City of Laredo Landfill Permit Amendment 1693B
City of Laredo, Texas
Permit Amendment MSW Permit 1693B
Laredo, Texas
Webb County, Texas
August 2014
Revised June 2015

PART III
Attachment 10
Soil and Liner Quality Control Plan
§330.339

6.18.15

TX F3272

10A Soil and Liner Quality Control Plan for the Type I Cells

SOIL AND LINER QUALITY CONTROL PLAN
CONSTRUCTION QUALITY ASSURANCE/
QUALITY CONTROL MANUAL

MSW Permit No. 1693 B

Prepared for:
CITY OF LAREDO
Webb County, Texas

Prepared by:

Terracon Consultants, Inc.
25809 Interstate 30
South Bryant, Arkansas 72022

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LAREDO LANDFILL
PART III
Attachment 10
Soil and Liner Quality Control Plan

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STATE OF TEXAS
DAVID C. McCORMICK
81508
REGISTERED PROFESSIONAL ENGINEER

TX F3272

SECTION 1: GENERAL

1.0 INTRODUCTION

1.1 Purpose

This Construction Quality Assurance/Quality Control (CQA) Manual shall serve as the Soil Liner and Quality Control Plan (SLQCP) as specified under Title 30, Chapter 330.339 of the Texas Administration Code (TAC) Municipal Solid Waste Management Regulations (MSWMR) for the CQA of soils and geosynthetic installation. The purpose of this CQA Manual or CQA Plan is to provide quality assurance guidelines to be implemented by CQA personnel during construction of a composite liner system as required under Subtitle D regulations. This CQA Manual outlines quality control procedures-and measures for the following:

- Composite liner (soil and geosynthetic) construction including full time field observation, appropriate laboratory and field testing, and proper acceptance criteria for constructed work;
- Lines of communication and responsibilities of the owner, quality assurance team, design engineer, construction contractors, and other involved parties regarding adherence to the CQA guidelines; and
- Proper documentation procedures to demonstrate that the constructed composite liner meets the requirements of construction drawings and specifications.

1.2 Scope

The scope of this CQA Manual includes the CQA of the soils and geosynthetics for construction of the City of Laredo landfill in Webb County, Texas. CQA of the selection, evaluation, processing, placement, and compaction of soils for earthwork of low-permeability soil liners is included in the scope. CQA applicable to manufacturing, shipping, handling, and installing of all geosynthetics, and for the granular drainage system (leachate collection system) is also included.

In particular, full-time CQA during installation of the soils, geosynthetics, and leachate collection system is considered to be an essential part of ensuring the quality construction of a landfill for ultimate protection of the surrounding environment, and compliance with the regulations of the Texas Commission on Environmental Quality (TCEQ).

1.3 Definitions

Construction Drawings- A part of the construction specifications which illustrates layouts, typical sections, and scope of work to be performed.

Construction Specifications- The qualitative requirements for products, materials, and workmanship upon which the project is based.

Flexible Membrane liner (FML)- This material is a geosynthetic. It is an impermeable synthetic material used as an integral part of the liner system. (Also referred to as a geomembrane)

Geocomposite- This material is a geosynthetic. For this site, the geocomposite will consist of a geonet with a non-woven geotextile fused to both sides and will serve the purpose of a drainage layer on slopes.

Geonet- This material is a geosynthetic. It is a highly permeable synthetic net generally serving the purpose of a drainage layer.

Geosynthetics- A generic classification given to synthetic (man-made plastic) materials used in geotechnical engineering applications.

Geotextile- This material is a geosynthetic. It is a permeable synthetic textile generally serving the purpose of a filter interface between two types of soils or materials and has a high permeability. It may also serve as protection to the FML.

Non-Conformance- A deficiency in documentation, product, material and/or procedure that renders the procedure and/or quality of the document, product, or material unacceptable.

Project Documents- Contractor(s) submittals, construction specifications, construction drawings, record drawings, construction quality control and quality assurance plans, safety plan, and project schedule, and any other document related to the project.

Quality Assurance- A planned and systematic pattern of actions implemented by the quality assurance team to assure conformity of the services provided with the quality assurance plan. Regulatory requirements, and the construction drawings and specifications. The quality assurance team shall be a party independent of the owner, manufacturer and construction contractor(s).

Quality Control- Actions that are implemented to measure and regulate the characteristics and/or properties of an item, material or service to comply with the requirements of the construction drawings and specifications, and regulatory requirements.

Record Drawings- Drawings developed by the quality assurance team during liner construction which includes actual constructed dimensions, details and coordinates of the composite liner system.

2.0 PARTIES TO CQA AND QUALIFICATIONS

Figure 1 (see Appendix A) presents an organization chart depicting the relationships between the involved parties (Design Engineer, CQA officer, CQA Monitors, Construction Contractor(s) and Quality Assurance Laboratory) and the Owner.

2.1 Owner

The Owner owns and is responsible for the facility. For this project, the Owner is the City of Laredo in Webb County, Texas. The owner is responsible for the design, construction, and operation of the Municipal Solid Waste Landfill (MSWLF). The Owner must obtain a permit and assure the TCEQ, by submission of the Soil Liner Evaluation Report (SLER) and Flexible Membrane Liner Evaluation Report (FMLER), that the facility has been constructed as specified in the design, which was submitted to obtain the permit. Qualifications for the Owner do not apply.

2.2 Permitting Agency

The permitting agency for MSWLF's in the state of Texas is the Texas Commission on Environmental Quality (TCEQ). The permitting agency is authorized by law to issue a permit for the construction of a MSWLF. It is the responsibility of the permitting agency to review the Owner's permit application for compliance with the agency's regulations and to make a decision to issue or deny a permit based on this review. The agency also has the responsibility and authority to review all CQA documentation during and after facility construction to confirm that the approved CQA Plan was followed and that the facility was constructed as specified in the design.

2.3 Project Manager

The Project Manager is the official representative of the Owner who shall be in charge of coordinating the field activities. All other parties, excluding the Owner, shall report either directly or indirectly to the Project Manager. The selection of the Project Manager is the direct responsibility of the Owner; therefore, qualifications for this position are determined by the Owner independently of this CQA Manual.

2.4 Design Engineer

The primary responsibility of the Design Engineer is to design a MSWLF that fulfills the operational requirements of the facility and the performance requirements of the Permitting Agency. The Design Engineer is also responsible for approving submittals, resolving technical issues related to construction, interpretation of construction drawings and specifications, periodic review of CQA documentation, modifying construction site activity, specifying specific corrective measures when necessary, and maintaining record drawings.

2.5 CQA Consulting Firm

The CQA Consulting Firm shall be a party independent from the Owner, Manufacturer, Installer or other contractors, that is responsible for observing, testing and documenting activities related to the CQA of earthwork and/or geosynthetics for construction of the landfill. Subsequent to installation of each liner system (clay liner and FML), the CQA Consulting Firm will be responsible for issuing an evaluation report to document the construction.

The CQA Consulting Firm shall be a well-established engineering firm with experience in

providing CQA services for soils and geosynthetics and preparation of quality assurance documentation. The CQA Consulting Firm shall include the CQA Officer and an appropriate number of CQA Monitors.

2.5.1 CQA Officer

The CQA Officer shall be an employee of the CQA Consulting Firm, who will be responsible for all aspects of the CQA Manual implementation. The CQA Officer shall be a person acting in compliance with the provisions of the Texas Engineering Practice Act and other state laws and regulations, and shall possess adequate formal academic, practical, technical, and managerial experience to successfully oversee and implement construction quality assurance activities for a MSWLF. The CQA Officer shall be registered in the State of Texas as a Professional Engineer. For clay liner construction, the CQA Officer may be certified and recognized as a Professional Geologist by the American Institute for Professional Geologists (AIPG).

