling and testing.

E. Interface Shear Testing - Interface shear strength testing of the geomembrane and related materials is the responsibility of the ENGINEER. The results must comply with the criteria determined by the ENGINEER, as specified in the Construction Drawings. All testing must demonstrate the minimum required peak and residual shear strengths and minimum large strain shear strength as specified on the Drawings, and those results must be completed by the ENGINEER prior to delivery of the materials. Testing for geosynthetic to geosynthetic, or geosynthetic to soil interface, shall be conducted according to the current version of ASTM D5321. Testing for interfaces involving

geosynthetic clay liner (GCL) shall be conducted according to the current version of ASTM D6243-09.

## 2.4 WELDING ROD AND/OR WELDING PELLETS

A. The Manufacturer shall certify that the welding rod and/or pellets used for extrusion welding shall be produced from the same resin type as that used to manufacture the geomembrane supplied for this Project.

B. The Manufacturer shall certify that the welding rod and/or pellets meet the following requirements:

| PROPERTY | TEST METHOD | REQUIRED VALUES | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Density, g/cm$^3$ | ASTM D1505 | 0.940 (minimum avg.) | Every 20,000 lbs |
| Carbon Black Content, % | ASTM D1603 or D4218 | 2.0 – 3.0 | Every 20,000 lbs |

C. The ENGINEER will perform conformance sampling and testing of the welding rod and/or pellets with a testing frequency of three tests per project or construction season.

## 2.5 GEOMEMBRANE PENETRATION BOOTS

A. The GEOSYNTHETIC CONTRACTOR shall furnish any geomembrane penetration boots and other materials required for completion of the geomembrane installation. The geomembrane boots shall be of the same density and thickness as the geomembrane panels. All field fabricated boots must be tested using a method approved by the ENGINEER.

B. The geomembrane Manufacturer shall provide a statement of hydraulic or pneumatic testing demonstrating that any shop-fabricated unit does not leak. A description of the method used for testing in the shop shall be submitted to the ENGINEER for prior approval.

C. Geomembrane penetrations are to be constructed only at the locations shown on the Plans. The GEOSYNTHETIC CONTRACTOR is cautioned that no deviation in the quantity or configuration of geomembrane penetrations will be accepted without the advance written approval of the ENGINEER.

D. The GEOSYNTHETIC CONTRACTOR shall construct penetrations in accordance with the procedures described in ASTM D6497-02, Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures, or as described by this Specification.

E. All penetrations through the geomembrane shall be thoroughly and securely sealed. The seal between the geomembrane and the pipe shall be without any detectable leakage.

F. In attaching the geomembrane penetration boot in the field, no field seams will be allowed in locations or configurations that do not allow for Construction Quality Control testing. Visual observation is not considered a sole acceptable method for in-field quality control.

G. Where clamps, fasteners, gasket seals or sealants are used, the GEOSYNTHETIC CONTRACTOR shall use only materials that are compatible with the geomembrane.

## PART 3 EXECUTION

### 3.1 SITE PREPARATION

A. All required grading, grooming, and construction quality assurance (CQA) testing on any low permeability soil or GCL to be covered by the geomembrane shall be complete and accepted by the ENGINEER prior to geomembrane placement.

B. The surface to be covered by the geomembrane shall be cleared of sharp objects, angular stones, sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The geomembrane subgrade shall have a smooth, finished surface, free from pockets, holes, soft spots, ruts greater than 1 inch in depth, discontinuities that will cause bridging and overstress the material, and free of substantial amounts of loose soil as determined by the PROJECT ENGINEER. The geomembrane subgrade shall be inspected for unsuitable areas or soft spots before the geomembrane is placed, and additional surface preparation will be required to eliminate any unsuitable areas as determined by the ENGINEER.

C. The GEOSYNTHETIC CONTRACTOR and ENGINEER shall carefully and completely inspect the geomembrane subgrade surface immediately prior to the deployment of each geomembrane panel. No geomembrane shall be placed on unsuitable geomembrane subgrade surface, or without the ENGINEER's written approval. The ENGINEER and the GEOSYNTHETIC CONTRACTOR's Quality Control (QC) inspector shall furnish their signatures on a Geomembrane Subgrade Acceptance Log prior to the installation of each panel or series of panels placed on a daily basis.

D. Under no condition shall the geomembrane be placed over standing water on the underlying surface.

## 3.2 SEAMING METHODS

A. The geomembrane panels shall be joined utilizing approved seaming methods. Dual-track fusion welding shall be the required method on all seams where it is feasible. Extrusion welds shall be made only where approved by the ENGINEER.

B. The GEOSYNTHETIC CONTRACTOR shall properly maintain and set-up the welding equipment prior to seaming operations on a regular as needed basis, in the manner specified by the Manufacturer. For wedge welding equipment this is expected to include as a minimum; checking the condition and adjusting the position of the nip rollers, hot wedge, and contour rollers. As well, the GEOSYNTHETIC CONTRACTOR shall properly examine and check the cartridge heaters, thermocouples, drive chains, and electronics for proper operation at the frequency recommended by the Manufacturer. The CQA Observers shall record and document the set-up, maintenance and adjustment process, as well as the settings/conditions each time acceptable seaming of the geomembrane has been confirmed by trial weld results.

C. All geomembrane surfaces that are to become a seam interface are to be free of dust, dirt, excess moisture or any other condition that may affect the quality of the seam.

D. Seaming will not be allowed during rain or snowfall, unless proper precautions are made to allow the seam to be made on dry geomembrane materials and underlying surface. Seaming is also subject to wind and temperature restrictions as described in Article 3.3.M.

E. The seams shall be produced using one of the following methods:

1. Dual-Track Fusion (Wedge) Weld – A seam produced by melting the two intimate surfaces by running a hot metal wedge between the surfaces, followed immediately by pressure to form a homogeneous bond. This seam has a center air channel for non-destructive testing of the seam. Panels to be seamed shall be overlapped sufficiently to allow proper destructive testing of seams. The GEOSYNTHETIC CONTRACTOR shall mark the liner where the Duel-Track Fusion Welding machine settings are adjusted (including speed, temperature and pressure). Measurable setting values shall be indicated on the liner.

2. Extrusion Weld – A seam produced by extruding molten HDPE at the edge of two overlapped panels. A bonded seam is completed when molten HDPE melts portions of the overlapping sheets to form a homogeneous weld. The center of the extrudate bead shall be located directly over the edge of the upper geomembrane. Panels to be seamed shall be overlapped a minimum of 4 inches. An electric rotary grinder and #80 grit paper, or finer, shall be used to remove the surface sheen in the area to be seamed. Grinding shall be completed no more than 10 minutes prior to seaming. Any grinding marks shall be oriented perpendicular to seam direction, and their depth shall be less than 5% of the sheet thickness. Grinding marks shall not appear beyond 0.25" of the extrudate after it is applied. The leading edge of the upper sheet shall be ground to a 45-degree bevel.

Beveling shall be completed prior to tack welding to control damage to the lower sheet.

## 3.3 INSTALLATION

A. Based on the approved geomembrane panel diagram and material certifications, the individual panels will be numbered and seams will be identified by using the panel numbers that create the seam. The HDPE panels shall be installed in a manner that minimizes seams. Seams shall be placed where normally applied stresses will be minimal. Longitudinal seams shall be oriented to be no greater than ten degrees from parallel with the direction of the slope. All panels placed on slopes greater than 25% shall extend down the full length of the slope unless the slope length is greater then the manufactured roll length. Any cross seams on slopes greater than 25% shall be staggered such that seams between adjacent panels are separated by a minimum of 10 feet. On slopes less than 25%, cross seams shall be placed no closer than five feet from the top of a steeper slope, or five feet from the toe of a steeper slope. All seam overlaps shall be shingled in a downslope direction. In no case shall parallel seams be placed within five feet of the centerline of any leachate collection pipe.

B. Piecework resulting in the placement and seaming of small panels not identified by the panel diagram shall not be permitted. Any material variation from the approved panel diagram must be pre-approved by the ENGINEER prior to altering the installation.

C. During installation, and any other period of exposure of geomembrane, pedestrian and equipment activity over the geomembrane shall be kept to a minimum, and restricted to only that which is necessary for geomembrane construction.

D. Smoking is not permitted on the geomembrane.

E. Construction workers shall take precautions not to damage the geomembrane surface. Construction workers shall wear smooth-soled footwear, and exercise care not to drag tools across the geomembrane surface. All large tools are to have smooth base plates or shoes. Construction and landfill staff shall be informed of the restricted access to areas of geomembrane placement by use of barriers and signs posted as necessary. Only hook blade knives shall be used to cut geomembrane.

F. The GEOSYNTHETIC CONTRACTOR shall perform all activities of geomembrane construction in such a way as to avoid damage to the geomembrane, including the prudent use of rub sheets. Any damage caused to the geomembrane by the GEOSYNTHETIC CONTRACTOR shall be repaired or the material replaced at the expense of the GEOSYNTHETIC CONTRACTOR.

Generators and other stationary equipment that must be lubricated, fueled and/or oiled and that are staged on the geosynthetics must be placed within spill containment pads designed to prevent spillage of gasoline, diesel fuel or oil on the geosynthetics. If any such equipment is not placed in a spill containment structure, it must not be fueled on the geosynthetics.

G. Wheeled vehicle traffic is prohibited above the geomembrane. Low ground pressure vehicles only will be allowed to traverse any geomembrane covered with a foot of soil. Three feet of soil must be in place over the geomembrane to permit heavy wheeled vehicles to travel across the geomembrane.

H. The GEOSYNTHETIC CONTRACTOR shall complete his work in a manner that will prevent water or wind from getting under the partially installed geomembrane. This could include, but is not limited to, installing sandbags along the leading edges. Should excessive moisture become trapped below the geomembrane, or should wind damage occur due to the negligence of the GEOSYNTHETIC CONTRACTOR, the GEOSYNTHETIC CONTRACTOR, at no extra cost to the OWNER, will be required to perform all work, including removing and replacing as much of the in-place geosynthetic material as the ENGINEER directs, to assure that the integrity of the geomembrane and the underlying subbase or geosynthetic clay liner (GCL) has not been compromised.

I. Seams shall be welded throughout the entire length of the panels during initial panel seaming.

J. Sandbags or other approved ballast shall be used to prevent bridging or material movement in areas such as toe of slope or near sumps. Ballast shall not be used to force the geomembrane into contact with the underlying subbase.

K. Special care shall be taken to prevent tensile stress in the geomembrane and geomembrane seams in all corners and grade changes.

L. The GEOSYNTHETIC CONTRACTOR shall exercise his best judgment and care to provide sufficient slack in the geomembrane to allow for thermal contraction without "trampolining", but to also avoid excessive slack such that wrinkling will be minimized during seaming and placement of overlying soil or geosynthetic materials.

M. The geomembrane shall not be seamed when ambient or sheet temperatures are below 32° F, when the sheet temperature exceeds 158° F, or when the air temperature is above 120° F unless the GEOSYNTHETIC CONTRACTOR demonstrates, to the satisfaction of the ENGINEER, that procedures can be implemented which will result in the proper installation and seaming of the geomembrane.

For seaming activities below 32° F the GEOSYNTHETIC CONTRACTOR shall use procedures set forth in GRI GM9. Maximum allowable time between trail welds shall be adjusted to 2 hours, decreasing one-half hour for each 10° F below 32° F.

N. Adjacent geomembrane panels shall be allowed to reach essentially equivalent temperatures prior to seaming to avoid development of fish mouths.

O. If fish mouths are created at the seam overlaps, they shall be cut to achieve a flat overlap. The cut shall be made with keyhole ends, and a patch shall be placed over the cut as required by Article 3.4.

P. Wrinkles shall not exceed a height to width ratio of 0.5, or as deemed acceptable by the ENGINEER. The height of the wrinkle shall be measured from the base to the peak of the wrinkle. The width of the wrinkle shall be measured along the base of the wrinkle.

Q. Geomembrane covering operations shall be performed in a manner that does not damage the geomembrane lining system. Geomembrane covering operations shall be performed only in the presence of a Construction Observer such that the condition and cleanliness of the geomembrane is observed at the time the material is covered, and any effects of the covering operation on the geomembrane lining system can be observed.

R. In the event wrinkles develop during any covering operation that are capable of folding over, the excess material shall be cut out to achieve a flat overlap, or the covering operation shall be delayed until such time wrinkling subsides to acceptable levels. Any geomembrane cut shall be made with keyhole ends, and a patch shall be placed over the cut as required by Article 3.4. Wrinkles that do not lay flat and whose height to width ratio does not exceed 0.5 are susceptible to damage by soil placement equipment, and shall be carefully monitored by the ENGINEER during cover operations.

## 3.4 REPAIRS

A. All geomembrane panels and seams shall be examined by the ENGINEER for uniform texturing, defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The geomembrane surface shall be clean at the time of examination. Each suspect location shall be repaired and all repairs shall be non-destructively tested.

B. Damaged and/or unacceptable geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be repaired to the satisfaction of the ENGINEER.

C. Any portion of the geomembrane, or any portion of a seam exhibiting a flaw or failing a destructive or non-destructive test, or an area where a wrinkle had been cut out shall be repaired, as follows:

1. Geomembrane patches shall be used for holes over 1/8 of an inch in diameter, tears, and contamination by foreign matter. Patches shall be constructed of the same geomembrane, and will be joined to the panel using extrusion welding, or fusion welding where possible.

2. Geomembrane patches or caps shall extend at least 6 inches beyond the edge of the defect or failed seam area, and all corners of material to be patched. The corners of the patch shall be rounded to a radius of at least 3 inches.

3. Spot extrusion welding shall be used to repair pinholes, or other minor localized flaws, only as approved by the ENGINEER.

4. Geomembrane caps shall be used to repair failed seams that are left in-place. Seams that fail destructive or non-destructive testing may also be removed and replaced if determined necessary by the ENGINEER.

## PART 4 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

### 4.1 GENERAL

A. Before installation begins, and weekly thereafter (more often if determined necessary by the ENGINEER) project coordination meetings shall be held with the designated representative of the GEOSYNTHETIC CONTRACTOR, PROJECT ENGINEER and OWNER in attendance to review the following information:

1. Progress of the work.

2. Adherence to the Specifications.

3. Adherence to the Construction Quality Assurance Program described in this Section, including the timely submission of the pertinent forms.

4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work.

5. Problem resolutions to be implemented during the upcoming week.

The NYSDEC site engineer shall be invited to each construction meeting.

B. All of the Forms specified and required must be submitted to the ENGINEER in a timely fashion.

C. The OWNER and ENGINEER must approve any changes in the proposed method of work, subcontractors to be utilized, geomembrane resin, or manufacturing in advance.

D. The GEOSYNTHETIC CONTRACTOR assumes all responsibility relevant to providing an acceptable product.

### 4.2 INSTALLATION QA/QC

A. The ENGINEER and GEOSYNTHETIC CONTRACTOR shall visually inspect all material to be included in the work and compare roll identification numbers with those on the certifications provided by the manufacturer to assure delivery of the appropriate material.

B. Damage to geomembrane during installation shall be repaired according to Article 3.4. If the ENGINEER determines that any damage cannot adequately be repaired, the damaged material will be replaced.

C. The GEOSYNTHETIC CONTRACTOR will be required to conduct both destructive and non-destructive testing on seams during the geomembrane installation, as part of the Construction Quality Control program. All trial and installed seam samples shall be tested according to ASTM D6392-08, as modified by this Specification.

D. The GEOSYNTHETIC CONTRACTOR will be required to complete trial seams throughout the project. The GEOSYNTHETIC CONTRACTOR will be required to utilize control charts to determine whether adjustments in the welding parameters are required during production seaming, per GRI GM14. The trial seams shall be provided in a timely fashion such that adequate time is available for field destructive testing, and preparation of the associated documentation by the ENGINEER prior to production welding.

E. Trial Seams –

1. Trial seams shall be produced:

    a. each day, at the start of each workday;

    b. after every five hours of continuous operation;

    c. after equipment maintenance, repair or replacement;

    d. after lunch and/or dinner; and,

    e. if the geomembrane temperature changes by more than 25°F in one hour.

    Trial seams shall be required each day for each piece of seaming equipment and each welding crew combination (including welding technician, seam cleaners and/or grinders). The trial seams will be performed on strips of geomembrane from approved rolls and shall be produced at the work location such that the conditions mimic those under which production seams will be made.

2. A trial seam shall be a minimum of 5 feet in length for self-propelled seaming devices, and a minimum of 3 feet for hand-held seaming devices. The material for the trial seam and the test fixture for making the field tests shall be provided by the GEOSYNTHETIC CONTRACTOR at no additional cost. One-inch wide cutouts of the trial seams will be subject to shear and peel testing by the GEOSYNTHETIC CONTRACTOR's QC technician at the site. A minimum of 5 cutouts will be tested for shear, and a minimum of 5 cutouts will be tested for peel. Only the upper weld area need be tested in peel. The ENGINEER shall document the locus of break code for each specimen as shown in Figure 3 and Figure 4 of ASTM D6392.

3. All trial seam specimens must be acceptable or the trial seam will be repeated until all results from a given trial seam are found acceptable. If any trial seam fails at any time during the workday, the reason for the failure shall be resolved before any production seaming of the geomembrane by the subject equipment and crew. All trial seam welding and testing must be observed by the ENGINEER.

4. A trial seam specimen will be considered a failure if:

   a. For hot wedge seams:

      i. the bonded thickness of the seam fails before the adjacent sheet material; or,

      ii. the shear strength of the specimen is less than 120 lb/in; or,

      iii. the peel strength is less than 91 lb/in; or,

      iv. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.1 of GRI GM19.

   b. For extrusion fillet seams:

      i. the bonded thickness of the seam fails before the adjacent sheet material; or,

      ii. the shear strength of the specimen is less than 120 lb/in; or,

      iii. the peel strength is less than 78 lb/in; or,

      iv. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.1 of GRI GM19.

   c. In the shear or peel test, locus of break codes AD or AD-Brk >25% for hot wedge seams, AD1 or AD2 for extrusion fillet seams are reported by the ENGINEER. AD-WLD and SIP are the exceptions.

   d. Upon visual inspection, the weld shows:

      i. Excessive deformation or stepping of the bottom sheet when viewed in cross-section.

      ii. Discoloration of the sheet such as that occurring from brittle failure.

      iii. Inadequate or excessively narrow or flat weld bead (for extrusion seams).

iv. Water blisters in weld bead (for extrusion seams).

v. Misaligned weld bead, i.e., weld not reasonably centered with respect to overlap (for extrusion seams).

vi. Thinning of the sheet adjacent to the weld.

vii. Overgrinding marks outside of the extrudate bead (for extrusion seams).

F. The field tensiometer shall be strong enough to permit the operator to determine that the seam is at least as strong as either sheet, and shall permit accurate measurement of specimen elongation. The tensiometer shall have been calibrated within the 6-month period prior to its use onsite.

G. Should the ENGINEER, at any time during the installation, believe the production seaming process may not be performing adequately, he may, to avoid destructive sampling of the installed geomembrane, request additional trial seams. The GEOSYNTHETIC CONTRACTOR shall do this at no additional cost.