2.5.2 CQA Monitors

The CQA Monitors shall be employees of the CQA Consulting Firm or approved independent subconsultants, who shall be responsible for full-time observation and documentation of quality assurance activities during construction of the composite liner system. The CQA Monitors shall be specifically trained in quality assurance of soils and/or geosynthetics.

2.6 CQA Laboratory

The CQA Laboratory will be a firm responsible for conducting laboratory tests on soil and geosynthetic samples obtained from the project. The laboratory shall be independent of the Owner, Manufacturer, and construction contractors. The laboratory and the CQA Consulting Firm may be one in the same.

The laboratory shall have experience in testing the types of soils and geosynthetics to be installed, be familiar with appropriate testing standards {i.e., American Society for Testing and Materials (ASTM), National Sanitation Foundation (NSF), Corps of Engineers (COE), and other applicable test methods}, and be capable of providing test results in accordance with these testing standards in a timely manner.

2.7 Earthwork Contractor

The Earthwork Contractor shall be a firm responsible for soil components of the composite liner construction, which may include the clay liner, granular drainage material, and protective cover. The Earthwork Contractor may also provide backfilling of the anchor trenches.

The Earthwork Contractor shall have a demonstrated history of successful earthwork construction in the State of Texas. This contractor shall be pre-qualified and approved by the Owner and Design Engineer.

2.8 Geosynthetic Manufacturer

The Geosynthetic Manufacturer will be the firm responsible for production of the flexible membrane liner (FML) and other geosynthetics, and possibly for delivery of the geosynthetic materials. The Geosynthetic Manufacturer shall be able to provide sufficient production capacity and qualified personnel to meet the demands of the project.

This firm shall be pre-qualified and approved by the Owner and Design Engineer. The Geosynthetic Manufacturer shall provide a quality control manual for the manufacturing process and a list of material properties including certified test results.

2.9 Geosynthetic Installer

The Geosynthetic Installer shall be responsible for the installation, and other aspects, of the geosynthetic materials. Other responsibilities of the Geosynthetic Installer may include handling, storing, and delivering of geosynthetic materials for the project.

The Geosynthetic Installer shall be trained and qualified to install the geosynthetics. The Installer shall be approved by the Owner and Design Engineer. This firm shall provide a statement of qualifications to conduct geosynthetic installation, a quality control manual for installation and qualifications of field crews.

2.10 Surveyor

The Surveyor shall be responsible for all survey control during construction in accordance to the design specifications and plans, and shall be registered in the State of Texas as a Professional Land Surveyor. The Surveyor will be chosen and approved by the Owner and Design Engineer.

3.0 DUTIES OF CQA PERSONNEL

The personnel for the CQA Consulting Firm will include a CQA Officer and one or more, as necessary, CQA Monitors. The following sections provide a brief description of the responsibilities of these personnel.

3.1 CQA Officer

The CQA Officer shall be a person acting in compliance with the provisions of the Texas Engineering Practice Act and other state laws and regulations, and shall possess adequate formal academic, practical, technical (including all types of FMLs to be installed), and managerial experience to successfully oversee and implement construction quality assurance activities for a MSWLF. Specific responsibilities of the CQA Officer include:

- Reviewing the Site Development Plan, design criteria, and plans and specifications for clarity and completeness so that the CQA Plan can be implemented;
- Educating all CQA personnel on CQA requirements and procedures;

- Scheduling and coordinating full-time CQA inspection activities;
- Reviewing all changes to the design, plans, and specifications;
- Directing, supporting and verifying that all monitoring, sampling, documenting and other CQA activities are conducted in accordance with this manual;
- Verifying that a contractor's construction quality control plan is in accordance with the site-specific CQA Plan;
- Reviewing all Manufacturer QC certifications and list of guaranteed physical property values;
- At the Owner's request, reporting to the contractor results of all observations and tests as the work progresses and interacting with the contractor to provide assistance in modifying the materials and work to comply with the specified design; and
- Providing to the Owner reports on the inspection results.

The CQA Officer shall report directly to the Owner and/or Project Manager.

3.2 CQA Monitors

The overall responsibility of the CQA Monitors, as outlined in this manual, includes full-time monitoring, sampling, documentation, and performing general overall CQA of the soils and geosynthetics contractors work activities. The CQA Monitors shall observe and document the activities of the contractor(s) in sufficient detail, and must perform tests, when appropriate, to provide a high level of confidence that the work performed and work product are fully compatible with the requirements of the construction drawings and specifications. The CQA Monitors performing daily QA/QC observation and testing shall be under the direct supervision of the CQA officer. The CQA Monitor shall be an engineering technician with a minimum of four years of directly related experience, or a graduate engineer or geologist with one year or directly related experience.

4.0 COMMUNICATION AND MEETINGS

To ensure a high degree of quality during construction, clear and open channels of communication are essential. To that end, meetings are a critical factor.

4.1 Overall Communication Relationship

Only individuals assigned to this project and as defined in this manual shall communicate with the Owner and/or Project manager, and construction contractor(s). All communications should be through proper channels as defined by the organization chart illustrated in Figure 1. Communication of an official capacity shall be concise and direct. If written communications are warranted, they shall be documented on the appropriate forms and subsequently filed or passed on for review through the proper channels.

4.2 Meetings

4.2.1 Preconstruction Meeting

A meeting should be held prior to construction once the design has been completed, permits have been obtained from the appropriate state and federal agencies, the CQA Plan has been submitted to the TCEQ for review, and the construction contract(s) have been awarded. The Owner and/or the Project Manager, Design Engineer, CQA personnel, and construction contractors should all be present, and the TCEQ personnel shall be notified. The purpose of this meeting will be to:

- Provide each party with all relevant CQA documents and support information;
- Review the construction drawings and specifications, work area security plan, safety guidelines, and related issues, and familiarize each party with the CQA Plan and its role relative to the construction drawings and specifications and other design criteria;
- Evaluate the CQA Plan and determine any changes necessary to ensure that the facility will be constructed to meet or exceed the specified design;
- Review the responsibilities of each party and establish lines of authority and communication for proper interaction among all involved parties;
- Discuss established procedures to address sampling, testing and construction nonconformances and methods for resampling, retesting, and repairs;
- Review methods for documenting, reporting, distributing, and storing of all data, documents, and reports;
- Review the project schedule; and
- Conduct a site walk-around to inspect and evaluate the work area, stockpile area, laydown area, access roads, haul roads, medical service area, and other related items.

The meeting should be documented by a person designated by the Project Manager, and minutes and other relative documents should be provided to all parties. The documents resulting from this meeting shall be kept on file by the CQA personnel.

4.2.2 Progress Meetings

These meetings shall be held either daily or weekly, depending on the length and progression of the project, and should be held at the work site prior to commencement of work activities for the period. Attendance of these meetings is required of the construction contractor(s), the CQA Monitors, and as necessary, the Project Manager. Other involved parties may be required to attend these meetings as problems arise that warrant their attendance. The purpose of this meeting is to:

- Review the activities, accomplishments, problems, and data accumulated from the previous day or week;
- Review the work locations and activities for the day or week;
- Discuss the contractor's personnel and equipment assignments for the day or week; and
- Discuss any potential construction problems that may occur during the day or week, and how these problems may be addressed.

This meeting should be documented by the CQA Monitor, and minutes will be provided to all parties involved and to the Owner.

4.2.3 Problem or Work Deficiency Meetings

Special meetings may be arranged to discuss construction problems and/or deficiencies that have occurred or may develop. At a minimum, the meeting should be attended by the construction contractor(s) and CQA personnel. If the problem may require a design modification, the Project Manager and/or Owner and the Design Engineer shall also be present. The purpose of the meetings will be to define and discuss the problem and/or deficiency. The meeting should be documented by a person designated at the beginning of the meeting and kept on file by the CQA personnel. Minutes of the meeting shall be distributed to all involved parties and the Owner.

5.0 DOCUMENTATION

The effectiveness of this CQA Manual depends ultimately on recognition of the construction activities to be inspected, and thorough monitoring, testing, and documentation of the construction activities by the CQA personnel. Documentation shall consist of non-conformance and corrective action reports, design and specification changes, daily construction reports, inspection and tests data sheets, panel layout drawings, and all other documentation accumulated by the CQA personnel during construction of the MSWLF. Forms to be utilized in the field to collect data and document activities are included in Appendix B. All documentation accumulated during construction of the MSWLF shall be properly filed and stored.

5.1 Daily Recordkeeping

Standard daily reporting procedures should include preparation of a daily construction report, inspection and test data sheets, and, when warranted, non-conformance and corrective measure reports.

5.1.1 Daily Construction Report

This report, prepared by the CQA personnel, should summarized all construction activities and discussions with the construction contractor(s), which took place that day, and should provide a chronological frame work for identifying and documenting all other reports. Daily construction reports should include the following:

- Date, project name and number, and location. (The date along with the project number shall serve as a cross reference number for all other reports and data accumulated on that day.);
- Weather conditions summary;
- A chronological listing of any meetings held;
- A description of all construction work, including locations, performed for the day;
- An inventory of all equipment and personnel that performed work on the composite liner for the day, and the locations and type of work they performed;
- Descriptions and data of tests and observations, identified as passing or failing, and the measures taken in the case of a failing item or test;

- Concise locations where nonconformances occurred, and the corrective measures implemented to correct the non-conformance. (Attach any Non-conformance and Corrective Measure reports that were written.);
- Description of any minor field changes or conditions not included on the construction drawings and/or specifications;
- Description of offsite materials received, and quality verification documentation (vendor certification) of the materials; and
- Signature of the CQA personnel.

5.1.2 Inspection and Test Data Sheets

These data sheets should, at a minimum, include the following:

- Date, project name and number, and location of inspections and tests performed;
- A summary of tests results identified as passing or failing (non-conformance), and any retests (corrective measures) that are performed; and
- A summary of inspection activities and referenced construction drawings and specifications when appropriate.

All inspection and test data information shall be documented and kept on file by the CQA personnel.

5.1.3 Non-conformance and Corrective Measure Reports

All non-conformances shall be documented on the daily construction reports, inspection and test data sheets, and elsewhere as required. The extent of the non-conformance shall be evaluated by additional testing, observations, review of records, or any other means deemed appropriate by the CQA personnel. For non-conformances which are serious or complex in nature and/or require an engineering evaluation, a Non-conformance and Corrective Measure Report shall be written and the CQA Officer notified. All failed tests from field or laboratory CQA activities shall be provided in the final SLER and FMLER reports.

When a non-conformance occurs, the construction contractor(s) shall first be notified verbally by the CQA personnel, followed by a written notification, if necessary. If a Non-conformance and Corrective Measure Report is warranted, a copy shall be provided to the construction contractor(s) and the Design Engineer, and the Owner and/or the Project Manager. A copy of the Non-conformance and Corrective Measure Report shall also be kept on file by the CQA personnel.

For minor non-conformances, corrective action may be determined by the existing specifications, or the CQA personnel and the construction contractor(s) will discuss standard construction methods to correct the deficiency. For major non-conformances (those which require a Non-conformance and Corrective Measure Report), the CQA Officer, under direction of the Design Engineer, shall then assign the corrective action in writing.

Upon completion of the corrective action, the CQA personnel shall verify its completeness by

inspection and/or additional testing. Once evaluated as being corrected, the CQA personnel shall make record of this corrective action in the daily construction report and also in the Non-conformance and Corrective Measure Report. The corrective action implemented shall be reviewed and verified by the Design Engineer.

5.2 Design and Specification Changes

Design and specification changes may be warranted periodically during construction. These changes may only be made with written approval of the Design Engineer, and shall be initiated through change orders. All changes shall be reviewed by the CQA Officer.

5.3 Monthly Progress Report

The construction contractor(s) should prepare monthly progress reports summarizing construction, testing, inspection, and quality assurance activities. This report shall be reviewed by the CQA personnel. Once reviewed by the CQA personnel, it shall be given to the Project Manager for review and then to the Owner.

5.4 Photographic Documents

Daily photographs may be taken of the construction activities, and of significant problems that develop. If corrective actions are implemented, they may be photographed also. If photographs are taken, a photograph log should be kept in which each photograph is identified by time, date, location, and photographer. (A camera that has the capability to put the date on the picture would be beneficial). A brief description should accompany each photograph. The CQA personnel should sign all photographic reports.

5.5 Storage of Records

During construction of the MSWLF, the CQA personnel shall be responsible for possessing a copy of all CQA documents and proper filing of these documents so that past information may easily be obtained. CQA documents include copies of the construction drawings and specifications, CQA Manual, and originals of all daily construction reports, inspection and test data sheets, and all reports, documentation and drawings required by the CQA Manual.
Once facility construction is complete, the CQA document originals shall be stored by the CQA Officer in an organized manner to allow for easy access. All documentation shall be maintained through the operating and post closure monitoring periods of the facility.

6.0 EQUIPMENT CONTROL

6.1 Documentation of Testing Equipment

Prior to start of construction activities, the CQA personnel shall complete a list of all measuring, sampling and testing equipment to be available for use at the site. As additional equipment becomes available for use at site, it shall be added to the list. Each piece of equipment shall have a specific identity number. The equipment list shall contain the following information:

- Type of equipment (generic or trademark name);
- Manufacturer, model and serial number or identifying number if each piece of equipment; and
- Use of the equipment.

6.2 Calibration of Testing Equipment

All equipment shall be calibrated and its accuracy evaluated by the CQA personnel, before the equipment is approved for use at the site, as deemed necessary by the CQA Officer. A valid certificate of equipment calibration, issued by the manufacturer or a qualified laboratory, shall be provided to the CQA personnel for approval if an on-site calibration is not feasible. The calibration procedures and frequency of calibration shall be performed according to the manufacturer's instructions or ASTM standards, and equipment that is suspect or producing questionable results shall be immediately removed from service and recalibrated. CQA personnel reserve the right to remove equipment from service for any reason.

7.0 PROJECT CONTROL VISITS

Project control visits shall be conducted by the CQA Officer or their representative during the fulltime CQA monitoring of construction activities. The construction site shall be visited by the CQA Officer or their representative periodically (at least once every other week) during major construction and critical construction meetings to ensure successful implementation of the CQA Plan. These visits can be coordinated with similar visits by the Design Engineer, as appropriate. TCEQ officials may be informed of the dates of these visits prior to occurrence and the final evaluation reports will document the dates of the visits. At a minimum, the professional of record who signs the soil liner, geomembrane, and/or geosynthetic clay liner evaluation reports or their representative will be on site during all liner construction.

SECTION II: CLAY LINER EARTHWORK CQA

1.0 INTRODUCTION

This section contains the guidelines for inspection and testing of the constructed clay liner and the materials used to construct the clay liner. The clay liner shall be constructed, inspected, and tested based upon guidelines stated in this CQA Manual.

2.0 PRE-CONSTRUCTION ACTIVITIES

Soil to be used to construct the landfill liner may be present onsite or may have to be imported to the site. All material to be used in construction of the composite liner must meet certain criteria, as discussed in this section of the CQA Manual and/or in the construction drawings and specifications.

Soil sampling and testing shall occur throughout the construction of the clay liner. Soil brought onto the site shall be sampled and tested before it is used, to evaluate its properties. Once the

soil is placed as part of the constructed clay liner, it shall be sampled and tested again.

Certificates of acceptance may be used by the Project Manager and/or CQA personnel to establish the acceptability of materials. These certificates shall state that the material is in compliance or conformance with the appropriate code, standard, or specifications for this project.