H. The GEOSYNTHETIC CONTRACTOR shall complete non-destructive testing of all seams along their entire length, in the manner approved prior to installation, in the presence of the ENGINEER. The recommended test methods are as follows:

1. Pressurized Air Channel

a. All field seams made by a dual-track fusion wedge welding device will be tested by applying air pressure within the air channel to a sealed length of seam, and monitoring the pressure over time. The testing shall be conducted in accordance with GRI GM6 or ASTM D5820.

b. For the 60 mil geomembrane, the initial inflation pressure shall be a minimum of 30.0 psi and a maximum of 35.0 psi. The maximum allowable pressure drop over a 5 minute period shall be 2.0 psi.

c. A pressure gauge shall be inserted into the far end of the air channel to check for continuity in the air channel. Alternately, the far end of the seam may be cut to relieve the air pressure. An audible rush of air shall serve as an indicator that the test represents the entire length of seam.

d. Air channels that do not hold the minimum specified air pressure shall be further inspected to identify the location and nature of any defects or unbonded sections of seam. The seam will then be repaired and retested. The ENGINEER may, at his discretion, require the entire questionable seam area to be capped or replaced.

2. Vacuum Box Testing

a. Extrusion seams shall be inspected for unbonded areas or defects by applying a vacuum to a soaped section of seam. The vacuum shall be applied by a vacuum box equipped with a vacuum gauge, a clear glass view panel in the top, and a soft rubber gasket on the periphery of the open bottom. The testing shall be completed in accordance with ASTM D5641.

b. A section of the seam shall be soaped thoroughly and the inspection box shall be placed over the soaped seam section and the gasket sealed to the geomembrane. A vacuum of between 4 and 8 inches of Mercury (Hg) shall be applied to the box for a minimum of 10 seconds by use of a gasoline or electric driven power-vacuum pump apparatus. Adjacent placements of the vacuum box shall overlap the seam a minimum of 2 inches as viewed through the vacuum box-viewing window.

c. The ENGINEER shall witness the testing and the seam shall be clearly visible to the ENGINEER and GEOSYNTHETIC CONTRACTOR during the test. Unbonded areas or defects shall be marked by the PROJECT ENGINEER for repair by the GEOSYNTHETIC CONTRACTOR.

3. Spark Testing

a. Spark testing may be used on short, detail (sump, penetration) extrusion welds that cannot be tested by vacuum box testing, and can use Alternating Current (AC) or Direct Current (DC) equipment. The DC equipment (using the latest version of ASTM D6365) is required for use on this project unless the GEOSYNTHETIC CONTRACTOR provides a detailed Workplan to the ENGINEER regarding AC testing for approval, at least two weeks prior to beginning the testing.

b. The DC method typically uses a metal brush for the search electrode. For seams, a copper wire or tape is placed within the geomembrane/seam overlap, just to the inside of the center of the extruded bead. Prior to testing, a trial calibration seam must be made to confirm the minimum voltage required to discharge across a hole in the seam between the search electrode and the copper wire.

c. Spark testing must not be performed when the liner is wet. The test procedure for DC equipment can generally be describes as follows:

i. Connect the negative (ground) electrode of the testing equipment to the exposed end of the copper wire, or to a grounding rod if the copper wire is buried in the subgrade;

ii. Calibrate using a seam with a known leak path of the largest reached distance;

iii. Connect the positive electrode to the wire brush or other type of search electrode;

iv. Clean all debris and moisture from the seam area;

v. Apply a potential difference of between 20 and 55 kVDC, as determined in the calibration test, between the electrodes;

vi. Sweep the search electrode over the surface of the seam, maintaining contact with the extruded bead and the top of the lower geomembrane at the edge of the bead; and,

vii. Monitor for audible and/or visible spark discharges that are indicative of a defect. Mark defects for repair.

d. The exposed end of the wire must be cut short, and an extruded bead of molten polyethylene must be placed over the remaining wire exposure to ensure the wire is covered completely.

I. The OWNER will retain the services of a qualified ERT CONTRACTOR to conduct an electric leak location survey on the primary geomembrane liner after placement of the overlying 24-inch thick layer of ¾-inch stone. The survey shall be performed using a proven process of locating potential leak paths in installed geomembrane through the use of electrical methods. The method will require access to the soil liner, and shall be capable of placing a voltage across the geomembrane liner, and locating areas where electric current flows through discontinuities in the geomembrane. The electric leak survey shall conform to the following requirements:

1. The survey shall be performed only by ERT CONTRACTORS experienced in performing electric leak surveys. The ERT CONTRACTOR shall have a minimum of three years experience in performing electric leak surveys, and shall have performed a minimum of 500,000 square feet of similar testing on three different projects. Qualifications and experience statements for the personnel assigned to the project shall be submitted by the ERT CONTRACTOR to the ENGINEER for approval.

2. The electric leak survey will be performed on the primary geomembrane on the floor area only. The side slopes shall not be tested.

3. Testing shall be completed only after the ¾-inch stone has been placed and graded over the primary geomembrane liner system.

4. The survey shall be capable of detecting and locating defects of 0.01 square inches in size through the ¾-inch stone.

5. The ERT CONTRACTOR shall submit to the ENGINEER for approval a work plan outlining the specifications for the test, data analysis and reporting at least two weeks before commencing the survey. The work plan shall include test protocols such as probe spacing, etc., and other information regarding the requirements necessary for a successful survey such that the construction schedule

will not adversely affect the survey (e.g. provide for opening(s) in primary geomembrane at anchor trench).

6. The ERT CONTRACTOR shall complete a realistic test of the leak detection sensitivity as part of the leak location survey, using an artificial leak simulator for a 0.10 inch square leak. The leak location equipment and procedure shall be demonstrated to detect the artificial leak when the leak is midway between the measurement points on the surface of the ¾-inch stone.

7. The leak location survey shall commence only after the ENGINEER has confirmed the results of the leak detection sensitivity test. The leak location survey procedures shall be such that the measurements are made in the same manner as those employed in the leak detection sensitivity test.

8. The ERT CONTRACTOR shall submit to the ENGINEER for approval a electric leak location survey test report to include the following:

   a. Brief description of the survey site;

   b. Description of the liner system design and materials;

   c. Climatic conditions during the test program;

   d. Description of electrical leak location system components and specifications;

   e. Sampling density of the measurements;

   f. Type, location and size of detected potential leak paths;

   g. Survey of repaired areas; and,

   h. Map of the surveyed area.

J. All inadequate seams or portions thereof that fail the non-destructive testing shall be repaired in accordance with this Specification and the method approved by the ENGINEER. Should differences of opinion between the GEOSYNTHETIC CONTRACTOR and the ENGINEER develop during the installation relevant to seam integrity, the ENGINEER may, at his discretion, obtain samples of the seams in dispute for field and/or laboratory testing. The GEOSYNTHETIC CONTRACTOR will be responsible for patching the resulting void in accordance with the previously approved procedures at no additional cost to the OWNER.

K. Destructive Sample Collection - Samples of the in-place seams shall be cut from the installed geomembrane at a frequency one per 500 feet of production seaming. Any seam that is reconstructed must be sampled destructively as well.

L. The destructive sample cutout sections shall be 12 inches wide by 40 inches long with the seam centered lengthwise. The sample size can be reduced to 34 inches if the GEOSYNTHETIC CONTRACTOR does not elect to have a cutout section for their use. A 1-inch wide specimen shall be cut from each end of the sample, and these two specimens shall be peel tested in the field in accordance with 4.2.E.4. The remaining sample shall be cut into two parts and distributed as follows:

1. One 12-inch by 18-inch sample to the CQA MANAGER for independent laboratory testing; and,

2. One 12-inch by 18-inch sample to the OWNER for archive storage.

3. The remainder of the sample shall be available for the GEOSYNTHETIC CONTRACTOR if requested at the time of sample collection.

M. The 12-inch by 18-inch laboratory sample will provide five specimens for shear testing and five specimens for peel testing. Specimens that will be subject to peel and shear testing shall be selected alternately from the sample. All peel tests shall be performed on the outer track of dual track fusion welds. The laboratory shall report the locus of break code for each specimen according to the definitions included in Figure 3 and Figure 4 of ASTM D6392. The laboratory sample will be considered acceptable only if all ten specimens meet the minimum requirements. The specimen will be considered a failure if:

1. For hot wedge seams:

    a. the bonded thickness of the seam fails before the adjacent sheet material; or,

    b. the shear strength of the specimen is less than 120 lb/in; or,

    c. the peel strength is less than 91 lb/in; or,

    d. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.1 of GRI GM19; or,

    e. the shear percent elongation is less than 50% as determined in accordance with Paragraph 6.1 of GRI GM19.

2. For extrusion fillet seams:

    a. the bonded thickness of the seam fails before the adjacent sheet material; or,

    b. the shear strength of the specimen is less than 120 lb/in; or,

    c. the peel strength is less than 78 lb/in; or,

d. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.1 of GRI GM19; or,

e. the shear percent elongation is less than 50% as determined in accordance with Paragraph 6.1 of GRI GM19.

3. In the shear or peel test, locus of break codes AD or AD-Brk >25% for hot wedge seams, AD1 or AD2 for extrusion fillet seams are reported by the ENGINEER. AD-WLD and SIP are the exceptions.

4. Upon visual inspection, the weld shows:

a. Excessive deformation or stepping of the bottom sheet when viewed in cross-section.

b. Discoloration of the sheet such as that occurring from brittle failure.

c. Inadequate or excessively narrow or flat weld bead (for extrusion seams).

d. Water blisters in weld bead (for extrusion seams).

e. Misaligned weld bead, i.e., weld not reasonably centered with respect to overlap (for extrusion seams).

f. Thinning of the sheet adjacent to the weld.

g. Overgrinding marks outside of the extrudate bead (for extrusion seams).

N. If a sample fails destructive testing, the welding path must be retraced to intermediate locations at least ten feet in each direction from the location of the sample that failed the test, and a second sample shall be taken for an additional field test. If the tracking samples pass, the seam must be reconstructed between the location of the two tracking samples and the original sampled location. If the tracking sample fails, this process must be repeated. The seam between two passing test locations shall be capped, the cap seams shall be nondestructively tested, and shall include one field peel and shear test location along the reconstructed seam.

O. The ENGINEER and GEOSYNTHETIC CONTRACTOR shall visually inspect all geomembrane seams. Extrusion welds shall be centered above the overlap, shall be free from blisters, and shall not include grinding marks that show more than 0.25 inches outside of the extrusion bead. If such grinding marks are found, the seam shall be repaired to the ENGINEER's satisfaction.

P. All welds shall be observed for traces of deformation to the geomembrane panels. Any seams, which in the opinion of the ENGINEER, have caused excessive deformation of the sheet, show signs of discoloration, exhibit thinning or stepping of the sheet, or show visual signs of overheating of the geomembrane panels, shall be repaired at no additional

cost to the OWNER regardless of the result of any destructive testing on the seam. The deficient seam or portion thereof shall be cut out, the geomembrane panels again overlapped and seamed, or the questionable seam length shall be capped, as approved by the ENGINEER.

Q. The GEOSYNTHETIC CONTRACTOR shall not place overlying materials on the installed geomembrane until the ENGINEER has reviewed and accepted the written test results for the geomembrane to be covered. At a minimum, the pre-delivery testing, the daily log of trial seam results, laboratory destructive sample results, non-destructive test results, record drawings of the completed area, and approval of the seams in place will be reviewed.

R. The GEOSYNTHETIC CONTRACTOR shall provide a report to the OWNER and the ENGINEER at the conclusion of the work which shall include the following:

1. The quality control tests used as specified and/or directed, including all requirements of the Report section of the specified test method.

2. Complete description of field sampling procedure, number of test specimens, and size of test specimens.

3. Log of all Construction Quality Control work.

S. The GEOSYNTHETIC CONTRACTOR shall be responsible for all costs incurred by the OWNER including, but not limited to, additional field and laboratory CQA testing resulting from greater than five percent of the CQA testing not meeting or exceeding the Specifications.

T. All seams must be subjected to accepted Construction Quality Control or Construction Quality Assurance (CQA/CQC) testing.

## 4.3 WARRANTY

A. The GEOSYNTHETIC CONTRACTOR shall issue a warranty on the installation of geomembrane for a minimum period of 1 year.

B. The GEOSYNTHETIC CONTRACTOR shall issue a warranty on the geomembrane material for a minimum period of 5 years.

END OF SECTION

# SECTION 02598

# LLDPE GEOMEMBRANE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The GEOSYNTHETIC CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the installation of all geomembrane, complete with appurtenances, as shown, specified or required by the Drawings.

### 1.2 RELATED SECTIONS

A. Section 02595 - Geotextiles

B. Section 02599 Geocomposites

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D792-08 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

2. D1004-09 Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting

3. D1505-10 Standard Test Method for Density of Plastics by the Density-Gradient Technique

4. D1603-11 Standard Test Method for Carbon Black in Olefin Plastics

5. D3895-07 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

6. D4218-96 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

7. D4354-99 Standard Practice for Sampling of Geosynthetics for Testing

8. D4833-07 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

9. D4873-02 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

10. D5199-11 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

11. D5321-08 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

12. D5596-03 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

13. D5641-94 Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

14. D5820-95 Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

15. D5994-10 Standard Test Method for Measuring Core Thickness of Textured Geomembrane

16. D6365-99 Standard Practice for the Nondestructive Testing of Geomembrane Seams Using the Spark Test

17. D6392-08 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

18. D6497-02 Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures

19. D6693-04 Standard Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes

20. D7466-08 Standard Test Method for Measuring the Asperity Height of Textured Geomembrane

B. Geosynthetic Research Institute (GRI):

1. GRI GM6 (1994) Pressurized Air Channel Test for Dual Seamed Geomembranes

2. GRI GM9 (1995) Cold Weather Seaming of Geomembranes

3. GRI GM14 (1998) Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes

4. GRI GM17 (2011) Test Methods, Test Properties, and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

5. GRI GM19 (2011) Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. The most current version of the specified test method shall be followed by the Manufacturer, GEOSYNTHETIC CONTRACTOR or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Minimum Value – Property value representing the lowest individual allowable value obtained when tested according to the specified test method. This applies to individual readings, such as thickness; or where only one specimen is tested for the specified parameter.

B. Minimum Average Value – Property value representing the lowest allowable value for the average of results for the specimens tested.

C. Minimum Average Roll Value (MARV) – Property value calculated as the average test result minus two standard deviations. Statistically, this implies a 97.5 percent confidence that any specimen tested during quality assurance will exceed the value reported.

D. Nominal Value – Property value that is representative of a measurable property, determined under a set of prescribed test conditions, by which a product may be described.

E. Typical Roll Value – Property value calculated as the average or mean obtained from test data.

F. Unit – For the purposes of this project, a "Unit" shall be a single roll of geo synthetic material.

G. Lot - For the purposes of this project, a "Lot" will be defined as a single run of geosynthetic material from the same production facility, where the tooling and raw materials of production have not changed during manufacturing.

## 1.5 SUBMITTALS

A. The GEOSYNTHETIC CONTRACTOR shall submit to the ENGINEER all items included in this Article. Submittals shall be provided as follows:

1. With the GEOSYNTHETIC CONTRACTOR's BID:

a. A project reference list documenting the experience of the GEOSYNTHETIC CONTRACTOR on a minimum of 5 projects consisting of at least 10 million square feet of installed textured LLDPE geomembrane.

b. A copy of the Manufacturer's Manufacturing Quality Assurance/ Manufacturing Quality Control (MQA/MQC) Plan for the complete geomembrane manufacturing process.

c. A schedule of operations, including means and methods of installation.

d. The width of the geomembrane panels to be used for the project and the proposed method of joining adjacent geomembrane panels.

e. The documented historic pass/fail rate for LLDPE geomembrane seam destructive tests performed on seams created by the proposed welding crew members.

2. At least 15 days prior to delivery of geomembrane to the site, unless otherwise noted below:

a. Working drawings, including proposed panel diagram and details of proposed work, extrusion welds, pipe boots, and details of sealing around all necessary geomembrane penetrations, to be submitted at least 30 days prior to delivery of geomembrane to the site. The panel diagram must depict and/or note the planned number and orientation of panels, the minimum panel size, seam orientation and overlap direction, placement of seams in corners, treatment of tee seams, and the GEOSYNTHETIC CONTRACTOR's preferred sequence of panel placement. The LLDPE panels shall be orientated in a manner that minimizes seams and shall not have cross seams placed on slopes greater than 25% unless the slope length exceeds the manufactured roll length. The ENGINEER prior to geomembrane installation must approve the panel diagram. The ENGINEER, in writing, prior to altering the installation, must approve proposed revisions to the panel diagram.

b. Welding Rod - Manufacturing Quality Assurance (MQA) test data from the geomembrane Manufacturer demonstrating that the resin utilized in the production of the geomembrane and welding rod and/or pellets meets the requirements specified in Article 2.2. The packages containing the welding rod and/or pellets must contain a label identifying the resin lot utilized in their manufacture.

c. Geomembrane - Manufacturing Quality Control (MQC) data certificates for the geomembrane to be delivered to the site. The reports shall reference the resin lot used in the manufacture of the sheet, and shall include the quality control test results obtained during the manufacture of the material. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates. Material with unacceptable MQC data will be segregated from approved material and shall be marked for rejection. The geomembrane will be rejected or if it is

found to have defects, rips, holes, flaws, deterioration, or other damage deemed unacceptable by the ENGINEER.

d. Resin - Resin Manufacturer's certificate for each resin lot utilized by the geomembrane Manufacturer in the production of the geomembrane and welding rod/pellets to be delivered to the site.

e. Geomembrane Sample - Samples of the proposed geomembrane shall be sent to the ENGINEER for interface shear testing to be done at the cost of the GEOSYNTHETIC CONTRACTOR within 5 days after the ENGINEER makes such request. The GEOSYNTHETIC CONTRACTOR shall coordinate the quantity and dimensions of the samples with the ENGINEER.

3. At least 15 days prior to installation:

a. Resumes of geomembrane crew; including, Supervisor, QC Manager, Master Seamers, and all Welding Technicians. The resumes shall include prior experience in installing Textured LLDPE geomembrane. All individuals who will perform welding on this project shall be certified by the welding equipment manufacturer as having been trained in the use of the equipment; or, in lieu of such certification, the GEOSYNTHETIC CONTRACTOR shall provide other suitable evidence that demonstrates the proposed welding personnel possess intimate knowledge of welding equipment design, set-up, operation and maintenance. Individual geomembrane crew members will be subject to the approval of the ENGINEER.

b. A copy of the GEOSYNTHETIC CONTRACTOR's standard operating procedure (SOP) for operating an ATV or other utility vehicle on site, particularly with respect to specific uses of such vehicles and the prevention of damage to materials.

c. Field tensiometer calibration certificate showing that the equipment to be used for shear/peel testing in the field has been calibrated by a qualified individual within the previous 6 months.

4. During Installation Submitted Daily:

a. Completed Subgrade Acceptance Form, as endorsed by the ENGINEER, prior to geomembrane deployment in any area.

b. Construction progress reports clearly showing geomembrane placed by date.

c. Passing and failing test results for trial seams.

d. Documentation of passing and failing destructive and non-destructive testing of installed seams.

5. Within 5 days after completion:

a. Summary and log of all field quality control work completed by the GEOSYNTHETIC CONTRACTOR.

b. Certification statement signed by the Supervisor that geomembrane installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.

c. Statement of material and installation warranties.

B. The above-noted requirements shall apply to all shop-fabricated materials and those items specified for fabrication in the field

## 1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The GEOSYNTHETIC CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections, as well as work completed by the OWNER.

B. Geomembrane labeling, shipment and storage shall follow ASTM D4873 as modified according to this Specification.

C. Product labels shall be placed on the ends of rolls such that they can be seen when rolls are stacked, clearly showing the manufacturer or supplier name, style name, roll number, and roll dimensions.