2.1 Soil Materials

The soils associated with construction of the clay liner component of the composite liner shall be low-permeability clay. Soils to be used for the clay liner shall meet the following criteria:

- Must have a liquid limit of no less than 30;
- Must have a plastic index of no less than 15;
- Must have no less than 30 percent of the material passing the No. 200 sieve; and
- Must have a recompacted coefficient of permeability no greater than 1×10^{-7} cm/s.

2.2 Soil Sampling, Testing, and Documentation

Most of the sampling and testing performed for this project shall be conducted on a random basis. Random sampling and testing in this report refers to the fact that no preset location is designated, and the samples will be obtained or testing performed at random locations selected by the CQA personnel. Therefore, the sampling and testing will be limited by total number only and not by location, although adequate coverage will be achieved.
Judgmental sampling and testing may also be implemented by the CQA personnel. This method of sampling and testing generally is performed to evaluate suspect areas.

2.2.1 Sample Documentation

The CQA personnel shall be responsible for maintaining proper labeling and documentation of all soil samples. All test samples shall be numbered by the CQA personnel. Information documented for each soil sample shall include:

- Sample number;
- CQA personnel who obtained the sample;
- Location of testing (onsite or offsite);
- Data sample collected and sent off to be tested;
- Data results received or test completed at site;
- Test(s) performed on sample; and
- Test results, indication of failing or passing, and additional comments when appropriate.

The CQA personnel shall tag the sample or sample container immediately upon sampling, and shall be responsible for timely processing of test samples. The CQA personnel shall reserve the decision of the location where samples shall be obtained or tested, and which samples shall be sera in to the laboratory for testing.

2.2.2 Test Procedures

Test procedures utilized for the various laboratory tests shall be in compliance with the applicable ASTM and/or other standards as specified in the project documents or this manual. If changes in procedures or additional procedures are warranted, the revised or additional procedures shall be developed and/or approved by the Design Engineer. The laboratory test procedures shall adhere to the following test standards (shown in Table II-I), unless designated otherwise in the construction drawings and specifications.

TABLE II-1
LABORATORY TEST STANDARDS
City of Laredo
Webb County, Texas

STANDARD	TEST DESCRIPTION
ASTM D 2216	Laboratory determination of water (moisture) content of soil, rock, and soil-aggregate mixture.
ASTM D 4318	Atterberg limits. Plastic limit, liquid limit, and plasticity index
ASTM D 422 and D 1140	Particle size analysis of soils
ASTM D 698	Moisture-density relations of soils and soil-aggregate mixtures using a 5.5-lb hammer and 12-inch drop.
ASTM D 5084	Flexible wall permeability test.
Appendix VII (method 7) Corps of Engineers Manual, EM 1110-2-1906, Nov. 30, 1970 or more current version	Permeability tests with back pressure.

*Note: Maximum particle size shall be 1-inch in diameter.

3.0 CONSTRUCTION EVALUATION

3.1 Recording of Data

All data accumulated from inspection, sampling and testing during construction of the clay liner shall be documented and stored as previously stated.

3.2 Material Placement and Monitoring

The CQA personnel shall monitor all aspects of placement of the clay liner. The CQA Officer or their representative shall conduct sufficient site visits (at least once every other week during major construction) to ensure the successful implementation of the CQA Plan. At a minimum, the professional of record who signs the soil liner, geomembrane, and/or geosynthetic clay liner evaluation reports or their representative will be on site during all liner construction. Continuous monitoring of construction of the clay liner shall include the following:

- Removal of roots, rocks, rubbish, or soil that does not meet the specifications of the liner material;
- Adequate clod size reduction of liner material;
- Adequate spreading of liner material to obtain complete coverage and the specified maximum compacted lift thickness not to exceed the lengths of the pad or prong feet of the compaction equipment;
- Proper equipment is utilized to meet the performance requirement of the liner system;
- Adequate spreading and incorporation of water to obtain full penetration through clods and uniform distribution of the specified water content;
- Adequate interlift bonding is achieved;
- Adjustment to proper soil moisture content in the event of 2 significant prolonged rain or drought during construction;
- Prevention of significant water loss and desiccation cracking before and after compaction; and
- Proper tie-in to previously constructed liners are made.

Any deficiencies observed during placement of the clay liner shall be documented by the CQA personnel, and the construction contractor(s) and the Owner and/or Project Manager shall be notified.

3.3 Sampling and Testing Strategy

The sampling and testing frequency stated herein, specifies a minimum sampling and testing frequency. These frequencies can he increased to identify potential problem areas where additional tests shall be performed. Any additional testing required to be performed as a result of a failing test shall not contribute to the total number of tests performed in satisfying the minimum test frequency. At a minimum, the sampling and testing frequency shall meet the criteria stated in Table II-2.

Field tests shall be performed on each six inch lift within the area being lined. Test locations shall be chosen without bias; however, additional testing shall be performed in those areas that are suspect or of poor quality. During the progress of the work, all test locations shall be recorded on the soil liner worksheet (with identification number) by the CQA personnel to verify that no significant areas are untested. The soil liner worksheet and test location plan shall become part of the CQA documents.

TABLE II-2
SOIL CONSTRUCTION TESTING FREQUENCIES
City of Laredo
Webb County, Texas

SOIL TEST CATEGORY	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Quality Control Testing of Source Borrow Materials	Moisture/Density Relationship	ASTM D 698 or D 1557	Once per soil type (B)
	Sieve (Gradation)	ASTM D 422 or D 1140	
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906	1/Moisture/Density Relationship
Constructed Soil Liners	Field Density	ASTM D 1556, D 2167, or D 6938	1/8,000 ft^2 per 6-inch parallel lift[A]; 1/100 lineal ft per 12 inches sidewall liner (horizontal lifts)[A]
	Sieve (Gradation)	ASTM D 422 or D 1140	1/100,000 ft^2 per 6-inch parallel lift[A]; 1/2000 lineal ft per 12 inches sidewall liner (horizontal lifts)[A]
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906 (laboratory) Air-Entry Permeameter (field)	
	Thickness	Registered Surveyor	1/5,000 ft^2 (parallel lifts)[A]; 50-ft cross-sections (horizontal-lift sidewall liners)[A]

Notes:

A- A minimum of one of each of the designated tests must be conducted for each unit thickness of liner as indicated, regardless of liner area or length.

B- The soil type shall be based on different locations (i.e. off-site locations), color, and texture of the material.

3.4 Test Procedures and Requirements

- Nuclear Moisture/Density (ASTM D 6938) -The density and moisture content must be adequate to yield a coefficient of permeability of 1 x 10^{-7} cm/s or less based on preconstruction laboratory testing. Sections of compacted soil liner which does not pass should be reworked and retested until the section in question does pass. All field moisture/density test results shall be reported in the Soil Liner Evaluation Report (SLER). When taking field moisture/densities, all holes due to or created by density probes shall be backfilled and compacted with pure powder bentonite or a mixture of clay liner soil and powdered bentonite. Test method ASTM D 6938 is designated for use since this method replaced ASTM D 2922 in 2007.
- Moisture Content (ASTM D 2216) - At least once every seven days a sample should be secured and tested in the laboratory to maintain an accurate correction factor for the nuclear density equipment.
- Minus No. 200 Sieve Analysis (ASTM D 1140) - The clay liner shall have a percent passing the No. 200 sieve of no less that 30 percent and a maximum particle size of 1-inch in diameter.
- Coefficient of Permeability (ASTM D 5084 or Appendix VII (Method 7) of the Corps of Engineer Manual EM 1110-2-1906, November 30, 1970)- Undisturbed samples of the constructed liner shall be obtained for permeability testing. The liner coefficient of permeability must not exceed 1 x 10^{-7} cm/s.
- Atterberg Limits (ASTM D 4318) - The clay liner shall have a liquid limit of no less than 30 and a plasticity index of no less than 15.
- Moisture/Density Relation (ASTM D 698) - The clay liner shall be compared to at least 95 percent of standard (ASTM D 698) maximum dry density at or above optimum moisture content.

All voids created by sampling shall be backfilled and compacted with pure powdered bentonite or a mixture of clay liner soil and powdered bentonite.

3.5 Dimension Control

The Design Engineer or CQA Officer shall prepare a scale drawing of the area to be lined, and prior to placement of the initial lift, a grid shall be established across the base of the landfill and elevation data shall be recorded at designated point locations across the grid. Subsequent to placement of the final lift, the same point locations as previously surveyed shall be surveyed again and elevation data recorded as before. These corresponding point locations on each successive component of the landfill construction shall be within 0.3 horizontal feet of each other with proper adjustments for side slopes. The difference in the surveys will yield the constructed thickness of each component. Correction for side slopes will be necessary for appropriate measurement of thickness. The grid shall be established such that there will be at least one elevation point per 5,000 square feet of surface area.

The thickness verification shall be used to verify that each component of the clay liner has been constructed to the specified minimum thickness (2.0 feet minimum) as presented on the design drawings and in the specifications. The grades specified in the construction drawings shall be

verified to ensure proper performance of the leachate collection system. The surface of the clay liner shall be rolled with a flat wheel roller to achieve a smooth uniform surface prior to FML placement.

4.0 CQA INSPECTION

Soils CQA shall be performed on all earthwork components of the construction. Criteria to be used for determination of the acceptability of the construction work shall be as identified in the project specifications.

Construction evaluation testing shall consist of: (1) monitoring the earthwork; (2) evaluation of the adequacy of lift bonding; and (3) field and laboratory testing. All field and laboratory testing shall be conducted on in-place material or samples taken from the clay liner itself.

4.1 Monitoring

Monitoring the construction work shall consist of the following:

- Testing to determine the density, water content and other physical properties of the soil used in the construction:
- Monitoring the thickness of lifts as loosely placed and as compacted;
- Monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., sheepsfoot penetration, pumping, cracking. etc .); and
- Monitoring the number of passes used to compact each lift.

4.2 Evaluation of Lift Bonding

Evaluation of lift bonding may be determined by using test pits to make visual observations. All test pits shall be excavated in a manner acceptable to the CQA Officer and the Design Engineer. Test pits shall be at least one foot in depth. After observation by the CQA personnel, each pit shall be backfilled and compacted in accordance with this CQA Manual and the project specifications. The backfill shall be compacted using hand compaction equipment or other methods approved by the CQA Officer and Design Engineer. Each test pit will be backfilled with a mixture of clay liner material and powdered bentonite.

4.3 Field and Laboratory Tests

The field and laboratory test methods and testing frequencies are presented in Section 3.3. At locations where the field testing indicates densities below the requirements of the specifications, the failing area shall be reworked. For areas where the field testing indicates the moisture content is below the requirements, the area shall be scarified, moisture-conditioned, and recompacted. In any case, areas failing field tests will be reworked and recompacted until acceptable values are achieved.

4.3.1 Subgrade

During initial construction efforts or as necessary, the subgrade soils shall be continuously inspected to determine the suitability of the subgrade for placement of the liner material. Proof rolling should he conducted prior to construction, and suspect weak areas should be removed and replaced with fill material, or it should be reworked and recompacted.

4.3.2 Clay Liner

During the clay liner construction, continuous inspection shall be provided to ensure proper construction. Field moisture/density tests will be conducted with a nuclear moisture/density testing device. The tests shall be conducted at the frequency shown in Section 3.3. The density of the compacted clay material shall achieve a minimum of 95 percent of the Standard Proctor density, and the moisture content will be maintained at or above the optimum moisture content, both as determined from ASTM D 698.

Samples of the: material used in the liner construction shall be collected for laboratory testing as stated previously. Prior to construction, samples of the material to be used will be collected to perform Atterberg limits determinations, percent passing the No. 200 sieve, moisture/density relationship, and permeability testing. During construction, samples of the compacted liner will be collected to perform Atterberg limits determinations, minus No. 200 sieves, and permeability testing. All of the tests will be conducted at the frequency listed in Section 3.3.

4.4 Testing Frequency

All quality control testing shall be conducted in accordance with the project specifications or as directed by the Owner and/or the Project Manager in concurrence with the CQA personnel. The field testing methods, as described previously, shall be conducted by the CQA Monitor and periodically observed by the CQA Officer. The frequency of each type of test is provided in Section 3.3.

Sampling locations shall be selected by the CQA Officer or his designated representative (CQA Monitor), and the location of routine in-place density tests shall be determined using a nonbiased sampling plan.

A special testing frequency may be used at the discretion of the Owner and/or the Project Manager, and the CQA personnel when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas shall be considered for the following instances:

- Rollers slip during rolling operations;
- Fill is at improper and/or variable moisture content;
- Less than adequate number of roller passes are made;
- Dirt-clogged rollers are used to compact the material;
- Fill materials differ substantially from those specified:
- The degree of compaction is doubtful: and
- As directed by the Owner/Project Manager or CQA personnel.

During construction, the frequency of testing may also be increased in the following situations:

- Adverse weather conditions;
- Breakdown of equipment;
- At the start and finish of grading;
- Material fails to meet specifications; and
- The work area is reduced.

Laboratory testing shall be conducted at the minimum frequency shown in Section 3.3. Additional laboratory testing may be conducted, as necessary, for the following situations:

- Change in fill material type from those specified;
- The degree of compaction is doubtful;
- The amount of moisture is variable;
- Change in compaction efforts; and
- As directed by the Owner/Project Manager and/or CQA Officer.

4.5 Liner Perforations

Perforations that must be filled shall include, but not be limited to, the following:

- Nuclear moisture/density test probe locations;
- Laboratory test sampling locations; and
- Test pit locations.

All clay liner perforations shall be made in accordance with the testing methods and frequencies identified in Section 3.3. Construction permeability test samples shall be taken such that the sample tube is inserted into the liner normal (perpendicular) to the plane of the constructed surface.

Unless otherwise noted in the project specifications, or as directed by the Owner or his representatives, perforations for the density test probe and permeability locations shall be backfilled with pure powdered bentonite or a mixture of the same material type as removed and powdered bentonite. This mixture will be compacted in place with a tamping rod or other hand compaction equipment to achieve a similar density as the surrounding soil. Perforations created by test pits shall be backfilled as stated previously in Section 4.2 and the project specifications.

4.6 Deficiencies and Corrective Measures

If a deficiency is discovered in the earthwork product, the CQA personnel shall immediately determine the extent and nature of the deficiency. If the defect is indicated by an unsatisfactory test result, the CQA personnel shall determine the extent of the affected area by additional tests, observations, a review of records, or other means that is deemed appropriate. If the deficiency is related to adverse site conditions, such as overly wet soils or surface desiccation, the CQA personnel shall define the limits and nature of the deficiency.

4.6.1 Notification

After determining the extent and nature of the defect, the CQA personnel shall notify the Owner and/or the Project Manager, and the Earthwork Contractor, and schedule appropriate retests when the work deficiency is to be corrected.

4.6.2 Repairs and Retesting

The Earthwork Contractor shall correct the deficiency to the satisfaction of the CQA personnel, the plans and specifications, and all applicable regulations. If a project specification criterion cannot be met, or unusual weather conditions hinder the work, then the CQA Officer shall develop and present to the Owner/Project Manager suggested solutions for his approval.

All retests recommended by the CQA personnel must verify that the defect has been corrected before any additional work is performed by the contractor in the area of the deficiency. The CQA Officer shall also verify that all installation requirements are met and that all submittals are provided.