D. Each roll of product shall include any additional information required to allow the ENGINEER to relate that roll with the manufacturing quality control and raw material quality assurance documentation. Additionally, if any special handling is required, it shall be so marked on the outside surface of the wrapping, i.e., “Do not stack more than five rolls high,” etc.

E. During storage, the geomembrane shall be placed on a stable, relatively flat, dry, well-drained surface. The geomembrane shall not be placed on skids or other objects that may cause deformation of the geomembrane rolls. Adequate space shall be left between stacked rolls, such that roll labels can be examined. The geomembrane shall be protected from the following:

1. Mud and dust;

2. Site construction damage.;

3. Chemicals that are strong acids or bases;

4. Flames, sparks, geomembrane temperatures in excess of 150° F; and,

5. Any environmental condition that might damage the geomembrane.

F. Roll numbers on partially used rolls must be maintained such that each roll number can be readily identified prior to deployment of the remaining portions of the roll. In the event roll numbers for partial rolls cannot be identified, such rolls will be marked for rejection.

G. If the ENGINEER determines the geomembrane is damaged, the GEOSYNTHETIC CONTRACTOR shall make all repairs and replacements in a timely manner, so as to prevent delays in the progress of the work. As determined by the ENGINEER, any material damaged by the GEOSYNTHETIC CONTRACTOR, or damaged by others due to improper delivery and/or storage, shall be replaced by the GEOSYNTHETIC CONTRACTOR at no cost to the OWNER.

## PART 2 MATERIALS

### 2.1 GENERAL

A. The geomembrane shall be manufactured from first quality; virgin linear low-density polyethylene (LLDPE) resin with no more than 10% rework. If rework is used it must be identical to the parent materials. The LLDPE resin must blended with carbon black. The resin and finished product requirements are described in this Part, including the minimum Manufacturing Quality Assurance (MQA) and Manufacturing Quality Control (MQC) sampling and testing requirements.

B. The LLDPE sheet must be textured on both surfaces, and shall have a uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

C. The geomembrane may have a white surface to minimize geomembrane surface temperatures and reduce overall wrinkling in the panels during construction. Any non-black geomembrane must be suitable for exposure during the installation process without degradation to the physical and mechanical properties required by this Specification.

D. The ENGINEER will conduct conformance testing on the geomembrane in accordance with the project CQA/CQC Plan at the cost of the GEOSYNTHETIC CONTRACTOR. The GEOSYNTHETIC CONTRACTOR shall, at no additional cost to the OWNER, provide whatever reasonable assistance the ENGINEER may require in obtaining samples for conformance testing.

E. The GEOSYNTHETIC CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory

results, the GEOSYNTHETIC CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the project or cost to the OWNER.

## 2.2 RESIN

A. The textured LLDPE geomembrane shall be manufactured from high quality LLDPE resin with superior stress crack resistance. No post consumer resin of any type shall be added to the formulation. While more than one resin may be suitable, and will be considered, the GEOSYNTHETIC CONTRACTOR is cautioned that the ENGINEER and OWNER consider proper resin selection crucial to the successful completion of the project, and proposed resins will be most thoroughly and carefully reviewed. Once a resin has been accepted for use, all material for the project shall be manufactured from that resin unless approved by the ENGINEER. A batch of resin is defined as 200,000 lbs or one rail car whichever applies to the manufacturing process. If more than one resin batch is used for manufacture of membrane, testing will be required on all additional batches.

B. The following table represents the minimum required Manufacturing Quality Assurance (MQA) testing that must be conducted by the geomembrane Manufacturer on the resin used to produce the geomembrane:

**RESIN MQA**
**MINIMUM TESTING**

| PROPERTY | TEST METHOD | REQUIRED VALUES | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Density, g/cm$^3$ (allowable range) | ASTM D1505/D792 | < 0.926 | 1/batch |
| Melt Flow Index, g/10 min. | ASTM D1238-00 Condition E | ≤0.5g/10min | 1/batch |

## 2.3 GEOMEMBRANE

A. The sheet material shall be formulated from the appropriate polymers and compounding ingredients to form LLDPE geomembrane that meets all requirements of this specification.

B. The geomembrane Manufacturer shall complete Manufacturing Quality Control (MQC) testing on the geomembrane in accordance with the requirements summarized in the following table:

**GEOMEMBRANE MQA/MQCMINIMUM TESTING**

| PROPERTY | TEST METHOD | TEXTURED SHEET VALUE | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Core Thickness, mils (1) | ASTM D5994 | 40 nominal (-5%) | Each Roll |
| Asperity Height, mils (min. avg.) (2,3) | ASTM D7466 | 16 | Each Roll |
| Density, g/cm$^3$ (max.) | ASTM D1505/D792 | 0.939 | 1/batch |
| Tensile Properties (min. avg.) both directions<br>• Break strength, lb./in.<br>• Break elongation, % | ASTM D6693<br><br>Notes (4,5) | <br>60<br>250 | Every 2nd Roll |
| Carbon Black Content, % (min. avg.) (6,7) | ASTM D4218 | 2.0 - 3.0 | Every 2nd Roll |
| Carbon Black Dispersion | ASTM D5596 | Note (8) | Every 6th Roll |
| Standard Oxidative Induction Time, minutes (min.) | ASTM D3895 | 100 | 1/batch |
| Tear Resistance, lbs (min. avg.) | ASTM D1004 | 22 | Every 6th Roll |
| Puncture Resistance, lbs (min. avg.) | ASTM D4833 | 44 | Every 6th Roll |

NOTES:

1. The result obtained from D5994 will be an average of readings from 10 specimens per roll. The lowest allowable minimum average value shall be 38 mil, the lowest individual value for 8 out of the ten specimens shall be 36 mils, and the lowest individual value for any of the 10 specimens shall be 34 mil.
2. Of 10 readings, 8 must be ≥ 14 mils, and the lowest individual reading must be ≥ 12 mils.
3. Both sides of the double-sided textured sheet shall be measured on each roll (reference Article 2.1B).
4. Break elongation is calculated using a gage length of 2.0 inches at 2.0 in./min.
5. Break elongation shall be determined based on the average of 5 specimens in the machine direction and the average of 5 specimens in the cross machine direction (reported separately).
6. Other methods, such as D1603 (tube furnace) are acceptable if an appropriate correlation to D4218 can be established..

7. Carbon black content is only measured on the black backing of the white-surfaced geomembrane. Prior to measuring the carbon black content, the white surface shall be scrapped or ground off to avoid misrepresentative results in the final result.

8. Carbon black dispersion for 10 different views, with at least nine in Categories 1 or 2 and one (max.) in Category 3.

C. Geomembrane Conformance Testing - The ENGINEER shall take samples across the entire width of the geomembrane roll for conformance testing in accordance with the project CQA/CQC Plan.

D. Non-conforming material will not be used in the work. Additional sampling required to address non-conforming test results shall be performed in accordance with the project CQA/CQC Plan. The Project Engineer may reject the entire lot containing non-conforming rolls at any stage of extended sampling and testing.

E. Interface Shear Testing – Assignment and management of interface shear strength testing of the geomembrane and related materials is the responsibility of the ENGINEER, and will be completed at the cost of the GEOSYNTHETIC CONTRACTOR. The results must comply with the criteria determined by the ENGINEER, as specified in the Construction Drawings. All testing must demonstrate the minimum required peak and residual shear strength and minimum large strain shear strength as specified on the Drawings, and those results must be completed by the ENGINEER prior to delivery of the materials. Testing for geosynthetic to geosynthetic, or geosynthetic to soil interface, shall be conducted according to the current version of ASTM D5321.

## 2.4 WELDING ROD AND/OR WELDING PELLETS

A. The Manufacturer shall certify that the welding rod and/or pellets used for extrusion welding shall be produced from the same resin type as that used to manufacture the geomembrane supplied for this Project.

B. The Manufacturer shall certify that the welding rod and/or pellets meet the following requirements:

| PROPERTY | TEST METHOD | REQUIRED VALUES | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Density, g/cm$^3$ | ASTM D1505/D792 | 0.939 (maximum) | Every 20,000 lbs |
| Carbon Black Content, % | ASTM D1603 or D4218 | 2.0 – 3.0 | Every 20,000 lbs |

C. The ENGINEER will perform conformance sampling and testing of the welding rod and/or pellets with a testing frequency of three tests per project or construction season.

## 2.5 GEOMEMBRANE PENETRATION BOOTS

A. The GEOSYNTHETIC CONTRACTOR shall furnish any geomembrane penetration boots and other materials required for completion of the geomembrane installation. The geomembrane boots shall be of the same density and thickness as the geomembrane panels. All field fabricated boots must be tested using a method approved by the ENGINEER.

B. The geomembrane Manufacturer shall provide a statement of hydraulic or pneumatic testing demonstrating that any shop-fabricated unit does not leak. A description of the method used for testing in the shop shall be submitted to the ENGINEER for prior approval.

C. Geomembrane penetrations are to be constructed only at the locations shown on the Plans. The GEOSYNTHETIC CONTRACTOR is cautioned that no deviation in the quantity or configuration of geomembrane penetrations will be accepted without the advance written approval of the ENGINEER.

D. The GEOSYNTHETIC CONTRACTOR shall construct penetrations in accordance with the procedures described in ASTM D6497, Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures, or as described by this Specification.

E. All penetrations through the geomembrane shall be thoroughly and securely sealed. The seal between the geomembrane and the pipe shall be without any detectable leakage.

F. In attaching the geomembrane penetration boot in the field, no field seams will be allowed in locations or configurations that do not allow for Construction Quality Control testing. Visual observation is not considered a sole acceptable method for in-field quality control.

G. Where clamps, fasteners, gasket seals or sealants are used, the GEOSYNTHETIC CONTRACTOR shall use only materials that are compatible with the geomembrane.

# PART 3 EXECUTION

## 3.1 SITE PREPARATION

A. All required grading, grooming, and construction quality assurance (CQA) testing on any low permeability soil or other subgrade to be covered by the geomembrane shall be complete and accepted by the ENGINEER prior to geomembrane placement.

B. The surface to be covered by the geomembrane shall be cleared of sharp objects, angular stones, sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The geomembrane subgrade surface shall be cleared of sharp objects, angular stones sticks, or any materials that may contribute to punctures, shearing, rupturing or tearing of the geosynthetic materials. The geomembrane subgrade shall have a smooth, finished surface, free from pockets, holes, soft spots, ruts greater than 1 inch in depth, discontinuities that will cause bridging and overstress the material, and free of substantial amounts of loose soil as determined by the PROJECT ENGINEER. The subgrade shall be inspected for unsuitable areas or soft spots before the geomembrane is placed, and additional surface preparation will be required to eliminate any unsuitable areas as determined by the ENGINEER.

C. The GEOSYNTHETIC CONTRACTOR and ENGINEER shall carefully and completely inspect the subgrade surface immediately prior to the deployment of each geomembrane panel. No geomembrane shall be placed on unsuitable subgrade surface, or without the ENGINEER's written approval. The ENGINEER and the GEOSYNTHETIC CONTRACTOR's Quality Control (QC) inspector shall furnish their signatures on a Subgrade Acceptance Log prior to the installation of each panel or series of panels placed on a daily basis.

D. Under no condition shall the geomembrane be placed over standing water on the subgrade.

## 3.2 SEAMING METHODS

A. The geomembrane panels shall be joined utilizing approved seaming methods. Dual-track fusion welding shall be the required method on all seams where it is feasible. Extrusion welds shall be made only where approved by the ENGINEER.

B. The GEOSYNTHETIC CONTRACTOR shall properly maintain and set-up the welding equipment prior to seaming operations on a regular as needed basis, in the manner specified by the Manufacturer. For wedge welding equipment this is expected to include as a minimum; checking the condition and adjusting the position of the nip rollers, hot wedge and contour rollers. As well, the GEOSYNTHETIC CONTRACTOR shall properly examine and check the cartridge heaters, thermocouples, drive chains and electronics for proper operation at the frequency recommended by the Manufacturer. The CQA Observers shall record and document the set-up, maintenance and adjustment process, as well as the settings/conditions each time acceptable seaming of the geomembrane has been confirmed by trial weld results.

C. All geomembrane surfaces that are to become a seam interface are to be free of dust, dirt, excess moisture or any other condition that may affect the quality of the seam.

D. Seaming will not be allowed during rain or snowfall, unless proper precautions are made to allow the seam to be made on dry subgrade and geomembrane materials. Seaming is also subject to wind and temperature restrictions as described in Article 3.3.M.

E. The seams shall be produced using one of the following methods:

1. Dual-Track Fusion (Wedge) Weld – A seam produced by melting the two intimate surfaces by running a hot metal wedge between the surfaces, followed immediately by pressure to form a homogeneous bond. This seam has a center air channel for non-destructive testing of the seam. Panels to be seamed shall be overlapped sufficiently to allow proper destructive testing of seams. The GEOSYNTHETIC CONTRACTOR shall mark the liner where the Duel-Track Fusion Welding machine settings are adjusted (including speed, temperature and pressure). Measurable setting values shall be indicated on the liner.

2. Extrusion Weld – A seam produced by extruding molten LLDPE at the edge of two overlapped panels. A bonded seam is completed when molten LLDPE melts portions of the overlapping sheets to form a homogeneous weld. The center of the extrudate bead shall be located directly over the edge of the upper geomembrane. Panels to be seamed shall be overlapped a minimum of 4 inches. An electric rotary grinder and #80 grit paper, or finer, shall be used to remove the surface sheen in the area to be seamed. Grinding shall be completed no more than 10 minutes prior to seaming. Any grinding marks shall be oriented perpendicular to seam direction, and their depth shall be less than 5% of the sheet thickness. Grinding marks shall not appear beyond 0.25 inches of the extrudate after it is applied. The leading edge of the upper sheet shall be ground to a 45-degree bevel. Beveling shall be completed prior to tack welding to control damage to the lower sheet.

## 3.3 INSTALLATION

A. Based on the approved geomembrane panel diagram and material certifications, the individual panels will be numbered and seams will be identified by using the panel numbers that create the seam. The LLDPE panels shall be installed in a manner that minimizes seams. Seams shall be placed where normally applied stresses will be minimal. Longitudinal seams shall be oriented to be no greater than ten degrees from parallel with the direction of the slope. All panels placed on slopes greater than 25% shall extend down the full length of the slope unless the slope length is greater then the manufactured roll length. Any cross seams on slopes greater than 25% shall be staggered such that seams between adjacent panels are separated by a minimum of 10 feet. On slopes less than 25%, cross seams shall be placed no closer than five feet from the top of a steeper slope, or five feet from the toe of a steeper slope. All seam overlaps shall be shingled in a downslope direction. In no case shall parallel seams be placed within five feet of the centerline of any leachate collection pipe.

B. Piecework resulting in the placement and seaming of small panels not identified by the panel diagram shall not be permitted. Any material variation from the approved panel diagram must be pre-approved by the ENGINEER prior to altering the installation.

C. During installation, and any other period of exposure of geomembrane, pedestrian and equipment activity over the geomembrane shall be kept to a minimum, and restricted to only that which is necessary for geomembrane construction.

D. Smoking is not permitted on the geomembrane.

E. Construction workers shall take precautions not to damage the geomembrane surface. Construction workers shall wear smooth-soled footwear, and exercise care not to drag tools across the geomembrane surface. All large tools are to have smooth base plates or shoes. Construction and landfill staff shall be informed of the restricted access to areas of geomembrane placement by use of barriers and signs posted as necessary. Only hook blade knives shall be used to cut geomembrane.

F. The GEOSYNTHETIC CONTRACTOR shall perform all activities of geomembrane construction in such a way as to avoid damage to the geomembrane, including the prudent use of rub sheets. Any damage caused to the geomembrane by the GEOSYNTHETIC CONTRACTOR shall be repaired or the material replaced at the expense of the GEOSYNTHETIC CONTRACTOR.

Generators and other stationary equipment that must be lubricated, fueled and/or oiled and that are staged on the geosynthetics must be placed within spill containment pads designed to prevent spillage of gasoline, diesel fuel or oil on the geosynthetics. If any such equipment is not placed in a spill containment structure, it must not be fueled on the geosynthetics.

G. Wheeled vehicle traffic is prohibited above the Textured LLDPE geomembrane. Low ground pressure vehicles only will be allowed to traverse any LLDPE panels covered with a foot of soil. Three feet of soil must be in place over the LLDPE geomembrane to permit heavy wheeled vehicles to travel across the LLDPE geomembrane.

H. The GEOSYNTHETIC CONTRACTOR shall complete his work in a manner that will prevent water or wind from getting under the partially installed geomembrane. This could include, but is not limited to, installing sandbags along the leading edges. Should excessive moisture become trapped below the geomembrane, or should wind damage occur due to the negligence of the GEOSYNTHETIC CONTRACTOR, the GEOSYNTHETIC CONTRACTOR, at no extra cost to the OWNER, will be required to perform all work, including removing and replacing as much of the in-place geosynthetic material as the ENGINEER directs, to assure that the integrity of the geomembrane and the underlying subbase or has not been compromised.

I. Seams shall be welded throughout the entire length of the panels during initial panel seaming.

J. Sandbags or other approved ballast shall be used to prevent bridging or material movement in areas such as toe of slope or near sumps. Ballast shall not be used to force the geomembrane into contact with the subgrade.

K. Special care shall be taken to prevent tensile stress in the geomembrane and geomembrane seams in all corners and grade changes.

L. The GEOSYNTHETIC CONTRACTOR shall exercise his best judgment and care to provide sufficient slack in the geomembrane to allow for thermal contraction without "trampolining", but to also avoid excessive slack such that wrinkling will be minimized during seaming and placement of overlying soil or geosynthetic materials.

M. The geomembrane shall not be seamed when ambient or sheet temperatures are below 32° F, when the sheet temperature exceeds 158° F, or when the air temperature is above 120° F unless the GEOSYNTHETIC CONTRACTOR demonstrates, to the satisfaction of the ENGINEER, that procedures can be implemented which will result in the proper installation and seaming of the geomembrane.

For seaming activities below 32° F the GEOSYNTHETIC CONTRACTOR shall use procedures set forth in GRI GM 9. Maximum allowable time between trail welds shall be adjusted to 2 hours, decreasing one-half hour for each 10 deg F below 32 deg F.

N. Adjacent geomembrane panels shall be allowed to reach essentially equivalent temperatures prior to seaming to avoid development of fish mouths.

O. If fish mouths are created at the seam overlaps, they shall be cut to achieve a flat overlap. The cut shall be made with keyhole ends, and a patch shall be placed over the cut as required by Article 3.4.

P. Wrinkles shall not exceed a height to width ratio of 0.5, or as deemed acceptable by the ENGINEER. The height of the wrinkle shall be measured from the base or subgrade to the peak of the wrinkle. The width of the wrinkle shall be measured along the base of the wrinkle.

Q. Geomembrane covering operations shall be performed in a manner that does not damage the geomembrane lining system. Geomembrane covering operations shall be performed only in the presence of a Construction Observer such that the condition and cleanliness of the geomembrane is observed at the time the material is covered, and any effects of the covering operation on the geomembrane lining system can be observed.

R. In the event wrinkles develop during any covering operation that are capable of folding over, the excess material shall be cut out to achieve a flat overlap, or the covering operation shall be delayed until such time wrinkling subsides to acceptable levels. Any geomembrane cut shall be made with keyhole ends, and a patch shall be placed over the cut as required by Article 3.4. Wrinkles that do not lay flat and whose height to width ratio does not exceed 0.5 are susceptible to damage by soil placement equipment, and shall be carefully monitored by the ENGINEER during cover operations.