SECTION III: HIGH DENSITY POLYETHYLENE CQA

1.0 INTRODUCTION

This section of the CQA Manual addresses the quality assurance of the installation of High Density Polyethylene (HDPE) Geomembranes. This plan does not address design guidelines, geosynthetic selection (which includes compatibility between geomembrane and contained material), and installation specifications. This plan stresses documentation during the quality assurance process and therefore requires the participation of knowledgeable quality assurance personnel.

The plan includes references to test procedures of the American Society for Testing and Materials (ASTM) and the Geosynthetic Institute (GSI) test standards.

The overall goal of the geosynthetic quality assurance program is to assure that proper construction techniques and procedures are implemented, and that the composite liner is built in accordance with the construction drawings and specifications.

The flexible membrane liner (FML) portion of the liner system shall be installed and tested based upon the construction drawings and specifications, and this manual. To monitor compliance, the quality assurance program shall include:

- A review of the construction contractor(s) quality control submittals;
- Material conformance testing (testing of FML prior to installation);
- Construction testing (testing of FML during and after installation); and
- Construction monitoring.

2.0 GEOMEMBRANE MANUFACTURING AND DELIVERY

2.1 Manufacturing

The High Density Polyethylene (HDPE) lining materials shall be new products designed and manufactured specifically for use as a landfill liner, and shall have satisfactorily demonstrated by prior use to be suitable material for use as a landfill liner (See Table III-1 for standard test methods and testing frequencies). The HDPE shall be supplied as a single ply continuous sheet in rolls, with a minimum width of 15 feet and a nominal thickness of 60 mils (0.060 inch). The HDPE lining material shall be certified in writing by the manufacturer to meet the minimum typical physical property values. The contractor shall provide the material property data to the Owner/Project Manager when the product is delivered to the site.

Extrusion resin used for extrusion welding with extrudate to make field seams between HDPE sheets and for repairs shall be HDPE sheet resin. Physical properties shall be the same as HDPE lining sheets.

2.1.1 Raw Materials

The raw material shall be first quality HDPE resin containing no more than 2% clean reground polymer by weight and shall be certified by the resin manufacturer for the following properties (as a minimum):

- Density;
- Specific gravity; and
- Melt index.

2.1.2 Geomembrane Production

The Geomembrane Manufacturer shall provide the Owner and/or Project Manager with the following:

- A properties sheet including at least all specified properties measured using test methods indicated in the specifications, or equivalent;
- The sampling procedure and results of testing; and
- A statement that property values given in the properties sheet are guaranteed by the Geomembrane Manufacturer.

The Owner and/or Project Manager will provide the CQA Officer with all information on the geomembrane provided by the Geomembrane Manufacturer. The CQA Officer shall verify that:

- Properties guaranteed by the Geomembrane Manufacturer meet all the specifications; and
- The measurements of properties by the Geomembrane Manufacturer are properly documented and test methods used are acceptable.

2.1.3 Geomembrane Rolls

Prior to shipment, the Geomembrane Manufacturer shall provide the Owner/Project Manager with a quality control certificate for each roll of geomembrane provided. The quality control certificate shall be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate shall include:

- Roll numbers and identification; and
- Sampling procedures and results of quality control tests including at least density, thickness, tensile strength, carbon black content and dispersion, puncture resistance, tear resistance, and dimensional stability tests, conducted in accordance with the methods indicated in the specifications or equivalent methods approved by the Designer.

The Owner/Project Manager shall provide the CQA Officer with the information on rolls provided by the Geomembrane Manufacturer. The CQA Officer shall:

- Verify that the quality control certificates have been provided for all rolls: and
- Review the quality control certificates and verify that the measured roll properties meet the specifications.

2.2 Transportation, Handling and Storage

Transportation of the geomembrane is the responsibility of the Geomembrane Manufacturer. Geomembrane Installer, or other party as provided in contract agreement(s). All handling on site is the responsibility of the Installer.

The CQA personnel shall verify the following:

- Handling equipment used on the site is adequate and does not pose any risk of damage to the geomembrane: and
- The Installer's personnel handle the geomembrane with care.

Upon delivery at the site, the Installer and the CQA personnel shall conduct a surface inspection of all rolls for defects and/or damage. This inspection shall be conducted without unrolling rolls unless defects or damages are found or suspected. The CQA personnel shall document each roll of FML delivered to the site. The CQA personnel shall indicate to the Owner and/or Project Manager:

- Rolls, or portions thereof, which should be rejected and removed from the site because they have severe flaws; and
- Rolls which include minor repairable flaws.

The Installer will be responsible for proper storage of the geomembrane. The Project Manager shall provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible. Storage space should be protected from theft, vandalism, passage of vehicles, etc. The CQA personnel shall verify that storage of the geomembrane

ensures adequate protection against dirt, debris and other sources of damage.

2.3 Conformance Testing

Upon delivery of the geomembrane, the CQA personnel shall ensure that samples are removed at the specified frequency and forwarded to the independent laboratory for testing to ensure conformance to both the design specifications and the list of guaranteed properties.

As a minimum, tests to determine the following characteristics shall be performed on geomembranes:

- Thickness (measured at several random locations on the sample);
- Tensile characteristics (yield strength, elongation at yield. break strength, elongation at break);
- Specific Gravity;
- Carbon Black Content; and
- Carbon Black Dispersion.

2.3.1 Test Procedures

The following test procedures shall be complied with:

- Thickness (ASTM D 5199 for smooth sheet and ASTM 5944 with Asperity Height GRI GM12 for textured sheet);
- Tensile strength (ASTM D 6693);
- Specific Gravity (ASTM D 1505);
- Carbon Black Content (ASTM D 1603); and
- Carbon Black Dispersion (ASTM D 5596).

In the above list of test procedures, ASTM D 6693 has replaced ASTM D 638 for tensile strength testing and will therefore is recommended in lieu of ASTM D 638. Where optional procedures are noted in the test method, the requirements of the specifications shall prevail.

2.3.2 Sampling Procedures

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 CQA personnel shall mark the machine direction on the samples with an arrow.

Unless otherwise specified, samples shall be taken at a rate of one per lot or one per 100.000 ft2, whichever is least. Thickness measurements shall be taken in the field at a rate of one measurement every 5 feet along the leading edge of each panel.

2.3.3 Test Results

The CQA Officer examines all results from the laboratory conformance testing and shall report

any non-conformance to the Project Manager.

3.0 INSTALLER QUALIFICATIONS

The installer shall be responsible for field handling, storing, placing, seaming, and other site aspects of the geosynthetic installation. Other responsibilities may include transportation of the geomembrane to the site and construction of anchor trenches and all temporary anchoring or loading required to support the liner during installation.

The installer shall be a well established firm which has installed more than 10,000,000 ft^2 of HDPE geomembrane in North America. The Installer shall be able to provide sufficient equipment and qualified personnel to meet the demands of this project. The Installer shall be approved and/or licensed by the Geomembrane Manufacturer. The Installer shall be pre-qualified and approved by the Design Engineer and the Owner.

All personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one seamer shall have experience seaming a minimum of 1,000,000 ft^2 of HDPE geomembrane using the same type of seaming apparatus in use at the site. The most experienced seamer, the "master seamer", shall provide direct supervision, as required, over less experienced seamers. No field seaming shall take place without the master seamer being present.

The Installer shall provide the Owner/Project Manager with a list of proposed seaming personnel and their professional records. This document shall be reviewed by the Owner/Project Manager and the CQA personnel. Any proposed seaming personnel deemed insufficiently experienced shall not be accepted by the Owner/Project Manager or shall be invited to pass a seaming test.