## 3.4 REPAIRS

A. All geomembrane panels and seams shall be examined by the ENGINEER for uniform texturing, defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The geomembrane surface shall be clean at the time of examination. Each suspect location shall be repaired and all repairs shall be non-destructively tested.

B. Damaged and/or unacceptable geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be repaired to the satisfaction of the ENGINEER.

C. Any portion of the geomembrane, or any portion of a seam exhibiting a flaw or failing a destructive or non-destructive test, or an area where a wrinkle had been cut out shall be repaired, as follows:

1. Geomembrane patches shall be used for holes over 1/8 of an inch in diameter, tears, and contamination by foreign matter. Patches shall be constructed of the same geomembrane, and will be joined to the panel using extrusion welding, or fusion welding where possible.

2. Geomembrane patches or caps shall extend at least 6 inches beyond the edge of the defect or failed seam area, and all corners of material to be patched. The corners of the patch shall be rounded to a radius of at least 3 inches.

3. Spot extrusion welding shall be used to repair pinholes, or other minor localized flaws, only as approved by the ENGINEER.

4. Geomembrane caps shall be used to repair failed seams that are left in-place. Seams that fail destructive or non-destructive testing may also be removed and replaced if determined necessary by the ENGINEER.

# PART 4 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

## 4.1 GENERAL

A. Before installation begins, and weekly thereafter (more often if determined necessary by the ENGINEER) project coordination meetings shall be held with the designated representative of the GEOSYNTHETIC CONTRACTOR, PROJECT ENGINEER and OWNER in attendance to review the following information:

1. Progress of the work;

2. Adherence to the Specifications;

3. Adherence to the Construction Quality Assurance Program described in this Section, including the timely submission of the pertinent forms;

4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work; and,

5. Problem resolutions to be implemented during the upcoming week.

B. All of the Forms specified and required must be submitted to the ENGINEER in a timely fashion.

C. The OWNER and ENGINEER must approve any changes in the proposed method of work, subcontractors to be utilized, geomembrane resin, or manufacturing in advance.

D. The GEOSYNTHETIC CONTRACTOR assumes all responsibility relevant to providing an acceptable product.

## 4.2 INSTALLATION QA/QC

A. The ENGINEER and GEOSYNTHETIC CONTRACTOR shall visually inspect all material to be included in the work, and compare roll identification numbers with those on the certifications provided by the manufacturer to assure delivery of the appropriate material.

B. Damage to geomembrane during installation shall be repaired according to Article 3.4. If the ENGINEER determines that any damage cannot adequately be repaired, the damaged material will be replaced.

C. The GEOSYNTHETIC CONTRACTOR will be required to conduct both destructive and non-destructive testing on seams during the geomembrane installation, as part of the Construction Quality Control program. All trial and installed seam samples shall be tested according to ASTM D6392, as modified by this Specification.

D. The GEOSYNTHETIC CONTRACTOR will be required to complete trial seams throughout the project. The GEOSYNTHETIC CONTRACTOR will be required to utilize control charts to determine whether adjustments in the welding parameters are required during production seaming, per GRI GM14. The trial seams shall be provided in a timely fashion such that adequate time is available for field destructive testing, and preparation of the associated documentation by the ENGINEER prior to production welding.

E. Trial Seams

1. Trial seams shall be produced:

a. each day, at the start of each workday;

b. after every five hours of continuous operation;

c. after equipment maintenance, repair or replacement;

d. after lunch and/or dinner; and,

e. if the geomembrane temperature changes by more than 25°F in one hour.

Trial seams shall be required each day for each piece of seaming equipment and each welding crew combination (including welding technician, seam cleaners and/or grinders). The trial seams will be performed on strips of geomembrane from approved rolls, and shall be produced at the work location such that the conditions mimic those under which production seams will be made. In the case of tie-ins to old liner, the trial seams are not required because these seams are not expected to pass the testing requirements; therefore, all tie-in seams shall be over-capped.

2. A trial seam shall be a minimum of 5 feet in length for self-propelled seaming devices, and a minimum of 3 feet for hand-held seaming devices. The material for the trial seam and the test fixture for making the field tests shall be provided by the GEOSYNTHETIC CONTRACTOR at no additional cost. One-inch wide cutouts of the trial seams will be subject to shear and peel testing by the GEOSYNTHETIC CONTRACTOR's QC technician at the site. A minimum of 5 cutouts will be tested for shear, and a minimum of 5 cutouts will be tested for peel. Only the upper weld area need be tested in peel. The ENGINEER shall document the locus of break code for each specimen as shown in Figure 3 and Figure 4 of ASTM D6392-99.

3. All trial seam specimens must be acceptable or the trial seam will be repeated until all results from a given trial seam are found acceptable. If any trial seam fails at any time during the workday, the reason for the failure shall be resolved before any production seaming of the geomembrane by the subject equipment and crew. All trial seam welding and testing must be observed by the ENGINEER.

4. A trial seam specimen will be considered a failure if:

   a. For hot wedge seams:

      i. the bonded thickness of the seam fails before the adjacent sheet material; or,

      ii. the shear strength of the specimen is less than 60 lb/in; or,

      iii. the peel strength is less than 50 lb/in; or,

      iv. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.2 of GRI GM 19.

b. For extrusion fillet seams:

v. the bonded thickness of the seam fails before the adjacent sheet material; or,

vi. the shear strength of the specimen is less than 60 lb/in; or,

vii. the peel strength is less than 44 lb/in; or,

viii. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.2 of GRI GM 19.

c. In the shear or peel test, locus of break codes AD or AD-Brk >25% for hot wedge seams, AD1 or AD2 for extrusion fillet seams are reported by the ENGINEER. AD-WLD and SIP are the exceptions.

d. Upon visual inspection, the weld shows:

i. Excessive deformation or stepping of the bottom sheet when viewed in cross-section.

ii. Discoloration of the sheet such as that occurring from brittle failure.

iii. Inadequate or excessively narrow or flat weld bead (for extrusion seams).

iv. Water blisters in weld bead (for extrusion seams).

v. Misaligned weld bead, i.e., weld not reasonably centered with respect to overlap (for extrusion seams).

vi. Thinning of the sheet adjacent to the weld.

vii. Overgrinding marks outside of the extrudate bead (for extrusion seams).

F. The field tensiometer shall be strong enough to permit the operator to determine that the seam is at least as strong as either sheet, and shall permit accurate measurement of specimen elongation. The tensiometer shall have been calibrated within the 6-month period prior to its use on-site.

G. Should the ENGINEER, at any time during the installation, believe the production seaming process may not be performing adequately, he may, to avoid destructive sampling of the installed geomembrane, request additional trial seams. The GEOSYNTHETIC CONTRACTOR shall do this at no additional cost.

H. The GEOSYNTHETIC CONTRACTOR shall complete non-destructive testing of all seams along their entire length, in the manner approved prior to installation, in the presence of the ENGINEER. The recommended test methods are as follows:

1. Pressurized Air Channel

   a. All field seams made by a dual-track fusion wedge welding device will be tested by applying air pressure within the air channel to a sealed length of seam, and monitoring the pressure over time. The testing shall be conducted in accordance with GRI GM6 or ASTM D5820.

   b. For the 40 mil geomembrane, the initial inflation pressure shall be a minimum of 25.0 psi and a maximum of 30.0 psi. The maximum allowable pressure drop over a 5 minute period shall be 2.0 psi.

   c. A pressure gauge shall be inserted into the far end of the air channel to check for continuity in the air channel. Alternately, the far end of the seam may be cut to relieve the air pressure. An audible rush of air shall serve as an indicator that the test represents the entire length of seam.

   d. Air channels that do not hold the minimum specified air pressure shall be further inspected to identify the location and nature of any defects or unbonded sections of seam. The seam will then be repaired and retested. The ENGINEER may, at his discretion, require the entire questionable seam area to be capped or replaced.

2. Vacuum Box Testing

   a. Extrusion seams shall be inspected for unbonded areas or defects by applying a vacuum to a soaped section of seam. The vacuum shall be applied by a vacuum box equipped with a vacuum gauge, a clear glass view panel in the top, and a soft rubber gasket on the periphery of the open bottom. The testing shall be completed in accordance with ASTM D5641.

   b. A section of the seam shall be soaped thoroughly and the inspection box shall be placed over the soaped seam section and the gasket sealed to the geomembrane. A vacuum of between 4 and 8 inches of Mercury (Hg) shall be applied to the box for a minimum of 10 seconds by use of a gasoline or electric driven power-vacuum pump apparatus. Adjacent placements of the vacuum box shall overlap the seam a minimum of 2 inches as viewed through the vacuum box-viewing window.

   c. The ENGINEER shall witness the testing, and the seam shall be clearly visible to the ENGINEER and GEOSYNTHETIC CONTRACTOR during the test. Unbonded areas or defects shall be marked by the PROJECT ENGINEER for repair by the GEOSYNTHETIC CONTRACTOR.

3. Spark Testing

a. Spark testing may be used on short, detail (sump, penetration) extrusion welds that cannot be tested by vacuum box testing, and can use Alternating Current (AC) or Direct Current (DC) equipment. The DC equipment (using the latest version of ASTM D6365) is required for use on this project unless the GEOSYNTHETIC CONTRACTOR provides a detailed Workplan to the ENGINEER regarding AC testing for approval, at least two weeks prior to beginning the testing.

b. The DC method typically uses a metal brush for the search electrode. For seams, a copper wire or tape is placed within the geomembrane/seam overlap, just to the inside of the center of the extruded bead. Prior to testing, a trial calibration seam must be made to confirm the minimum voltage required to discharge across a hole in the seam between the search electrode and the copper wire.

c. Spark testing must not be performed when the liner is wet. The test procedure for DC equipment can generally be describes as follows:

   i. Connect the negative (ground) electrode of the testing equipment to the exposed end of the copper wire, or to a grounding rod if the copper wire is buried in the subgrade;

   ii. Calibrate using a seam with a known leak path of the largest reached distance;

   iii. Connect the positive electrode to the wire brush or other type of search electrode;

   iv. Clean all debris and moisture from the seam area;

   v. Apply a potential difference of between 20 and 55 kVDC, as determined in the calibration test, between the electrodes;

   vi. Sweep the search electrode over the surface of the seam, maintaining contact with the extruded bead and the top of the lower geomembrane at the edge of the bead; and,

   vii. Monitor for audible and/or visible spark discharges that are indicative of a defect. Mark defects for repair.

d. The exposed end of the wire must be cut short, and an extruded bead of molten polyethylene must be placed over the remaining wire exposure to ensure the wire is covered completely.

I. All inadequate seams or portions thereof that fail the non-destructive testing shall be repaired in accordance with this Specification and the method approved by the ENGINEER. Should differences of opinion between the GEOSYNTHETIC CONTRACTOR and the ENGINEER develop during the installation relevant to seam

integrity, the ENGINEER may, at his discretion, obtain samples of the seams in dispute for field and/or laboratory testing. The GEOSYNTHETIC CONTRACTOR will be responsible for patching the resulting void in accordance with the previously approved procedures at no additional cost to the OWNER.

J. Destructive Sample Collection - Samples of the in-place seams shall be cut from the installed geomembrane at a frequency one per 500 feet of production seaming. Any seam that is reconstructed must be sampled destructively as well.

K. The destructive sample cutout sections shall be 12 inches wide by 40 inches long with the seam centered lengthwise. The sample size can be reduced to 34 inches if the GEOSYNTHETIC CONTRACTOR does not elect to have a cutout section for their use. A 1-inch wide specimen shall be cut from each end of the sample, and these two specimens shall be peel tested in the field in accordance with 4.2.E.4. The remaining sample shall be cut into two parts and distributed as follows:

1. One 12-inch by 18-inch sample to the CQA MANAGER for independent laboratory testing; and,

2. One 12-inch by 18-inch sample to the OWNER for archive storage.

3. The remainder of the sample shall be available for the GEOSYNTHETIC CONTRACTOR if requested at the time of sample collection.

L. The 12-inch by 18-inch laboratory sample will provide 5 specimens for shear testing and 5 specimens for peel testing. Specimens that will be subject to peel and shear testing shall be selected alternately from the sample. All peel tests shall be performed on the outer track of dual track fusion welds. The laboratory shall report the locus of break code for each specimen according to the definitions included in Figure 3 and Figure 4 of ASTM D6392. The laboratory sample will be considered acceptable only if all 10 specimens meet the minimum requirements. The specimen will be considered a failure if:

1. For hot wedge seams:

    a. the bonded thickness of the seam fails before the adjacent sheet material; or,

    b. the shear strength of the specimen is less than 60 lb/in; or,

    c. the peel strength is less than 50 lb/in; or,

    d. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.2 of GRI GM19; or,

    e. the shear percent elongation is less than 50% as determined in accordance with Paragraph 6.2 of GRI GM19.

2. For extrusion fillet seams:

    a. the bonded thickness of the seam fails before the adjacent sheet material; or,

    b. the shear strength of the specimen is less than 60 lb/in; or,

    c. the peel strength is less than 44 lb/in; or,

    d. greater than 25% of the originally bonded area separates during peel strength testing as determined in accordance with Paragraph 6.2 of GRI GM19;

    e. the shear percent elongation is less than 50% as determined in accordance with Paragraph 6.2 of GRI GM19.

3. In the shear or peel test, locus of break codes AD or AD-Brk >25% for hot wedge seams, AD1 or AD2 for extrusion fillet seams are reported by the ENGINEER. AD-WLD and SIP are the exceptions.

4. Upon visual inspection, the weld shows:

    a. Excessive deformation or stepping of the bottom sheet when viewed in cross-section.

    b. Discoloration of the sheet such as that occurring from brittle failure.

    c. Inadequate or excessively narrow or flat weld bead (for extrusion seams).

    d. Water blisters in weld bead (for extrusion seams).

    e. Misaligned weld bead, i.e., weld not reasonably centered with respect to overlap (for extrusion seams).

    f. Thinning of the sheet adjacent to the weld.

    g. Overgrinding marks outside of the extrudate bead (for extrusion seams).

M. If a sample fails destructive testing, the welding path must be retraced to intermediate locations at least 10 feet in each direction from the location of the sample that failed the test, and a second sample shall be taken for an additional field test. If the tracking samples pass, the seam must be reconstructed between the location of the two tracking samples and the original sampled location. If the tracking sample fails, this process must be repeated. The seam between 2 passing test locations shall be capped, the cap seams shall be nondestructively tested, and shall include one field peel and shear test location along the reconstructed seam.

N. The ENGINEER and GEOSYNTHETIC CONTRACTOR shall visually inspect all geomembrane seams. Extrusion welds shall be centered above the overlap, shall be free

from blisters, and shall not include grinding marks that show more than 0.25 inches outside of the extrusion bead. If such grinding marks are found, the seam shall be repaired to the ENGINEER's satisfaction.

O. All welds shall be observed for traces of deformation to the geomembrane panels. Any seams, which in the opinion of the ENGINEER, have caused excessive deformation of the sheet, show signs of discoloration, exhibit thinning or stepping of the sheet, or show visual signs of overheating of the geomembrane panels, shall be repaired at no additional cost to the OWNER regardless of the result of any destructive testing on the seam. The deficient seam or portion thereof shall be cut out, the geomembrane panels again overlapped and seamed, or the questionable seam length shall be capped, as approved by the ENGINEER.

P. The GEOSYNTHETIC CONTRACTOR shall not place overlying materials on the installed geomembrane until the ENGINEER has reviewed and accepted the written test results for the geomembrane to be covered. At a minimum, the pre-delivery testing, the daily log of trial seam results, laboratory destructive sample results, non-destructive test results, record drawings of the completed area, and approval of the seams in place will be reviewed.

Q. The GEOSYNTHETIC CONTRACTOR shall provide a report to the OWNER and the ENGINEER at the conclusion of the work which shall include the following:

1. The quality control tests used as specified and/or directed, including all requirements of the Report section of the specified test method.

2. Complete description of field sampling procedure, number of test specimens, and size of test specimens.

3. Log of all Construction Quality Control work.

R. The GEOSYNTHETIC CONTRACTOR shall be responsible for all costs incurred by the OWNER including, but not limited to, additional field and laboratory CQA testing resulting from greater than 5 percent of the CQA testing not meeting or exceeding the Specifications.

S. All seams must be subjected to accepted Construction Quality Control or Construction Quality Assurance (CQA/CQC) testing.

## 4.3 WARRANTY

A. The GEOSYNTHETIC CONTRACTOR shall issue a warranty on the installation of geomembrane for a minimum period of 1 year.

B. The GEOSYNTHETIC CONTRACTOR shall issue a warranty on the geomembrane material for a minimum period of 5 years.

END OF SECTION

# SECTION 02599

# GEOCOMPOSITES

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The GEOSYNTHETICS CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to complete the installation of all geocomposite layers as shown, specified, or required.

### 1.2 RELATED SECTIONS

A. Section 02278 - Geosynthetic Clay Liner

B. Section 02595 - Geotextile

C. Section 02597 – HDPE Geomembrane

D. Section 02598 – LLDPE Geomembrane

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D413 Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate

2. D792 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

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

4. D1603 Standard Test Method for Carbon Black In Olefin Plastics

5. D3786/D3786M Standard Test Method for Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method

6. D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique

7. D4354 Standard Practice for Sampling of Geosynthetics for Testing

8. D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity

9. D4533) Standard Test Method for Trapezoid Tearing Strength of Geotextiles

10. D4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

11. D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

12. D4716 Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

13. D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile

14. D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

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

16. D5100 Standard Test Method for Adhesion of Mineral Aggregate to Hot Bitumen

17. D5199 Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

18. D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles

19. D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

20. D6243 Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

21. D7005 Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites

22. F904 Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made from Flexible Materials

B. Geosynthetic Research Institute (GRI):

1. GRI GC8 Determination of the Allowable Flow Rate of a Drainage Geocomposite

C. The most current version of the specified test method shall be followed by the Manufacturer, GEOSYNTHETICS CONTRACTOR or authorized testing laboratory.

## 1.4 DEFINITIONS

A. Minimum Value – Property value representing the lowest individual allowable value obtained when tested according to the specified test method. This applies to individual readings, such as thickness; or where only one specimen is tested for the specified parameter.

B. Minimum Average Value – Property value representing the lowest allowable value for the average of results for the specimens tested.

C. Minimum Average Roll Value (MARV) – Property value calculated as the average test result minus two standard deviations. Statistically, this implies a 97.5 percent confidence that any sample tested during quality assurance will exceed the value reported.

D. Nominal Value – Property value that is representative of a measureable property, determined under a set of prescribed test conditions, by which a product may be described.

E. Typical Roll Value – Property value calculated as the average or mean obtained from test data.

## 1.5 SUBMITTALS

A. The GEOSYNTHETICS CONTRACTOR shall submit to the ENGINEER all items included in this Article. Submittals shall be provided as follows:

1. Submitted with the BID:

    a. A project reference list demonstrating the GEOSYNTHETICS CONTRACTOR's experience on a minimum of 5 projects, totaling at least two million square feet of installed Geocomposite material.

    b. A statement of each Geocomposite material Manufacturer's experience, including the manufacturing and supplying company's name, address and employee contact.

    c. A copy of each Geocomposite material Manufacturer's Manufacturing Quality Assurance/Manufacturing Quality Control (MQA/MQC) Plan.