Prior to installation of the FML, the construction contractor shall:

- (Along with the manufacturer) submit a complete description of its quality control program, as applicable, for manufacturing, handling, installing, testing, repairing and providing a completed liner in accordance with requirements of the CQA manual and construction drawings and specifications;
- Submit installation drawings, description of installation procedures, and a schedule for performing/completing the work;
- Submit written certification (geomembrane quality control certificates) by the lining manufacturer that the lining materials to be installed conform to the requirements of the CQA manual and construction drawings and specifications;
- Submit for approval by the Design Engineer, certification that the surface on which the lining will be placed is acceptable; and
- Submit a complete description of welding procedures for making field seams and repairs

The quality control plans to be implemented for construction of the FML by the lining manufacturer and construction contractor(s) shall be in accordance with applicable paragraphs of the CQA Manual and the construction drawings and specifications.

4.0 GEOMEMBRANE INSTALLATION

4.1 Earthwork

4.1.1 Surface Preparation

The Earthwork Contractor shall be responsible for preparing the supporting soil according to the Design Engineer's specifications. All subgrade surfaces shall be maintained in a moist, smooth, uniform, and compacted condition and shall be checked to ensure the following prior to installation of the FML:

- All lines and grades have been verified by the project surveyor;
- Excessive desiccation and cracking in the clay liner does not exist or has been repaired;
- The subgrade has been prepared in accordance with the CQA manual and construction drawings and specifications; and
- The surface has been rolled and compacted and is free of surface irregularities which could damage the liner.

The CQA personnel shall verify that:

- The surface to be lined has been rolled and compacted so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade;
- The surface of the supporting soil does not contain stones which may be damaging to the geomembrane: and
- There is no area excessively softened by high water content.

The installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. This certificate of acceptance shall be given by the Installer to the Project Manager, and subsequently to the CQA personnel.

After the supporting soil has been accepted by the Installer, it shall be the Installer's responsibility to indicate to the Owner/Project Manager any change in the supporting soil condition that may require repair work. If the CQA personnel concurs with the Installer, then the Owner/Project Manager shall ensure that the supporting soil is repaired by the Earthwork Contractor.

4.1.2 Crest Anchorage System

The anchor trench shall be excavated by the Earthwork Contractor (unless otherwise specified) to the lines and widths shown on the design drawings, prior to geomembrane placement. The CQA personnel shall verify that the anchor trench has been constructed according to design drawings. The anchorage system shall be designed where, if enough lateral pressure is exerted on the geomembrane, the geomembrane will pull out of the trench instead of causing a failure in the sheet.

If the anchor trench is excavated in a supporting soil susceptible to desiccation, no more than the amount of trench required for the geomembrane to be anchored in one day shall be excavated (unless otherwise specified) to minimize desiccation potential of the anchor trench soils. Backfilling of the anchor trench shall be conducted in accordance with the project specifications.

4.2 Geomembrane Placement

4.2.1 Panel Identification

A panel is the unit area of geomembrane which is to be seamed in the field, i.e., a panel is a roll or a portion of roll cut in the field.

Each panel shall be given an "identification code" (number or letter-number) consistent with the layout plan. This identification code shall be agreed upon by the Owner/Project Manager, Installer and the CQA personnel. This panel identification code shall be as simple and logical as possible. (Note that roll numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field.)

4.2.2 Panel Placement

4.2.2.1 Location

The CQA personnel shall verify that panels are generally installed at the location indicated in the Design Engineer's or Installer's layout plan, as approved or modified.

The CQA personnel shall establish an "as-built" panel layout drawing showing panel numbers. The panel layout drawing shall also include seam numbers, test locations, and repair locations.

4.2.2.2 Installation Schedule

Field panels will be installed to protect any GCL that was placed on any given day. Installation normally should begin at the high point area and proceed toward the low point with "shingle": overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling should be made if and only if weather conditions can be predicated with certainty. Otherwise, scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Installer is fully responsible for the decision made regarding placement procedures.

The CQA Officer shall evaluate every change in the schedule proposed by the Installer and advise the Project Manager on the acceptability of that change. The CQA personnel shall verify that the condition of the supporting soil has not changed detrimentally during installation.

The CQA personnel shall record the identification code, location and date of installation of each panel.

4.2.2.3 Weather Conditions

Geomembrane placement shall not proceed at an ambient temperature below 5°C (40°F) or above 40°C (104°F) unless otherwise authorized. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g. fog, dew), in an area of ponded water, or in the presence of excessive winds. Additionally, the CQA personnel shall verify that the supporting soil has not been damaged by weather condition.

The CQA personnel shall verify that the above conditions are fulfilled, and shall inform the Owner/Project Manager if geomembrane is installed during adverse weather conditions.

4.2.2.4 Method of Placement

The CQA personnel shall verify and document the following:

- Weather conditions including temperature, wind and humidity;
- Any small equipment with low contact pressure used by the Installer does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
- Verify that no stones, construction debris, or other hems are present beneath the geomembrane which could cause damage;
- All personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
- Verify that the surface beneath the geomembrane has not deteriorated since previous acceptance;
- The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
- Observe the condition of the panels as they are deployed, and note any defects;
- The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
- Adequate loading (e.g. sand bags), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g. by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels);
- Direct contact with geomembrane is minimized; i.e. the geomembrane in traffic areas is protected by geotextiles, extra geomembrane, or other suitable materials.

The CQA personnel shall inform the Project Manager if the above conditions are not fulfilled.

4.2.2.5 Damage

The CQA personnel, along with the Installer, shall inspect each panel after placement and prior to seaming for damage. The CQA personnel shall advise the Owner/Project Manager which panels, or portion of panels, should he rejected, repaired, or accepted. Damaged panels or portion of damaged panels which have been rejected shall be marked and their removal from this work area recorded by the CQA personnel. Repairs shall be made according to procedures described in Section 4.4.

4.3 Seaming

4.3.1 Seam Layout

The Design Engineer or the Installer shall provide the Owner/Project Manager with a drawing of the facility to be lined showing all expected seams. The Owner/Project Manager shall provide this seam layout to the CQA personnel. The CQA personnel shall review the seam layout and verify that it is consistent with accepted state of practice.

In general, seams should be oriented parallel to the line of maximum slope (i.e., oriented along, not across, the slope). In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam (i.e. parallel to the toe of slope) should be placed on a slope, unless otherwise specified.

A seam numbering system compatible with the panel numbering system shall be agreed upon by the CQA personnel and the Installer.

There are two types of seams typically used to join HDPE membrane. These seams include extrusion, single fusion, and double fusion welds. Figure 2 (see Appendix A) illustrates the types of seams, destructive tests, and failure modes. A description of each type of seam follows:

- Extrusion- Welding of a seam where a ribbon of molten resin is introduced along the edge of a seam overlap. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.
- Fusion- Welding of a seam where a heated wedge is placed between two overlapped sheets such that the surface of both sheets are heated above the melting point. Once heated by the wedge, the sheets are passed through a set of pressure wheels which compress the sheets together to form a continuous homogeneous fusion weld. This type of weld can be completed with either a single track or double track.

4.3.2 Overlapping and Temporary Bonding

The CQA personnel shall verify that:

- The panels of HDPE geomembrane are overlapped by a minimum of 4 inches for fusion welding and 3.5 inches for extrusion welding: and

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

The CQA personnel shall log all appropriate temperatures and conditions, and shall document and report to the Owner/Project Manager any non-compliance.

4.3.3 Seam Preparation

The CQA personnel shall verify that:

- Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
- If seam overlap grinding is required, the process is completed according to the geomembrane Manufacturer's instructions and in a way that does not damage the geomembrane; and
- Seams are aligned with the fewest possible number of wrinkles and "fishmouths".

4.3.4 Seaming Equipment and Products

Only equipment which has been specifically approved by the Owner/Project Manager and CQA personnel by make and model shall be used. Any proposed alternate processes shall be documented and submitted by the installer to the Owner/Project Manager for his approval. The Owner/Project Manager shall submit this documentation to the Design Engineer and the CQA Officer for their concurrence.