2. Fifteen days prior to site delivery, unless stated otherwise below:

    a. Resumes of all Geocomposite material installation crew members, including Supervisor and QC Manager, summarizing prior experience in installing

Geocomposite materials. Geocomposite material installation staff will be subject to approval by the ENGINEER and OWNER.

b. Manufacturing Quality Control (MQC) Manufacturing Quality Assurance (MQA) test data for the material to be delivered to the site. The reports shall include the test results for samples obtained prior to and during the manufacture of the geocomposite. In the event material is delivered prior to receipt of the manufacturer's data, the Geocomposite material without data will be stored separate from material with data. The Geocomposite material will be rejected if it does not meet the requirements of this Specification, or if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the ENGINEER.

c. Samples of the proposed Geocomposite materials shall be sent to the ENGINEER for interface shear testing within 5 days after such request is made by the ENGINEER. The GEOSYNTHETICS CONTRACTOR shall coordinate the quantity and dimensions of the samples with the ENGINEER. Interface shear testing shall be conducted in accordance with the CQA/CQC Plan by the ENGINEER on materials that will be used in the project.

d. Working Drawings including details of overlap and method of joining adjacent panels. This shall include geonet tieing detail; as well as, sewing thread type, stitch type, stitch density, and number of rows, etc.

3. Upon Completion:

a. Summary and log of all laboratory quality control and quality assurance data obtained by the GEOSYNTHETICS CONTRACTOR.

b. Summary and log of all field quality control data and information obtained by the GEOSYNTHETICS CONTRACTOR.

c. Statement of material and installation warranties.

## 1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. The GEOSYNTHETICS CONTRACTOR shall protect the work described in this Section before, during, and after installation, and shall protect the installed work specified in other Sections as well as work completed by the OWNER.

B. Geocomposite material labeling, shipment, and storage shall follow ASTM D4873, as modified by this Specification.

C. Product labels shall be placed on the ends of the roll such that they can be seen when rolls are stacked, and shall clearly show the manufacturer or supplier name, style name, date of manufacture, lot number, roll number, and roll dimensions.

D. If any special handling is required, it shall be so marked on the outside surface of the wrapping (e.g. "Do not stack more than five rolls high," etc).

E. Each geocomposite roll shall be wrapped with a material that will protect the material from damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

F. Storage areas shall be stable, dry, relatively flat, and well drained. During storage the geocomposite rolls shall be adequately covered and protected from the following:

1. Exposure of the geotextile component to ultraviolet (UV) radiation in excess of 30 days, and as restricted by Section 02595, Article 3.2;

2. Site construction damage;

3. Precipitation;

4. Chemicals that are strong acids or strong bases;

5. Flames, sparks, temperatures in excess of 49 deg C (120 deg F); and,

6. Any environmental condition that might damage the geocomposite.

G. Roll numbers on partially used rolls shall be maintained such that each roll number can readily be identified prior to deployment of the remaining portions of the roll.

H. If the ENGINEER determines the geocomposite drainage material is damaged or has been subjected to excessive exposure, the GEOSYNTHETICS CONTRACTOR shall make all repairs and replacements in a timely manner so as to prevent delays in the progress of the work. Any material damaged by the GEOSYNTHETICS CONTRACTOR, or damaged by others due to improper delivery or storage, as determined by the ENGINEER, shall be replaced by the GEOSYNTHETICS CONTRACTOR at no additional cost to the OWNER.

## PART 2 MATERIALS

### 2.1 GENERAL

A. The geocomposite drainage layer shall consist of a high density polyethylene (HDPE) geonet core between two layers of nonwoven, needlepunched geotextile. The geotextiles shall be heat-bonded to the geonet core. The geonet core and the geotextiles, as well as the geocomposite itself, shall be subject to Manufacturing Quality Assurance (MQA) and Manufacturing Quality Control (MQC) testing as required by this Specification.

B. Conformance testing will be conducted on the geocomposite by the ENGINEER in accordance with the project CQA/CQC Plan. The GEOSYNTHETICS CONTRACTOR

shall, at no additional cost to the OWNER, provide whatever reasonable assistance the ENGINEER may require in obtaining samples for conformance testing. Geosynthetic material sampling shall be in accordance with ASTM D4354, unless determined otherwise by the ENGINEER. Conformance testing shall be conducted by a qualified laboratory with GAI-LAP accreditation.

C. Conformance testing will be at the expense of the OWNER, unless the tests show the materials do not comply with the Specifications, in which case the GEOSYNTHETICS CONTRACTOR shall pay the cost of re-sampling and follow up testing.

D. The GEOSYNTHETICS CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the GEOSYNTHETICS CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the project or cost to the OWNER.

E. The Interface shear strength testing of the geocomposite and related materials is the responsibility of the OWNER. The results must comply with the criteria determined by the ENGINEER, as specified in the Construction Drawings. All testing must meet the minimum requirements, and the analysis of those results must be completed by the ENGINEER prior to installation of the materials. Testing for geosynthetic to geosynthetic, or geosynthetic to soil interface, shall be conducted according to the current version of ASTM D5321. Testing for interfaces involving geosynthetic clay liner (GCL) shall be conducted according to the current version of ASTM D6243.

## 2.2 GEOTEXTILE

A. The geotextile component of the geocomposite shall be subject to MQA sampling and testing to verify the products meet or exceed the material specifications identified in this Section. Sampling shall take place prior to lamination to the geonet.

B. The geotextile shall meet the following requirements:

| PROPERTY | TEST METHOD | VALUE | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Mass per Unit Area, oz/yd$^2$ (min. avg.) | ASTM D5261 | 6.0 | 35, 000 ft$^2$ |
| Puncture Resistance, lbs (min. avg.) | ASTM D4833 | 95 | 35, 000 ft$^2$ |
| Mullen Burst Strength, psi (min. avg.) | ASTM D3786 | 330 | 35, 000 ft$^2$ |
| Trapezoidal Tear Strength, lbs (min. avg.) | ASTM D4533 | 65 | 35, 000 ft$^2$ |
| Grab Tensile Strength(1), lbs (min. avg.) | ASTM D4632 | 160 | 35, 000 ft$^2$ |
| Grab Elongation(1), % (min. avg.) | ASTM D4632 | 50 | 35, 000 ft$^2$ |
| A.O.S., mm (max) | ASTM D4751 | 0.212 | 35, 000 ft$^2$ |
| Permittivity, sec$^{-1}$ (min. avg.) | ASTM D4491 | See Note 2 | 35, 000 ft$^2$ |

Note 1: Values required in weakest principal direction

Note 2: The minimum permittivity must be equivalent to a permeability two orders of magnitude greater than the adjacent soil material.

Note 3: The Manufacturer shall provide evidence of any representative UV Resistance testing on the polymer used in the manufacture of the geotextile that is satisfactory to the Project Engineer

## 2.3 GEONET CORE

A. The geonet core of the geocomposite shall be subject to MQA/MQC sampling and testing to verify the product meets or exceeds the material specifications identified in this Section.

B. The geonet core shall meet the following requirements:

| PROPERTY | TEST METHOD | VALUE | MINIMUM TEST FREQUENCY |
|---|---|---|---|
| Density, g/cm$^3$ (min. avg.) | ASTM D1505/D792 | 0.940 | 35, 000 ft$^2$ |
| Carbon Black, % (min. avg.) | ASTM D1603/D4218 | 2.0 – 3.0 | 35, 000 ft$^2$ |
| Thickness, mil (min. avg.) | ASTM D5199 | 270 ± 15 | 35, 000 ft$^2$ |

## 2.4 GEOCOMPOSITE

A. The geocomposite shall be subject to Manufacturing Quality Control (MQC) testing for ply adhesion that must be conducted by the Manufacturer. Transmissivity testing shall be

conducted by the OWNER on material provided by the GEOSYNTHETICS CONTRACTOR. The geocomposite shall meet the following minimum average values for the properties listed:

| PROPERTY | TEST METHOD | GEOCOMPOSITE USE | | | MINIMUM TEST FREQUENCY |
|---|---|---|---|---|---|
| | | POREWATER DRAIN | INFILTRATION DRAIN | GAS VENTING LAYER | |
| Ply Adhesion, lb/in (min. avg.) | ASTM D413 | 0.5 | 0.5 | 0.5 | 35, 000 $ft^2$ |
| Transmissivity[1,2], $m^2$/sec. (min.) | ASTM D4716 | TBD | TBD | TBD | 500,000 $ft^2$ |
| Maximum Normal Load[2] | NA | TBD | TBD | TBD | 35, 000 $ft^2$ |

Note 1: A single transmissivity test must be conducted by the OWNER on each Type of Geocomposite prior to delivery of the material, under the following general conditions:

- Layering/Adjacent materials - as per design;
- Flow direction – based on proposed orientation in the field:
- Load stepping for cases where GCL is used adjacent the geocomposite;
- Seating time – 100 hours at maximum normal load; and,
- Gradients – Above specified transmissivity required at a gradient of 0.02. Report flow measurements at 0.02, 0.05, 0.10 and 0.33

Note 2: Required Transmissivity and Maximum Normal Load to be specified in construction documents submitted to NYSDEC a minimum of 90 days before construction.

B. The GEOSYNTHETICS CONTRACTOR shall coordinate with the ENGINEER the delivery of the geocomposite samples required for the OWNER'S transmissivity testing.

## 2.5 FASTENERS

A. Geocomposite panel connections shall be secured with fasteners. Fasteners shall be locking plastic ties approximately six inches long, and the tensile strength shall be greater then a geonet strand, as confirmed by the ENGINEER in a field test. Fasteners shall be leachate compatible and shall not be capable of damaging adjacent geosynthetic materials. Fasteners shall be of a color that contrasts with the color of the geonet core. Samples of the fasteners shall be submitted to the ENGINEER for approval prior to use. Metallic ties shall not be used.

## 2.6 SEWING THREAD/NEEDLES

A. The upper geotextile of the geocomposite panels are to be joined by sewing, and shall be sewn only as approved by the ENGINEER.

B. Sewing thread shall consist of high strength polypropylene or polyester.

C. Materials, means and methods for sewing adjoining panels shall be as approved by the ENGINEER.

D. The GEOSYNTHETICS CONTRACTOR shall develop, and the ENGINEER shall approve, a plan to account for sewing needles used in the joining of the geocomposite in order to prevent lost or broken needles from damaging the adjacent geomembrane liner(s).

## PART 3 EXECUTION

### 3.1 SURFACE PREPARATION

A. The surface to be covered by the geocomposite shall be cleared of loose soil, sharp objects, stones, sticks, or any materials that may contribute to clogging, punctures, shearing, rupturing, or tearing of the geosynthetic materials. The geocomposite subgrade shall have a smooth, finished surface, free from pockets, holes, ruts, and discontinuities that will cause bridging of the material in the judgment of the ENGINEER. All soil subgrade to be covered by geocomposite shall be inspected for unstable areas or soft spots before the geocomposite is placed and additional surface preparation may be required to eliminate any unsuitable areas as determined by the ENGINEER.

### 3.2 INSTALLATION

A. The GEOSYNTHETICS CONTRACTOR shall install the Geocomposite materials to the lines and grades shown on the Construction Drawings in accordance with this Section and the Manufacturer's recommendations. Geocomposite panels shall be deployed in a manner that will not damage the geocomposite or underlying materials, and that will minimize wrinkling.

B. The Geocomposite materials shall be deployed in a manner that will limit the placement of cross seams (seams perpendicular to the slope direction). No cross seams shall be permitted on slopes greater than 25% unless the slope length exceeds the manufactured roll length.

C. All cross seams shall be shingled downslope, and all side seams (along panel length) shall be shingled in the same direction along the width of the slope.

D. Panels shall be joined along all edges by sewing the upper geotextile, tieing the net in a net to net contact, and overlapping the lower geotextile. For side-seams, panels shall be overlapped a minimum of 6-inches. Cross seams shall be overlapped a minimum of 12-inches. The geonet core shall be secured with approved plastic fasteners. The fasteners, after installation, shall be positioned in a way as not to damage the overlying GCL or underlying geomembrane.

1. The adjacent panels at side-seams shall be fastened with approved plastic fasteners at a spacing of 1 fastener every 5 feet of panel overlap, except on the top of the perimeter berm where the fasteners shall be spaced at six inches. Adjacent panels at side-seams on slopes greater than 25% will be tied every twelve inches. The adjacent panels at cross seams shall be fastened every 12-inches on slopes less than 25%; on slopes greater than 25%, there shall be a double row (six-inches apart) of ties at a spacing of twelve inches.

2. Geocomposite panels shall be staggered such that cross seams between adjacent panels are not continuous. Cross seams shall be offset a minimum of ten feet.

3. Overlaps for all seams oriented perpendicular to the flow path shall be achieved by pulling back the upper geotextile of the lower geocomposite, and the lower geotextile on the upper geocomposite. The adjoining geonet cores shall be shingled down slope with a minimum twelve-inch overlap. The upper geotextiles shall be rejoined by sewing, as approved by the ENGINEER.

E. The upper geotextile of adjacent geocomposite panels shall be joined by sewing. For sewn seams, the geotextile shall be overlapped a minimum of four inches, or as required by the sewing method approved by the ENGINEER.

F. Welding of the geonet to the geomembrane shall not be permitted.

G. The work shall be scheduled so that the geocomposite is covered within 30 days after placement. Failure to comply with this requirement will require replacement of the geocomposite unless the GEOSYNTHETICS CONTRACTOR demonstrates, to the satisfaction of the ENGINEER, the material has not been adversely affected.

H. Smoking is not permitted on any geosynthetic material.

I. The GEOSYNTHETICS CONTRACTOR shall be responsible for the protection of the geomembrane during the installation of the geocomposite drainage layer. In no way shall any tracked equipment, or any other equipment which may pose a risk of puncturing, tearing, or otherwise damaging the geosynthetics, be permitted for use during this phase of construction.

J. Wheeled vehicle traffic is prohibited above the geocomposite. Low ground pressure vehicles only will be allowed to traverse any geocomposite covered with a foot of soil. There must be at least three feet of cover material provided before any equipment with wheels is allowed to pass over the geocomposite.

## 3.3 REPAIRS

A. Any holes or tears in the geocomposite shall be repaired using material obtained from rolls approved by the ENGINEER for use at the site.

B. Patching of the geocomposite shall be accomplished by tying the geonet at a minimum of four locations, but not exceeding an interval of six-inches, and sewing the upper geotextile as approved by the ENGINEER. All approved patches shall extend a minimum of 6 inches in all directions from the edge of the defect.

## PART 4 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

### 4.1 GENERAL

A. Before installation begins, and weekly thereafter, (more often if determined necessary by the ENGINEER) project coordination meetings shall be held with the designated representative of the NYSDEC (if inclined), GEOSYNTHETICS CONTRACTOR, ENGINEER, and OWNER in attendance to review the following information:

1. Progress of the work;

2. Adherence to the Specifications;

3. Adherence to the Construction Quality Control Program described in this Section, including the timely submission of the pertinent forms;

4. Planned work and methods for the ensuing week, including estimate of time remaining to completion of the work; and,

5. Problem resolutions to be implemented during the upcoming week.

B. All information specified and required must be submitted to the PROJECT ENGINEER in a timely fashion.

C. Any changes in the proposed method of work, SUBCONTRACTORS to be utilized, manufacturing, or materials must be approved in advance by the ENGINEER. The GEOSYNTHETICS CONTRACTOR assumes all responsibility relevant to providing an acceptable product.

### 4.2 INSTALLATION QA/QC

A. The ENGINEER and GEOSYNTHETICS CONTRACTOR shall visually inspect all materials to be included in the work, and compare roll identification numbers with those provided by the manufacturer to assure installation of the approved materials. No material shall be installed prior to furnishing the required test results.

B. All panel seams shall be inspected and approved by the ENGINEER.

C. The ENGINEER shall obtain conformance samples across the entire width of the geocomposite rolls. Conformance testing will be completed by the ENGINEER in accordance with the project CQA/CQC Plan. The GEOSYNTHETICS CONTRACTOR shall, at no additional cost to the OWNER, provide whatever reasonable assistance the ENGINEER may require in obtaining the samples. Unless otherwise specified, samples shall be three feet long by the roll width, and shall not include the outer wrap. The ENGINEER shall mark the machine direction on the samples with an arrow.

D. Non-conforming material shall not be used in the work. In the event non-conforming results are obtained from the laboratory, the nearest numbered rolls on each side of the non-conforming roll shall be sampled and tested for the full suite of conformance tests, until the extent of non-conformance is established. The OWNER reserves the right to reject the lot of rolls at any stage of extended sampling and testing.

E. Conformance testing will be at the expense of the OWNER, unless the test shows the geocomposite drainage material and/or its components do not comply with the Specifications, in which case the GGEOSYNTHETICS CONTRACTOR shall pay all sampling and testing cost. The GEOSYNTHETICS CONTRACTOR shall be solely responsible for the quality of the material provided. Should any of the tests performed on the material yield unsatisfactory results, the GEOSYNTHETICS CONTRACTOR will be responsible for replacing the material with satisfactory materials without delay to the project or cost to the OWNER.

F. Damage to the geocomposite materials during installation shall be repaired according to Article 3.3. If the ENGINEER determines the damage is un-repairable, the damaged material will be replaced.

G. The geotextiles shall be heat-bonded over the entire surface of the geonet. If a significant portion of the upper or lower geotextile, as determined by the ENGINEER, is not bonded to the surface of the geonet, the ENGINEER shall reject the questionable portion of the roll, or require the unbonded area to be cut out and replaced in accordance with the requirements of this Specification.

## 4.3 WARRANTY

A. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the installation of geocomposite drainage layer material for a minimum period of 1 year.

B. The GEOSYNTHETICS CONTRACTOR shall issue a warranty on the geocomposite material for a minimum period of 1 year.

END OF SECTION

# SECTION 02600

# GEOGRIDS

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. The Manufacturer shall furnish all materials, equipment, tools and appurtenances required to complete the installation of all geogrids and geotextiles used to reinforce and stabilize soil as shown, specified or required.

### 1.2 RELATED SECTIONS

A. Section 02222 - Subgrade

B. Section 02224 – Structural Fill

C. Section 02233 – Bedding and Backfill

D. Section 02595 – Geotextile

E. Section 02836 – MSE Baskets

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D123-09 Standard Terminology Relating to Textiles
2. D792-08 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
3. D1248-05 Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable
4. D1388-08 Standard Test Method for Stiffness of Fabrics
5. D1505-03 Standard Test Method for Density of Plastics by the Density-Gradient Technique
6. D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700kN-m/m$^3$))
7. D2455-89(1996)e1 Standard Test Method for Identification of Carboxylic Acids in Alkyd Resins (Withdrawn 2005)

8. D3776/3776M-09a Standard Test Methods for Mass Per Unit Area (Weight) of Fabric

9. D4101-09 Standard Specification for Polypropylene Injection and Extrusion Materials

10. D4354-99 (2009) Standard Practice for Sampling of Geosynthetics for Testing

11. D4355-07 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus

12. D4439-04 Standard Terminology for Geosynthetics

13. D4595-09 Standard Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method

14. D4603-03 Standard Test Method for Determining Inherent Viscosity of Poly(Ethylene Terephthalate)(PET) by Glass Capillary Viscometer

15. D4759-02(2007) Standard Practice for Determining the Specification Conformance of Geosynthetics

16. D5261-92(2009) Standard Test Method for Measuring Mass per Unit Area of Geotextiles

17. D5262-07 Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics

18. D5321-08 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

19. D5818-06 Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics

20. D6637-01(2009) Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

21. D6706-01(2007) Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil

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

23. G22-76(1996)(Withdrawn 2001) Standard Practice for Determining Resistance of Plastics to Bacteria

B. Environmental Protection Agency (EPA):

1. Test Method 9090A Compatibility Test For Wastes and Membrane Liners

C. Federal Highway Administration (FHWA):

1. FHWA Publication No FHWA-NH1-00-043 Mechanically Stabilized Earth Walls and Construction Guidelines, March 2001

2. FHWA Publication No FHWA-RD-97-144 Testing Protocols for Oxidation and Hydrolysis of Geosynthetics

D. Geosynthetic Research Institute (GRI):

1. GRI GG1 Geogrid Rib Tensile Strength

2. GRI GG2 Geogrid Junction Strength

3. GRI GG4(b) Determination of the Long-Term Design Strength of Flexible Geogrids

4. GRI GG7 Carboxyl End Group Content of PET Yarns

5. GRI GG8 Determination of the Number Average Molecular Weight of PET Yarns Based on a Relative Viscosity Value

6. GRI GT7 Determination of Long-Term Design Strength of Geotextiles

### 1.4 THE MOST CURRENT VERSION OF THE SPECIFIED TEST METHOD SHALL BE FOLLOWED BY THE MANUFACTURER, EARTHWORK CONTRACTOR OR AUTHORIZED TESTING LABORATORY.TOLERANCES

A. The horizontal and vertical alignment tolerance, and Certification Survey requirements, is as described in Appendix B

B. The elevation and inclination tolerance, and Certification Survey requirements, is as described in Appendix B.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

A. Acceptable Manufacturers include Miragrid, Huesker, Stratagrid, and Tensar. Requests for substitutions will be considered if supported with adequate documentation of equivalence.

B. Provide all materials for Primary and Secondary Reinforcing from a single manufacturer. Near Face reinforcement can be supplied from a separate manufacturer.

## 2.2 GEOGRIDS

A. Primary Reinforcement

1. Open area: 60 percent minimum

2. Long-term allowable design loads ($T_{AL}$) as shown in Attachment F-1 of the Engineering Report.

   a. $T_{AL}$ to consider reductions for creep, chemical and biodegration, and installation damage

   b. Service time to be 100 year minimum

   c. Backfill will be structural fill (refer to Section 02224) or Number 1, Number 2 and Number 4 stone (refer to Section 02233) as shown in the Construction Drawings

## 2.3 PRE-APPROVAL SUBMITTALS

A. Manufacturer shall submit manufacturer's information for each type and strength of geosynthetic product to be used. Submittal shall contain quality control testing and manufacturer control procedures. At a minimum the following shall be submitted:

1. The primary resin used in manufacturing shall be identified as to its ASTM type, class, grade, and category.

   a. For HDPE resin type, class, grade and category in accordance with ASTM D-1248 shall be identified. For example type III, class A, grade E5, category 5.

**HIGH DENSITY POLYETHYLENE (HDPE) MQA MINIMUM TESTING**

| PROPERTY | TEST METHOD | REQUIRED VALUE | UNITS |
|---|---|---|---|
| Density (allowable range) | ASTM D1505/D792-08 | Report Value | g/mol |

   b. For PP resins, group, class and grade in accordance with ASTM D-4101 shall be identified. For example group 1, class 1, grade 4.

   c. For Polyester (PET) resins minimum production intrinsic viscosity (ASTM-4603) and maximum carboxyl end groups (ASTM D-2455) shall be identified.

**POLY(ETHYLENE TEREPHTHALATE) (PET) MQA MINIMUM TESTING**

| PROPERTY | TEST METHOD | REQUIRED VALUE | UNITS |
|---|---|---|---|
| Hydrolysis Resistance (min.) | GRI GG8/ASTM D4603 | Report Value | g/mol |
| Carboxyl End Group (max.) | GRI GG7/ASTM D2455 | Report Value | Meq/kg |

d. For all products the minimum UV resistance as measured by ASTM D-4355 shall be identified.

2. The adequacy of the data in support of allowable strength ($T_a$) for geosynthetic reinforcements including:

   a. Laboratory test results documenting creep performance over a range of load levels for minimum duration of 10,000 hr. in accordance with ASTM D-5262.

   b. Laboratory test results and methodology for extrapolation of creep data for 75- and 100- year design life.

   c. Laboratory test results documenting ultimate strength in accordance with ASTM D-4595, or GRI-GG1 for geogrids. Tests to be conducted at a strain rate of 10 percent per minute.

   d. Laboratory test results and extrapolation techniques, documenting the hydrolysis resistance of PET, oxidative resistance of PP and HDPE, and stress cracking resistance of HDPE for all components of geosynthetic and values for partial factor of safety for aging degradation calculated for a 75- and 100-year design life. Recommended methods are outlined in FHWA RD 97-144.

   e. Field and laboratory test results along with literature review documenting values for partial factor of safety for installation damage as a function of backfill gradation.

   f. Laboratory tests documenting pullout interaction coefficients for various soil types or site specific soils in accordance with GRI: GG5 and GT7.

   g. Laboratory tests documenting direct sliding coefficients for various soil types or project specific soils in accordance with ASTM D-5321

3. The adequacy of the QA/QC plan for the manufacture of geosynthetic reinforcements. Including at a minimum:

   a. Manufacturing quality control program and data indicating minimum test requirements, test methods, test frequency, and lot size for each product. The following is a minimum list of criteria required for approval:

| **PROPERTY** | **TEST METHOD** | **Miragrid 20XT** | **Miragrid 22XT** | **MIN TEST FREQUENCY(1) (sq. ft.)** |
|---|---|---|---|---|
| Tensile Strength at Ultimate | ASTM D6637 | 13,705 lbs/ft | 20,559 lbs/ft | 150,000 |
| Tensile Strength at 5% Strain | ASTM D6637 | 5,340 lbs/ft | 6,700 lbs/ft | 150,000 |
| Creep Reduced Stength | ASTM D5262 | 8,674 lbs/ft | 13,012 lbs/ft | 150,000 |

| | | | | |
|---|---|---|---|---|
| Long Term Allowable Design Load[(2)] | GRI GG-4(b) | 7,510 lbs/ft | 11,266 lbs/ft | 150,000 |

Notes:
1. One test minimum to be performed on each geogrid product.
2. Long Term Allowable Design Strength values are for sand, silt and clay.

### 2.4 CONSTRUCTION SUBMITTALS

A. The Manufacturer shall submit a manufacturer's certification that the geosynthetics supplied meet the respective index criteria set when the geosynthetic was approved by the owner, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Engineer can require the Manufacturer to supply test data from an agency approved laboratory to support the certified values submitted, at the Manufacturer's cost.

## PART 3 EXECUTION

### 3.1 DELIVERY, STORAGE, AND HANDLING

A. Geosynthetics shall be unloaded and inspected for damage prior to storing on level ground or pallets. The Earthwork Contractor shall protect the work described in this Section before, during, and after installation, and shall protect the installed work covered by other Sections.

B. The Manufacturer/Earthwork Contractor shall, during all periods of shipment and storage, protect the geosynthetics from direct sunlight, ultraviolet rays, temperatures greater than 120°F, mud, dirt, dust, debris and other deleterious sources.

C. If the Engineer determines material is damaged the Manufacturer/Earthwork Contractor shall immediately make all repairs and replacements, at no additional cost to the Owner.

### 3.2 INSTALLATION

A. The geosynthetic reinforcement shall be installed in accordance with the manufacturer's recommendations, unless otherwise modified by these specifications. The geosynthetic reinforcement shall be placed within the layers of the compacted soil as shown on the Construction Drawings or as directed.

B. The geosynthetic reinforcement shall be placed in continuous longitudinal strips in the direction of main reinforcement. Joints in the design strength direction (perpendicular to the slope) shall not be permitted.

C. Horizontal coverage of less than 100 percent shall not be allowed unless specifically detailed in the Construction Drawings. In the case of 100% coverage in plan view adjacent strips need not be overlapped.

D. Adjacent rolls of geosynthetic reinforcement shall be overlapped or mechanically connected where exposed in a wrap-around face system, as applicable.

E. Place only that amount of geosynthetic reinforcement required for immediately pending work to prevent undue damage. After a layer of geosynthetic reinforcement has been placed, the next succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geosynthetic reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geosynthetic reinforcement and soil.

F. Geosynthetic reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geosynthetic reinforcement has been placed, suitable means, such as pins or small piles of soil, shall be used to hold the geosynthetic reinforcement in position until the subsequent soil layer can be placed. Under no circumstances shall a track-type vehicle be allowed on the geosynthetic reinforcement before at least nine inches of soil has been placed. Sudden braking and sharp turning – sufficient to displace fill – shall be avoided.

G. During construction, the surface of the fill should be kept approximately horizontal. Geosynthetic reinforcement shall be placed directly on the compacted horizontal fill surface. Geosynthetic reinforcements are to be placed within three inches of the design elevation and extend the length as shown on the elevation view unless otherwise directed by the Owner's Engineer. Correct orientation of the geosynthetic reinforcement shall be verified by the Earthwork Contractor/Earthwork Surveyor.

## 3.3 FILL PLACEMENT

A. MSE Structural fill shall be compacted as specified by project specifications or to at least 90 percent of the maximum density determined in accordance with ASTM D1557, whichever is greater. Moisture contents shall be controlled to be between Optimum +1% and Optimum -3% as determined by the aforementioned test.

B. Density testing shall be made in accordance with the Project CQA/CQC Plan.

C. Backfill shall be placed, spread, and compacted in such a manner to minimize the development of wrinkles and/or displacement of the geosynthetic reinforcement.

D. Fill shall be placed in nine inch maximum lift thickness where heavy compaction equipment is to be used, and three inch maximum uncompacted lift thickness where hand operated equipment is used.

E. Backfill shall be graded away from the slope crest and rolled at the end of each work day to prevent ponding of water on surface of the reinforced soil mass.

F. Tracked construction equipment shall not be operated directly upon the geosynthetic reinforcement. A minimum fill thickness of nine inches is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and the geosynthetic reinforcement.

G. If approved by the Engineer, rubber-tired equipment may pass over the geosynthetic reinforcement at speeds of less than five miles per hour. Sudden braking and sharp turning shall be avoided.

H. Self propelled compaction equipment and construction equipment such as dump trucks, non low pressure dozers etc shall be kept away from the face of the berm. None of the above equipment shall operate within the granular fill zone (four feet from front of MSE berm face). A vibrating plate compactor shall be used to compact the granular fill.

### 3.4 FINAL SLOPE GEOMETRY VERIFICATION

A. Earthwork Contractor/Earthwork Surveyor shall confirm that as-built slope geometries conform to approximate geometries shown on construction drawings.

## PART 4 FIELD QUALITY CONTROL

### 4.1 STRUCTURAL FILL MATERIAL

A. Soil Testing

1. Perform soil testing in accordance with the Project CQA/CQC Plan.

B. In-place Soil Moisture-Density Testing

1. Perform in place density testing, ASTM 6938, at the frequency described in the Project CQA/CQC Plan.

### 4.2 GEOREINFORCEMENT

A. Inspect all rolls as deployed for damage.

B. Monitor placement of fill and geosynthetics.

C. Perform check for tolerance with design geometry by survey.

**END OF SECTION**

# SECTION 02650

# POLYVINYL CHLORIDE (PVC) PIPE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Work covered by this Section includes the requirements, materials, and methods for installing PVC piping, appurtenances, and fittings, as shown on the Drawings.

B. The CONTRACTOR shall furnish and install the various pipelines and appurtenant work as indicated in the Drawings and as specified herein, or as reasonably required to produce a complete, proper, and functional installation in accordance with the intent of the design.

### 1.2 RELATED SECTIONS

A. Section 02223 - Common Trench Backfill

B. Section 02233 - Bedding and Backfill

C. Section 02595 - Geotextile

### 1.3 DELIVERY, STORAGE, AND HANDLING

A. The CONTRACTOR and PROJECT ENGINEER shall inspect the pipe shipment upon arrival to identify any apparent damage to the pipe and to verify and document that the proper pipe has been received by recording the pipe designations marked on the pipe and by spot measuring the pipe inside diameter (ID) and outside diameter (OD).

B. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skids in a manner to avoid shock or impact. Chains, cables, or hooks shall not be inserted into the pipe end.

C. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches or when handling the pipes. The CONTRACTOR shall take measures to avoid damaging the pipe.

D. The pipe shall be stored on a hard, clean, well drained and near level surface. The pipe may be set on wooden sleepers and shall not be stacked more than four feet high. When pipe is stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. All pipes, fittings, and appurtenances to be used in this work shall be handled with extreme care. Proper and suitable tools and appliances for safe convenient handling and laying of the pipes shall be used.

F. PVC pipe and fittings shall be protected from damage by sharp objects through all phases of work.

G. If any defective pipe is discovered after being laid or placed, removal and replacement with a sound pipe will be required without cost to the OWNER.

# PART 2 MATERIALS

## 2.1 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

A. All PVC piping shall be perforated or solid wall PVC pipe as required and shown on the Drawings. The size of the pipe and any perforation design shall be as specified.

B. All pipe fittings shall be of the same schedule, or greater, as the adjoining pipe, except for transition or special couplers as noted on the Drawings.

C. Pipe and fittings of the same type shall be the products of a single manufacturer or as approved by the PROJECT ENGINEER.

D. If required, PVC primers conforming to ASTM F656, and PVC solvent cement conforming to ASTM D2564 shall be used for socket type connections as shown on the Drawings.

# PART 3 EXECUTION

## 3.1 INSPECTION

A. Each length of pipe and each fitting shall be carefully inspected prior to installation. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the PROJECT ENGINEER, shall be rejected and immediately marked and removed from the job site by the CONTRACTOR.

B. Bedding and other trench conditions shall be carefully inspected prior to laying pipe in each stretch of open trench. All conditions shall be made available to the PROJECT

ENGINEER for inspection purposes, and the PROJECT ENGINEER shall be further advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Each stretch of completed pipeline shall be inspected prior to backfilling. Backfilling operations shall not be initiated prior to inspection by the PROJECT ENGINEER.

## 3.2 PREPARATION

A. All pipes and fittings shall be maintained in a clean condition before, during, and after installation. Pipe and fitting interiors and joint surfaces, shall be thoroughly inspected prior to installation to verify the all loose soil, debris or other foreign materials have been removed from the pipe prior to joining and burial.

## 3.3 PIPE INSTALLATION

A. Pipe installation shall be performed by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

B. Pipe shall be accurately installed to the lines and grades shown in the Drawings, or as approved by the PROJECT ENGINEER, so that inverts are smooth. Each pipe length, or 20 foot run, whichever is less shall be field checked for grade and alignment during installation.

C. Deflections in horizontal or vertical alignment at joints are not permitted without the consent of the PROJECT ENGINEER. If so approved, the deflections shall not exceed the manufacturer's recommendation.

D. When requested by the PROJECT ENGINEER, a qualified field representative of the manufacturer shall be present at the job site for the first day of pipe laying to assure that proper procedures are followed, and during leakage testing (as applicable).

E. The PROJECT ENGINEER shall be notified in advance whenever an existing pipeline location conflicts with the proposed locations of the work.

F. Pipe Adapters - Join pipes of different materials with adapters specifically manufactured for that purpose and as approved by the PROJECT ENGINEER, or as detailed in the Drawings.

G. All piping shall be of the type and size as shown in the Drawings and described in this Section of the Specifications.

H. Pipes and fittings shall be carefully lowered into the trench.

I. Pipe and fittings shall be installed so that there will be no excess deviation at the joints and so that inverts present a smooth surface. Pipe and fittings that do not mate to form a tight fitting joint are not permitted.

J. Excavations shall be maintained substantially free of water during pipe installation. No pipes shall be laid in soils that have become softened due to water exposure, or in water, nor shall there be any joints made up in water. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the PROJECT ENGINEER.

K. Cleanliness of installed pipe and fitting interiors shall be maintained throughout the work.

L. Adjustments to the line and grade of pipe shall be done by scraping away or filling of bedding stone under the barrel of the pipe, and not by blocking or wedging.

M. Fittings shall be installed as required and in accordance with the Drawings and Specifications. The installation of fittings after the pipeline has been laid will not be permitted without the approval of the PROJECT ENGINEER. In such cases, details pertaining to the proposed type of fittings and the installation procedure shall be submitted by the CONTRACTOR to the PROJECT ENGINEER for review.

N. Approval by the PROJECT ENGINEER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without a written consent from the PROJECT ENGINEER.

O. All installed piping shall form completely connected systems including connections to appurtenances specified in other sections to result in a satisfactorily operating installation.

P. Perform field cutting of pipe with the use of a fine-toothed hacksaw, a handsaw, sawz-all, or a circular saw providing square ends for proper joints. Cut ends shall be beveled in accordance with manufacturer's instructions.

Q. All pipe ends not terminated by another specific fitting shall be capped with a slip cap or as directed by the PROJECT ENGINEER. Caps shall not be bonded to the pipe unless otherwise specifically noted in the Drawings.

R. Unless otherwise specified, pipe ends shall be temporarily capped and sealed securely to ensure no water or soil intrusion, pending future connection.

END OF SECTION

# SECTION 02660

# HIGH DENSITY POLYETHYLENE PIPE

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Work covered by this Section includes the requirements, materials, and methods for installing High Density Polyethylene (HDPE) leachate collection and transfer piping, siderisers and sumps, landfill gas piping, groundwater drain piping, fittings and appurtenances, as shown on the Drawings.

B. The CONTRACTOR shall furnish and install the various pipelines and appurtenant work as indicated in the Drawings and as specified herein, or as reasonably required to produce a complete, proper, and functional installation in accordance with the intent of the design.

### 1.2 RELATED SECTIONS

A. Section 02223 – Common Trench Backfill

B. Section 02233 – Bedding and Backfill

C. Section 02240 – Leachate Drainage Layer

### 1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

2. F2164 Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure

3. F2634 Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method

B. Code of Federal Regulations (CFR):

1. DOT 49 CFR 192.283 Research and Special Programs Administration, Department of Transportation – Part 192 – Transportation of Natural and Other

Gas by Pipeline: Minimum Federal Safety Standards 192.283 – Plastic Pipe: Qualifying Joining Procedures

## 1.4 DELIVERY, STORAGE, AND HANDLING

A. The CONTRACTOR and PROJECT ENGINEER shall inspect the pipe shipment upon arrival to identify any apparent damage to the pipe and to verify and document that the proper pipe has been received by recording the pipe designations marked on the pipe and by spot measuring the pipe inside diameter (ID) and outside diameter (OD).

B. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skids in a manner to avoid shock or impact. Chains, cables, or hooks shall not be inserted into the pipe end. The pipe and fittings shall not be dropped during any phase of the work.

C. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches or when handling the pipes.

D. The pipe shall be stored on a hard, clean, well drained and near level surface. The pipe may be set on wooden sleepers, spaced suitably and of such a width as not to allow deformation of the pipe at the point of contact with the sleeper or between the supports. Stacking of the pipe shall be limited to a height that will not cause excessive deformation of the pipe under anticipated temperature conditions. When pipe is stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. For convenience of handling, HDPE pipe is best protected from sunlight exposure to prevent bending of the pipe caused by uneven heating. Such protection typically consists of canvas covering, or other material as recommended by the manufacturer and approved by the PROJECT ENGINEER.

F. HDPE pipe and fittings shall be protected from damage through all phases of work.

G. Pipe products which are cracked, chipped, dented or gouged for a depth greater than 10% of the pipe wall thickness, or are otherwise damaged will not be approved for installation.

# PART 2 MATERIALS

## 2.1 HIGH-DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

A. All HDPE pipe and fittings shall be closed profile (smooth exterior wall) outside diameter product manufactured from virgin polyethylene resin. The resin shall be PE3408 conforming to ASTM D3350.

B. All polyethylene fittings shall have a pressure rating equal to or higher than the design pressure rating of the system. Pipe and fittings of the same type shall be products of a single manufacturer, or as approved by the PROJECT ENGINEER.

C. The size, perforation design (if necessary), and dimension ratio of HDPE pipe and fittings shall be as shown on the Drawings.

D. All piping and valves shall be supported as required to provide a structurally sound installation.

E. Electrofusion couplings may be used where typical fusion welding is impractical, subject to the approval of the PROJECT ENGINEER.

# PART 3 EXECUTION

## 3.1 INSPECTION

A. Each length of pipe and each fitting shall be carefully inspected prior to placement in the work. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the PROJECT ENGINEER shall be rejected, and will be marked by the PROJECT ENGINEER for removal from the job site by the CONTRACTOR.

B. Damaged pipe or fittings must be inspected and evaluated to determine if the damage impairs serviceability. For pressure piping systems, damage or butt fusion misalignment in excess of 10% of the minimum wall thickness required for pipeline operating pressure may be significant. If the pipeline is to operate at the maximum permissible pressure for the material and Dimension Ratio, the damage allowance is 10% of the pipe minimum wall thickness. If the pipeline is to operate at atmospheric pressure, the damage allowance is 15% of the pipe minimum wall thickness. If the pipe is to operate at lower pressure, damage depth may be greater. The shape of the damage must also be considered. For small damage areas where the depth is not excessive, sharp notches and cuts should be dressed smooth so the notch is blunted. Blunt scrapes or gouges less than the permissible depth will not require attention. Pipe or fittings that have sustained service impairing damage shall not be installed. Post-installation damage that exceeds

the allowable shall require that the damaged pipe or fitting be removed and replaced. Scrapes or gouges cannot be repaired by filling-in with extrusion or hot air welding.

C. Bedding, subgrade, and other trench conditions shall be carefully inspected prior to laying pipe. All pipe bedding and trench conditions shall be made viewable and accessible to the PROJECT ENGINEER for inspection purposes. The PROJECT ENGINEER shall be advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

D. Backfilling operations shall not be initiated by the CONTRACTOR prior to inspection of the pipe bedding and trench conditions by the PROJECT ENGINEER.

E. If any defective pipe is discovered subsequent to placement in the trench or partial burial, the pipe shall be removed and replaced with good quality pipe.

## 3.2 PREPARATION

A. Pipe and fitting interiors, joint surfaces and gaskets shall be thoroughly inspected prior to installation. Pipes and fittings shall be maintained in a clean condition. A clean cotton cloth shall be employed for cleaning; polyester materials shall not be used.

## 3.3 HDPE PIPE JOINING

A. The preferred method for joining HDPE pipe shall be the butt-fusion method, producing a uniform and monolithic pipe in accordance with the butt fusion joining procedures provided by the pipe manufacturer. Electrofusion or mechanical joints may be used where butt fusion welding is impractical, subject to the approval of the PROJECT ENGINEER. Extrusion welding or other means of joining HDPE pipe methods will not be permitted without the approval of the PROJECT ENGINEER. The CONTRACTOR shall submit the Manufacturer's standard operating procedures for all proposed pipe joining operations to the PROJECT ENGINEER for approval before work is initiated.

B. Randomly selected primary (carrier) pipe joints will be inspected and approved by the PROJECT ENGINEER prior to installing piping. All containment piping joints shall be visually inspected and approved by the PROJECT ENGINEER after pipe placement and temporary backfill.

C. The CONTRACTOR must consider ambient temperature when connections are to be made between two fixed points or structures in the work to compensate for the expansion and contraction potential of the pipe. Pipe length considerations shall be in accordance with the HDPE pipe manufacturer's guidelines.

D. Each individual performing fusion welding shall be certified by the Manufacturer to operate the butt fusion and electrofusion equipment through appropriate training in the use of the procedure. This certificate must be submitted to the PROJECT ENGINEER

prior to welding operations. Each individual must make a specimen joint from pipe sections joined according to the procedure that passes the inspection and test set forth below:

1. The individual must make a sample joint that passes the following inspections and tests, to be performed by the PROJECT ENGINEER:

    a. The joint must be visually examined during and after joining and found to have the same appearance as a photograph or sample of an acceptable joint, made in accordance with the accepted standards and procedures.

    b. The joint must be tested or examined by one of the following methods:

        i. Pressure and tensile test as described in 49 CFR Part 192.283.

        ii. Ultrasonic inspection, found to be free of flaws that would cause failure.

        iii. Butt-Fusion bend back test, as follows:

            - Allow the joint to cool for at least one hour before subjecting the pipe to a severe bond test;

            - Cut at least 3 longitudinal straps, 1-inch wide through the pipe joint such that a minimum of 12-inches of pipe remains on each side of the joint;

            - Hold each strap at the ends, bend the sample until the ends touch. (A vice or other mechanical device may be used.);

            - Maintain each sample in the bent position, and thoroughly examine the entire fusion area. If any separation, cracks or voids are observed, the joint is defective; and,

            - A joint is considered satisfactory if all bent samples are completely free of cracks or voids in the fusion area.

## 3.4 PIPE INSTALLATION

A. Skilled workers shall complete the pipe installation, with each pipe laying crew assigned a foreman in charge. The worker performing the welding (butt fusion and electrofusion) shall be certified by the pipe manufacturer.

B. Pipe shall be accurately installed to the lines and grades shown in the Drawings, or as approved by the PROJECT ENGINEER, so that inverts are smooth. Each pipe length, or 20 foot run, whichever is less, shall be field checked for grade and alignment during installation. The tolerance of the pipe slope will be as identified in Appendix B.

C. The PROJECT ENGINEER shall be notified in the event an existing pipeline location or other structure conflicts with the proposed location of the work.

D. Pipe sections shall be joined at ground level to a length not longer than that recommended by the manufacturer such that maximum, allowable stress, when pulling the pipe into position alongside the trench, is not exceeded. Use appropriate materials and equipment, when pulling butt-fused pipe sections alongside the trench to prevent pipe damage. Temporary end caps or plugs shall be used as necessary when pulling pipe into position to prevent soil or other debris from entering the pipe barrel.

E. Pipe and fittings shall be carefully lowered into the trench.

F. Pipe and fittings shall be installed so that there will be no excess deviation at the joints and so that inverts present a smooth surface.

G. Excavations shall be maintained free of water during pipe installation. No pipes shall be laid in water nor shall there be any joints made up in water. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the PROJECT ENGINEER.

H. All adjustments to the line and grade of pipe shall be done by scraping away or compacted filling of the bedding under the barrel of the pipe, and not by blocking or wedging.

I. All installed piping shall form completely connected systems including connections to valves and appurtenances specified in other sections to result in a satisfactory operating installation.

J. All solid-walled HDPE piping shall be leak tested with the exception of the leachate sump side slope riser pipes, and landfill gas collection system piping. Leak testing shall be performed in accordance with Part 4 of this section.

## 3.5 HDPE DOUBLE-WALL PIPE INSTALLATION

A. The diameter and dimension ratio of HDPE carrier and containment pipe shall be shown on the Drawings.

B. All HDPE pipe to be installed as a dual containment piping system shall be supplied with HDPE centralizers for centering the carrier pipe within the containment pipe. The centralizers shall be manufactured from virgin polyethylene resin. The centralizers shall be installed by the pipe manufacturer or be suitable for field extrusion welding to the pipe at intervals recommended by the manufacturer. The HDPE centralizers and centralizer spacing shall be as approved by the PROJECT ENGINEER.

C. HDPE pipe and fittings within manholes shall be flanged and gasketed connections unless otherwise shown on the Drawings. Backing rings shall be carbon steel and be designed to conform to ANSI Class 150. All flanged connections shall use steel bolts of the same material as the backing rings unless otherwise shown on the Drawings.

D. Leak detection riser pipes shall be connected to the containment pipe at its low points, as shown on the Drawings. The pipe and fittings shall be solid-walled, 4-inch diameter, SDR 17 HDPE with a slip-on cap and lock with keys. The protective casings shall be painted with rust inhibitive exterior grade oil base paint, using a color approved by the OWNER.

E. Leak testing of both the carrier pipe and containment pipe shall be performed as specified in Part 4 of this section.

## PART 4 LEAK TESTING

### 4.1 GENERAL

A. The CONTRACTOR shall be responsible for providing hydrostatic and/or pneumatic leak testing of all solid-walled HDPE pipes outside the landfill liner system. All leak testing shall be completed in accordance with the requirements and procedures included in Technical Note 802 – Leak Testing, prepared by Performance Pipe of Chevron Phillips Chemical Company, LP.

B. Hydrostatic testing shall be completed in conformance with the requirements of ASTM F2164-02, the Standard Practice for Field Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure.

C. If pneumatic testing is proposed, the CONTRACTOR shall submit to the PROJECT ENGINEER, for approval, a written procedure that will be followed to test the system, and to secure the pipe system during the test. Temperature measurements must be made at appropriate locations to ensure adequate data for evaluation of test results.

D. The tests can be made prior to backfilling as long as the PROJECT ENGINEER performs continuous inspection of the backfill process. Alternately, continuous inspection of the backfilling by the PROJECT ENGINEER may be waived by the OWNER if leak testing is performed when the pipe bedding, pipe, fittings and appurtenances have been installed and the trench has been partially backfilled. If leak testing is performed after partial backfilling, the joints and fittings will be left exposed for inspection during the test. The CONTRACTOR shall replace failed sections of pipe and/or fittings at no additional cost to the OWNER.

E. For sections of pipe that include thrust blocks, the leak test will not be conducted sooner than five days following the placement of the concrete.

F. Ends of pipe sections being tested shall be tightly closed by plugs, blind flanges, gates or otherwise for the duration of the test. The CONTRACTOR shall furnish all such material, supplies, apparatus, labor, and equipment as necessary for carrying out the test, and shall make all necessary arrangements for securing and furnishing water for hydrostatic testing purposes. Any proposed changes to the specified test procedures in

this Section shall be submitted to and approved by the PROJECT ENGINEER prior to testing.

G. If the test pressure varies, or a significantly lower but constant test pressure is maintained, the PROJECT ENGINEER will examine the pipe for leakage. The CONTRACTOR shall repair all leaks. If no leakage is found, the test will be repeated following depressurization, and a relaxation period of no less than 8 hours. The re-testing program shall continue for a duration determined by the PROJECT ENGINEER, not to exceed 8-hours. The results of the re-testing program will be reviewed by the PROJECT ENGINEER to determine whether the variable and/or lower test pressure results are acceptable.

H. All exposed pipes, fittings, joints, and other appurtenances shall be carefully examined by the PROJECT ENGINEER during the test. All joints showing visible or audible leakage shall be repaired and made leak proof. Any cracked or defective pipe or fitting discovered as a result of the leak tests, shall be removed and replaced by the CONTRACTOR with new sound material, and the leak test shall be repeated until satisfactory results are achieved.

## 4.2 HYDROSTATIC LEAK TEST

A. Prior to hydrostatic testing, the pipe shall be cleared of debris and thoroughly flushed with clean water. Before applying the specified test pressure, the piping system (including fittings) must be adequately restrained against movement, and all air shall be expelled from the section being tested. Each section of the pipe to be tested shall be slowly filled with clean water and the test pressures shall be applied in a manner satisfactory to the PROJECT ENGINEER.

B. Water used in testing or flushing the piping system shall be approved by the PROJECT ENGINEER.

C. The test section shall be pressurized to 150 percent of the design pressure, or the pressure rating of the lowest pressure rated component in the test section, as determined by the PROJECT ENGINEER and as measured at the lowest elevation in the test section.

D. During the initial expansion phase make-up water shall be added each hour for three (3) hours to maintain pressure. The volume of make-up water added during the expansion phase shall be metered and recorded by the PROJECT ENGINEER. The allowable amount of make-up water required during the expansion phase shall conform to the table summarized below:

| NOMINAL PIPE SIZE (in) | 1 HOUR TEST (gal/100ft of pipe) | 2 HOUR TEST (gal/100ft of pipe) | 3 HOUR TEST (gal/100ft of pipe) |
|---|---|---|---|
| 2 | 0.07 | 0.11 | 0.19 |
| 3 | 0.10 | 0.15 | 0.25 |
| 4 | 0.13 | 0.25 | 0.40 |
| 6 | 0.3 | 0.6 | 0.9 |
| 8 | 0.5 | 1.0 | 1.5 |
| 10 | 0.8 | 1.3 | 2.1 |
| 12 | 1.1 | 2.3 | 3.4 |

E. The test phase shall immediately follow the initial expansion phase and shall be a minimum of one (1) hour, or a maximum of three hours in duration. During the test phase pressure shall not be increase and there shall be no make-up water added. The final pressure and the duration of the test shall be monitored and recorded.

F. If the pressure remains steady (within 5% of test pressure) and no visual leaks are observed during the test phase, the test section is considered passing.

G. The test section shall be slowly depressurized upon completion of the test.

## 4.3 PNEUMATIC LEAK TESTING

A. Compared to hydrostatic testing, testing the pipe system with compressed gas (pneumatic testing) can be more dangerous because failure during pneumatic testing releases more energy. If pneumatic testing is proposed, the pipe must be tested under partially buried conditions to stabilize and restrain the pipe, and to moderate temperature fluctuations. The CONTRACTOR shall submit to the PROJECT ENGINEER for approval, a written procedure that will be followed to secure the pipe fittings and appurtenants during the test, and maintain worker safety.

B. The testing medium shall be oil free, non-flammable, and non-toxic. The test pressure shall not exceed the maximum allowable test pressure for any non-isolated component in the test section.

C. Temperature gauges (0° to 100° C) shall be installed at the locations necessary to adequately and accurately measure the internal temperature of the test gas in the entire test section.

D. The pressure in the carrier pipe test section shall be gradually increased to not more than 50 percent of the design pressure (or 50% of the pressure rating of the lowest pressure rated component in the test section, whichever is lower), and then increased in small

increments until the test stabilizes within ±2 psig of the test pressure of 150% of the system design pressure for 60 minutes. To run the test, reduce the pressure to the system design pressure for such time required to determine if leaks exist, but no less than 60 minutes. If the test pressure remains within 10% of the target value for the duration of the test, no leakage is indicated.

E. For containment pipe the expansion phase pressure shall be 6 psig, and the test pressure shall be 5 psig. Test pressure for the containment pipe shall be maintained for at least 15 minutes.

F. At the conclusion of the test, depressurize the test section by a controlled release of gas from the test section.

**END OF SECTION**

# SECTION 02836

# MSE BASKETS

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Mechanically stabilized earth (MSE) wire baskets for facing.

B. Face Fill and Backfill.

### 1.2 RELATED SECTIONS

A. Section 02222 - Subgrade

B. Section 02224 – Structural Fill

C. Section 02233 – Bedding and Backfill

D. Section 02595 - Geotextile

E. Section 02600 - Geogrids

### 1.3 REFERENCES

A. AASHTO M288 - Standard Specification for Geotextiles.

B. AASHTO Standard Specification for Highway Bridges.

C. FHWA NHI-00-043 – Mechanically Stabilized Earth Walls and Reinforced Soil Slope Design and Construction Guidelines (Demonstration Project 82), March 2001.

D. FHWA Federal Highway Administration - Design Guidelines.

### 1.4 SUBMITTALS

A. Product Data: Manufacturer's data sheets on each product to be used, including:

1. Preparation instructions and recommendations.

2. Storage and handling requirements and recommendations.

3. Installation methods.

B. Shop Drawings: Engineering drawings, elevations, and large-scale details of elevations, typical sections, details, and connections.

1. Include design calculations sealed by a Registered Professional Engineer licensed in the State of New York, if the proposed design deviates from that shown in the contract drawings.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

### 1.5 QUALITY ASSURANCE

A. Pre-Construction Meeting: Prior to construction of retaining walls, conduct a meeting at the site with the retaining wall materials supplier, the retaining wall installer, and the Contractor to review the retaining wall requirements. Notify the Owner and the Engineer at least three days in advance of the time of the meeting.

### 1.6 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

Prevent excessive mud, fluid concrete, epoxy, or other deleterious materials from coming in contact with and affixing to retaining wall materials.

### 1.7 TOLERANCES

A. The horizontal and vertical tolerances for the MSE baskets and Certification Survey requirements are as described in Appendix B.

## PART 2 PRODUCTS

### 2.1 MATERIALS

A. Wire Mesh Facing Forms (MSE Baskets): MSE Baskets shall consist of hot dipped galvanized four inch by four inch welded Grade 65 steel wire forms. Diagonal steel struts shall consist of hot dipped galvanized Grade 65 steel wire. The manufacturer shall provide a Test Report certifying the baskets and struts were manufactured in

accordance with ASTM A1064 and galvanized in accordance with ASTM A123 and ASTM A153.

1. Wire Mesh Minimum Diameters: 0.19 inch, vertical wires and 0.24 inches horizontal wire (before galvanizing).

2. Wire Strut Minimum Diameter: 0.243 inch (before galvanizing).

3. Stainless steel hog rings to connect vertical wires of adjacent facing units.

# PART 3 EXECUTION

## 3.1 PREPARATION

A. Do not begin reinforced slope construction until excavation to foundation elevation has been completed and the foundation for the reinforced fill has been properly prepared.

B. If subgrade preparation is the responsibility of others, notify Engineer of unsatisfactory preparation. Do not begin work until unsatisfactory conditions have been rectified.

C. Excavation:

1. Excavate subgrade vertically to plan elevation and horizontally to designed geo-reinforcement lengths.

2. Geotechnical Engineer will inspect foundation area to ensure proper bearing strength.

3. Remove soils not meeting required strength and replace with Structural Fill.

## 3.2 CONSTRUCTION

A. Construct slope system in accordance with specifications, approved shop drawings and manufacturer's instructions.

B. Facing Form Installation:

1. Place the first course of wire mesh facing forms with the horizontal legs resting on the foundation material.

2. Verify that the first row of facing forms is level from end to end and from front-to-back.

3. Overlap or butt the adjacent facing units. Tie together vertical wires of adjacent facing units as required to maintain alignment and prevent escape of backfill material.

4. Use a string line or equivalent to align straight sections.

5. Place subsequent courses of facing forms on previous courses, at a setback, if any, as shown on shop drawings.

6. Align subsequent courses of facing forms using a string line or other suitable method that is independent of the final position of the underlying course of facing forms.

C. Geo-reinforcement placement:

1. See Section 02600 for geo-reinforcement placement, and as supplemented below specifically for wire basket faces portions of the MSE berm.

2. Extend the geo-reinforcement beyond the slope face by the amount required for the wrapped face and for anchorage at the top of the wrap.

3. After placement of geo-reinforcement and any required face wrap, place seven wire support struts on approximately 20-inch centers connecting the upper horizontal wire on the face of facing form to the transverse wire at the rear of the facing form. Place one of the support struts at each end of the facing unit between the outer two vertical wires. Pull the geo-reinforcement taut to remove slack.

4. Stake or pin the geo-reinforcement near the ends as required to maintain alignment and tension during filling.

5. Place a minimum of three inches of fill between any overlapping layers of geo-reinforcement where overlapping occurs behind curves and corners of the slope.

6. Turning of vehicles should be avoided to prevent dislocation or damage to the geo-reinforcement and the connected wall facing units.

7. Tracked vehicles shall not be operated directly on the geo-reinforcement. A minimum of nine inches of fill cover over the geo-reinforcement is required for operation of tracked construction vehicles in the reinforced zone.

## 3.3 QUALITY ASSURANCE

A. Construction Quality Assurance and Quality Control shall be completed in accordance with the Project CQA/CQC Plan.

B. The contractor shall maintain adequate quality control during construction to result in product compliant with the specifications.

## 3.4 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

**END OF SECTION**

# SECTION 02936

# SEEDING

## PART 1 GENERAL

### 1.1 SUMMARY

A. The EARTHWORK CONTRACTOR shall furnish all labor, materials, equipment, tools, and appurtenances required to prepare the seedbed and complete the seeding of all areas of the Project as required by the Specifications as shown on the Drawings or as directed by the ENGINEER.

### 1.2 RELATED SECTIONS

A. Section 02224 - Structural Fill

B. Section 02235 - Topsoil

### 1.3 REFERENCES

A. FS O-F-241 - Fertilizers, Mixed, Commercial.

### 1.4 DEFINITIONS

A. Weeds - Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Broome Grass.

### 1.5 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition and application.

### 1.6 TESTS

A. The ENGINEER shall review the nutrient and composition analysis of the soil suitable to sustain vegetation to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.

1. Topsoil used shall have an organic matter content of at least 2% by weight.

2. Topsoil used shall have a pH no less than 5.5 and no greater than 7.

B. The liming material shall have a Calcium Carbonate Equivalence (CCE) of 60% or greater, 80% passing a 20 mesh sieve, 30% passing a 100 mesh sieve. The fineness factor shall be greater or equal to 0.06 with an Effective Neutralizing Value (ENV) of 36% or higher.

## 1.7 MAINTENANCE

A. The EARTHWORK CONTRACTOR shall submit maintenance data for continuing maintenance from the seed supplier. This information will include the minimum maintenance instructions, cutting method, and maximum grass height, as well as, recommended types, application frequency, and coverage of fertilizer to produce maximum growth of vegetation.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. The grass seed mixture shall be in sealed containers showing weight, seed mix, year of production, date of packaging, and location of packaging. A seed tag describing the percentage of pure live seed, germination rate, inert materials and testing date shall be provided for each container. Seed more than one year old or in damaged packaging is not acceptable.

B. Fertilizer shall be in waterproof bags showing weight, chemical analysis, and name of manufacturer. Fertilizer in damaged packaging is not acceptable.

C. Lime in damaged packaging shall not be accepted. The OWNER shall provide labeled non-damaged packages consisting of liming material with the following information included:

1. The name, office address, and plant location of the manufacturer;

2. The identification of the product as far as the type of liming material,

3. The brand;

4. The OWNER shall provide a statement including the minimum total neutralizing value stated as CCE and the minimum fineness;

5. The net weight of the liming material;

6. The kind and amount of foreign material within the material expressed by weight;

7. In the event that the product is relabeled, adulterated, hydrated, or otherwise changed, a notice shall be attached to the package by the OWNER;

8. A report of the calcium and magnesium content expressed as a percent by weight of each element; and,

9. The OWNER shall provide evidence that the CCE and ENV parameters comply with federal and state regulations.

# PART 2 PRODUCTS

## 2.1 SEED MIXTURE

A. All seeding rates are presented as pure live seed values. The seed tag from each bag of seed used on the project shall be provided to the ENGINEER prior to planting for approval. The minimum percentage of pure live seed shall be 90%.

B. Temporary Vegetation:

| **Mixture Type 1** | **Rate** | **Seeding Season** |
|---|---|---|
| Common White Clover | 8 lbs/ac | Spring, Summer, or Fall |
| *Perennial Rye Grass | 30 lbs/ac | Spring, Summer, or Fall |
| *"Aroostook" Winter Rye | 100 lbs/ac | Spring, Summer, or Fall |
| Annual Rye | 75 lbs/ac | Spring, Summer, or Fall |

*If temporary vegetation is undertaken during late fall, certified winter rye (cereal rye) may be substituted for perennial rye grass.

B. Permanent Slope Vegetation:

| **Mixture Type 2** | **Rate** | **Seeding Season** |
|---|---|---|
| Empire Birdsfoot Trefoil or White Clover | 8 lbs/ac | Early Spring |
| Tall Fescue | 20 lbs/ac | Early Spring |
| Redtop | 2 lbs/ac | Early Spring |
| Annual Rye | 90 lbs/ac | Early Spring |
| Perennial Rye | 90 lbs/ac | Early Spring |

| **Mixture Type 3** | **Rate** | **Seeding Season** |
|---|---|---|
| Creeping Red Fescue | 20 lbs/ac | Early Spring, Late August |

| | | |
|---|---|---|
| Tall Fescue | 20 lbs/ac | Early Spring, Late August |
| Redtop | 2 lbs/ac | Early Spring, Late August |
| Annual Rye | 90 lbs/ac | Early Spring |
| Perennial Rye | 90 lbs/ac | Early Spring |

Legumes that may be mixed with the grasses are Alfalfa, Birdsfoot Trefoil, Sweet and White Clover, and Hairy and Crown Vetch. If used, inoculates for legumes are to be added immediately prior to seeding.

C. Drainage Swale/Channel:

| **Mixture Type 4** | **Rate** | **Seeding Season** |
|---|---|---|
| Ladino Clover | 8 lbs/ac | Early Spring, Late August |
| Tall Fescue or Smooth Bromegrass | 20 lbs/ac | Early Spring, Late August |
| Redtop | 2 lbs/ac | Early Spring, Late August |
| Annual Rye | 90 lbs/ac | Early Spring |
| Perennial Rye | 90 lbs/ac | Early Spring |

D. Alternate seed mixtures may be proposed by the CONTRACTOR for evaluation and must be approved by the ENGINEER prior to use.

## 2.2 ACCESSORIES

A. Mulching Material - Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

B. Turf Reinforcement Mats (TRM) – Permanent erosion control mats, free from matter or substances harmful to vegetation growth. Damaged or torn TRM are not acceptable.

C. Fertilizer - FS O-F-24, Type I, Grade A; recommended for grass, with 50 percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil (as indicated in analysis) to the following proportions: nitrogen, 5 percent; phosphoric acid, 10 percent; soluble potash, 10 percent; or fertilizer proportions recommended by the ENGINEER based on the soil test results.

D. Water - Clean, fresh, and free of substances or matter that could inhibit vigorous growth of grass.

# PART 3 EXECUTION

## 3.1 INSPECTION

A. The ENGINEER shall verify that prepared soil base is ready to receive the work of this Section.

B. Seed tags shall be checked by the ENGINEER for acceptance.

C. After mulch installation, The ENGINEER shall inspect the seedbed to ensure 100% mulch coverage. The TRM shall be inspected to verify the material has no damage or tears.

## 3.2 SEEDBED PREPARATION AND FERTILIZING

A. The EARTHWORK CONTRACTOR shall prepare a continuous seedbed composed of three or six inches of topsoil on all slopes for interim or final cover, respectively. The topsoil shall be spread evenly in one lift.

B. The OWNER may submit evidence that the proposed topsoil material is adequate to the ENGINEER for his/her approval.

C. The EARTHWORK CONTRACTOR shall grade the seedbed to remove high spots and depressions. The EARTHWORK CONTRACTOR shall clean the surface of the seedbed of roots, plants, stones, clay lumps, materials larger than 1.5 inches in diameter, and other materials harmful or toxic to plant growth or detrimental to mowing and maintenance activities. The surface of the seedbed shall be scarified to a depth of at least four inches with a disk or other suitable implement.

D. Apply fertilizer at the rate determined by the ENGINEER based on the seedbed soil test results. Typical rates are 600 lbs/acre for permanent seeding using a 5-10-10 (5% Nitrogen, 10% Phosphorous, 10% Potash) or equivalent fertilizer. Unless otherwise directed by the ENGINEER, use a rate of 150 lbs/acre for drainage swales/channels using a 5-10-10 fertilizer. Soil amendments shall be mixed into the top two inches of the seedbed.

E. The EARTHWORK CONTRACTOR shall apply lime as needed to provide a final pH of 6.0 for the temporary and permanent seeding areas and a pH of 6.5 for the drainage swales/channels.

F. To prepare a firm seedbed, the EARTHWORK CONTRACTOR shall ensure the seedbed has soil moisture between 50 and 70 percent of field capacity.

G. On slopes, the EARTHWORK CONTRACTOR shall compact the seedbed using a bulldozer tracking perpendicular to the gradient, creating cleat marks along the contour to prevent erosion.

## 3.3 SEEDING

A. The EARTHWORK CONTRACTOR can mechanically and/or hydraulically plant the seed with the goal of evenly distributing the seed and maximizing soil to seed contact. Mulch shall be used to retain moisture, reduce soil temperature fluctuations, and reduce runoff and erosion. Seed mixtures, fertilizers, and liming will be applied in accordance with local Soil Conservation Service recommendations.

B. If inoculant is used in a seed, fertilizer, and lime slurry, it shall be used within 3 to 4 hours of introduction, or a fresh supply of inoculant shall be added. When legumes are to be included in a slurry mixture containing fertilizer, the pH shall be checked prior to application in that a low pH is detrimental to the inoculants. In a slurry mixture, the amount of inoculant added to the tank should be four times the rate prescribed by the manufacturer. The seedbed shall be wetted prior to application of the slurry by hydroseeding.

C. Do not seed area in excess of that which can be mulched on same day.

D. Do not sow immediately following rain, when ground is too dry, or during windy periods. Seeding shall take place at least 48 hours after a heavy rain.

E. Refer to seeding time listed in Part 2.1.

## 3.4 MULCHING AND MAINTENENACE

A. The EARTHWORK CONTRACTOR shall spread straw uniformly over the seeded area with no less than 100% coverage and at least a one-inch loose thickness.

B. Due to accessibility or steepness of slope, hydraulic mulching may be required. Hydraulic mulching shall consist of the mixing of virgin wood fiber mulch, pre-blended tackifier and/or other additives with water. The hydraulic mulch shall be mixed in standard hydraulic mulching equipment to form a homogenous slurry. The slurry shall be sprayed under pressure uniformly over the soil surface at the material application rate recommended by the supplier, and in opposing directions to ensure complete coverage. The hydraulic mulching equipment shall include a motorized continuous agitation system that keeps all materials in uniform suspension throughout the mixing and distribution cycles.

C. Upon application, hydraulic mulch shall form a blotter-like mat covering of the seedbed. This mat shall have good water absorption and percolation characteristics, and shall cover and bond grass seed in contact with the soil.

D. TRM shall be placed within swales and channels to ensure erosion protection. TRM mulch anchors shall be installed up and down the slope in direct contact with the soil. Turf reinforcement mats shall provide 100% coverage and mats should never be installed on the contour.

E. The EARTHWORK CONTRACTOR shall inspect the TRM for any damage, including tears before installation. If the EARTHWORK CONTRACTOR locates a tear, the impaired mat should be cut before the imperfection, removing the damaged area from the sheet.

F. Prior to TRM installation, anchor trenches shall be excavated a minimum of two feet outside the swale/channel and at the toe of the slope of the swale/channel side. The trenches shall be a six inch wide x six inch deep and extend along the entire length of the swale/channel.

G. At the top of the swale/channel slope, the TRM shall be placed within the trench with the edge parallel with the innermost wall of the trench so that the first six inches of material is resting against the inner wall. The TRM shall be flush along the soil surface of the trench and a metal geotextile pin, or equivalent anchoring device, shall be driven into the TRM and soil layers at the bottom of the trench. The anchoring devices shall be spaced in an interval of twelve inches or less. The trench shall be filled with soil and prepared to the seedbed quality stated in 3.2 of this section. The TRM shall be rolled over the soil-filled trench and down the swale/channel side slope until the toe of the slope is reached.

H. At the toe of the swale/channel slope, the TRM shall be placed flush along the closest trench wall and the bottom of the trench. The TRM shall be folded so that there are two layers of mat on the bottom and closest side of the trench. An anchoring device will be driven into the bottom of the trench at intervals no greater than twelve inches. The trench shall be filled with soil and prepared to the seedbed quality stated in 3.2 of this section. The TRM will be extended over the soil-filled anchoring trench and placed flush to the soil until the next toe trench is encountered. The same procedure will be followed for the adjacent toe trench.

I. TRM overlapped at the roll edge shall be overlapping at least six inches with anchoring devices driven into the TRM and soil layers at intervals of twelve inches.

J. TRM overlapped at the roll end shall have an overlap of twelve inches with anchoring devices driven into the TRM at intervals of six inches. An additional row of anchoring devices shall be placed approximately four inches away from the initial row and at an interval of twelve inches or less.

K. The anchoring devices shall have a minimum length of six inches.

L. Maintenance of the completed seeding shall begin immediately after mulch types are applied. The soil shall be kept moist to a depth of 2 inches during the seed germination period.

M. Reseed and mulch all areas greater than 4 square feet lacking uniform coverage, until such time a uniform stand of grass is obtained.

N. If damaged sections of TRM are found after installation, repair and/or replacement should be completed. A cut replacement piece shall be at least twelve inches larger than the

tear/rip in all directions. The TRM piece shall be anchored down with metal geotextile pins, or an equivalent securing device, at an interval of no more than six inches. Replacement of mats shall follow the above procedure and should be completed if there is multiple tears on one sheet.

O. Fertilize, reseed, and mulch soil below the TRM tear/rip.

**END OF SECTION**

# APPENDIX B

# Construction Stakeout and Record Survey Requirements

# Carroll Landfill
# Baseliner and MSE Berm Construction
# Construction Stakeout, Tolerance and Record Survey Requirements

Construction and Record Drawing survey requirements and tolerances for acceptance are summarized below.

**Record Survey and Mapping Requirements**

The various surfaces and layers comprising the baseliner system that are to be surveyed and mapped for record purposes are, in ascending order:

1. Limit of Excavation and Top of Subgrade;
2. Top of 24-inch thick (minimum) Secondary Soil Liner;
3. 60 mil HDPE Secondary Geomembrane Panels and Sample Locations;
4. Top of 12-inch thick (minimum) Liner Structural Fill Layer;
5. 60 mil HDPE Primary Geomembrane Panels and Sample Locations; and,
6. Top of 24-inch thick (minimum) Primary Drainage Layer Stone.

All groundwater and leachate drain pipe systems will be located by record survey before burial. The baseliner system will be considered acceptable provided the following design and/or regulatory slope criteria/frequency is met (accounting for significant figures):

**Surface 1 – Limit of Excavation**

- Floor area slopes must be >/= 2%. The Record Survey point frequency criteria will be on a maximum 50-foot grid spacing, with sufficient additional survey points along all slope changes/breaklines to adequately model the limit of excavation surface shape.

- Slopes shall be measured on points including as a minimum the top-of-slope, approximate mid-elevation of the slope and the toe of slope, taken along the line of maximum slope. Should lined slopes exceed fifty feet in length, the Record Survey point frequency criteria will be at a 50-foot grid spacing, plus the top-of-slope and toe-of-slope.

**Layer 1 – Subgrade, Layer 2 – Secondary Soil Liner and Layer 4 – Liner Structural Fill**

- Floor area slopes must be >/= 2% (regulatory basis) and </= 20% (stability basis). The Record Survey point frequency criteria will be on a maximum 50-foot grid spacing, with sufficient additional survey points along all slope changes/breaklines to adequately model the surface shape and certify layer thicknesses.

- The horizontal and vertical extent of all Subgrade Replacement Material will be located by Record Survey on a maximum 50-foot grid spacing, with sufficient additional survey points along all top/toe of slope changes/breaklines.

- Lined side slopes must range between > 25% and </= 33% (regulatory basis). The slope shall be measured on points including as a minimum the top-of-slope, approximate mid-elevation of the slope and the toe of slope, taken along the line of maximum slope. Should lined slopes exceed fifty feet in length, the Record Survey point frequency criteria will be at a 50-foot grid spacing, plus the top-of-slope and toe-of-slope.

- All groundwater and leachate collection drain trenches and pipe shall be surveyed at a spacing no greater than 50-feet along the trench, 20 feet for the pipe, and at all slope and direction changes from the upgradient end to the downgradient end. The Record Survey points will be for the invert and top of trenches, the top of the pipe/fittings, and valves. Alignments for all pipe shall be within 2.0 feet of the design alignment in the horizontal plane. All pipe must be ≥ 1.0% overall (regulatory basis) from the upgradient end to the downgradient end and +/- 0.2% calculated at a spacing of approximately 60 feet along the pipe run. There shall be no adverse slope across any length of measurement.

- Subgrade slope shall be no less than the minimum and no greater than the maximum slope as described by the Construction Drawings.

- Subgrade Replacement Material thickness shall be no less than the minimum and no greater than the maximum thickness and slope as described by the Construction Drawings.

- Secondary Soil Liner thickness must be a minimum of 24 inches with a tolerance of -0.0, +0.2 feet.

- Liner Structural Fill thickness must be a minimum of 12 inches with a tolerance of -0.0, +0.2 feet.

**Layer 3 and Layer 5 –** 60 mil HDPE Geomembrane Panels and Sample Locations

- Corners of each panel;

- All Seam Locations;

- All destructive sample locations and repairs;

- Pipe penetrations;

- Leak location survey defects and repairs; and,

- Certified horizontal limits.

**Layer 6 - Top of 24-inch Thick Primary Drainage Layer Stone**

- The Record Survey points will be obtained on a 50’ grid spacing, all slope changes, and the certified horizontal and vertical limits.Primary Drainage Layer thickness must be a minimum of 24 inches thick with a tolerance of -0.0, +0.2 feet..

**Special Considerations**

- The thickness of the Subgrade Replacement Material, secondary soil liner, the liner structural fill and the primary drainage layer stone will be verified by comparison of the

record survey elevations at the common/shared horizontal coordinates. The design layer thickness on the lined side slopes is established perpendicular to the slope, and adjustments must be made to the measured vertical differences obtained at shared horizontal coordinates to obtain the perpendicular thickness.

The various layers comprising the MSE Berm system that are to be surveyed and mapped for record purposes are as follows:

1. Geogrids/Geosynthetic Reinforcements.
2. MSE Baskets.

**Geogrids**

- The horizontal and vertical extent of the subgrade excavation for the MSE Embankment will be located by Record Survey on a maximum 50-foot grid spacing, with sufficient additional survey points along all slope changes/breaklines. This will ensure the subgrade excavation is positioned in a manner that will accommodate the proper positioning of the overlying structure.
- The horizontal and vertical alignment of reinforcing geosynthetics must be +/-2 inches from the design location at any point in the wall.
- The reinforcement inclination must be +/-2% from the horizontal.
- Geosynthetic reinforcements are to be placed +/-3 inches of the design elevation and extend the length as shown on the relevant elevation view.
- The wall height must be +/-1 inch per ten feet of wall height and a maximum differential of four inches.

**MSE Baskets**

- The horizontal and vertical position of each row must be checked on a maximum 50 grid spacing with sufficient additional survey points along all slope changes/breaklines to ensure the beginning position of the geogrid reinforcement is within the tolerances listed above.