The Installer shall provide documentation regarding the HDPE extrudate to the Owner/Project Manager and shall certify that the extrudate is compatible with the specifications.

The CQA personnel shall log pre-heater temperatures, extrudate temperatures and ambient temperatures.

The CQA personnel shall verify that:

- The installer maintains on-site the amount of spare operable seaming equipment agreed upon in the preconstruction meeting;
- Equipment used for seaming will not damage the geomembrane;
- The electric generator is placed on a smooth base such as a "rub sheet" (i.e., scrap geomembrane) such that no damage occurs to the geomembrane; and
- A smooth insulating plate or fabric is placed beneath the welding: equipment after usage.

4.3.5 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows:

- Unless authorized in writing by the Owner/Project Manager, no seaming shall be attempted below 5°C (40°F) nor above 40°C (104°F)
- In all cases, the geomembrane shall be dry and protected from wind.

If the Installer wishes to use methods which may allow seaming below 5 °C (40°F), an addendum to the contract between the Owner and the Installer is required which specifically states that the low temperature seaming procedure does not cause physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane. Then, the above quality assurance procedure shall be modified accordingly.

The CQA personnel shall verify that these weather conditions are fulfilled and will advise the Owner/Project Manager if they are not. The Owner/Project Manager shall decide if the installation shall be stopped or postponed.

4.3.6 Trial Welds

Trial welds shall be made at the beginning of each seaming period (i.e. start-up and after lunch), and at least once each five hours, for each seaming apparatus used that day. Also, each seamer shall make at least one trial weld each day. Trial welds shall be made under the same conditions as actual seams. Trial welds will be performed after each occurrence of a significantly different environmental conditions (such as temperature, humidity, dust, etc.), when seaming different geomembranes (e.g. tie-ins and smooth to texture). Both the welder and the machine must be tested for each new trial seam when extrusion welding. Only the machine needs to be tested for each new trial seam when fusion welding since the machine is not as operator dependant.

The trial seams shall be made from fragmented geomembrane. The trial weld test specimen shall be cut from a seam that is at least 10 feet long for a fusion weld and at least 3 feet long for an extrusion weld, with the seam centered lengthwise and at least a four inch overlap. Each trial test seam shall be at least 3 feet long by 1 foot wide. Test specimens, 1 inch wide, shall be cut from each end of the trial weld seam, and each shall be tested with a tensiometer for shear and peel strength. Four (six when possible if using dual track fusion welding) adjoining 1-inch wide specimens will be die-cut from the test seam sample. Two specimens will be tested in the field for shear and two for peel (4 when possible if testing both inner and outer welds for dual track fusion welding) The tensionmeter testing apparatus used for peel and shear tests must have an updated calibration certificate traceable to National Bureau of Standards (NBS). The failure criteria is the same as that for destructive seam testing. If the weld seam of a test specimen fails, the entire trial procedure shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be used for seaming until the deficiencies are corrected and two consecutive successful trial welds are achieved.

The CQA personnel shall observe all trial weld procedures and record the date, hour, ambient temperature, seaming unit and seamer, and pass/fail description.

4.3.7 General Seaming Procedures

Unless otherwise specified, the general seaming procedure used by the Installer shall be as follows:

- Seaming shall extend to the outside edge of panels to be placed in the anchor trench;
- If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support; and
- Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions. There shall be no unrepaired folds, large wrinkles or fish mouths allowed along the seam.

During welding operations, the CQA personnel shall document the following:

- The extrudate is purged prior to beginning each weld until all the heat-degraded extrudate is removed (extrusion welding only);
- Seam grinding has been completed less than one hour before seam welding (extrusion welding only);
- The ambient temperature measured at the FML surface is above 40 degrees Fahrenheit;
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only);
- The weld is free of dust and other debris;
- For cross seams, the seam is ground to a smooth incline prior to welding (fusion welding only);
- The seams are overlapped according to specifications;
- No solvents or adhesives are present in the seam area;
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing;
- The panels are being welded in accordance with the construction drawings and specifications; and
- There is no free moisture in the weld area.

The CQA personnel shall verify that the above seaming procedures (or any other procedures agreed upon) are followed, and shall inform the Owner/Project Manager if they are not.

4.3.8 Non-destructive Seam Continuity Testing

4.3.8.1 Procedure for Non-destructive Testing

The Installer shall non-destructively test 100 percent of all field seams and factory seams (if used) over their full length using air-pressure testing or a vacuum rest unit. The purpose of this test is to check the continuity of seams, and does not provide any information on seam strength. Continuity testing shall be done as the seaming work progresses, not at the completion of seaming. Air-pressure testing of seams shall be utilized whenever possible for double welded

fusion seams. If air-pressure testing is impractical or not productive, (such as for short double welded fusion seams, extrusion welded seams or failed air-tested seams), then the seams shall be vacuum tested for continuity.

Air-pressure testing procedures of double welded fusion seams are as follows:

- Seal both ends of the seam to be tested;
- Insert a needle pressure feed device into the air channel created by the fusion weld;
- Energize an air pump to a pressure of approximately 30 psi, close valve and sustain pressure for at least five minutes;
- A pressure loss of 4 psi is acceptable if it is determined that the air channel is not blocked between the sealed ends;
- If loss of pressure exceeds 4 psi within five minutes, locate faulty area and repair
- Before removing needle or pressure feed device, the opposite end of the air channel shall be pierced, and the resulting pressure drop observed, to assure the entire seam has been tested; and
- The geotechnical professional or his representative will observe and record all pressure gauge readings.

The following procedures shall be followed for vacuum testing (ASTM D 4437):

- Energize the vacuum pump and reduce the tank pressure to approximately 5 psi absolute;
- Wet a strip of geomembrane approximately 12 inches by 48 inches with a soapy solution;
- Place the vacuum box over the wetted area;
- Close the bleed valve and open the vacuum valve;
- Ensure that a leak tight seal is created;
- For a period of approximately 10 to 15 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles;
- If no bubble(s) appear during the test, (excluding the areas at the ends of the vacuum box), close the vacuum valve and open the bleed valve, wet another strip of seam, move the box over the next adjoining area with a minimum 3 inch overlap, and repeat the process; and
- All areas where soap bubbles appear shall be marked and repaired in accordance with Section 4.4.

4.3.8.2 Quality Assurance of Non-destructive Testing

The CQA personnel shall:

- Observe all continuity testing;
- Record location, date, test unit number, name of tester, pressures used, time and outcome of all testing; and
- Inform the Installer and Owner/Project Manager of any required repairs.

The Installer shall complete any required repairs in accordance with Section 4.4. Upon completion of the repair, the CQA personnel shall:

- Observe the repair and retesting of the repair;
- Mark on the geomembrane that the repair has been made; and
- Document the results.

The following procedures shall apply to locations where seams cannot be non-destructively tested:

- All such seams shall be cap-stripped with the same geomembrane; and
- If the seam is not accessible to testing prior to final installation, the seaming and capstripping operations shall be observed by the CQA personnel for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation shall be recorded by the CQA personnel.

4.3.9 Destructive Testing

There are two types of destructive seam testing required for the liner installation: peel adhesion (peel) and bonded seam strength (shear). The purpose of the peel and shear tests is to evaluate seam strength and to evaluate long-term performance. The location of where samples are obtained for seam weld testing shall be indicated on the as-built drawing. The seam identification number and the corresponding test results shall be recorded on the seam log.

4.3.9.1 Location and Frequency

The CQA personnel shall designate locations where seam samples will be cut out for laboratory testing. Locations shall be established as follows:

- Destructive test samples shall be taken at a minimum of one stratified location for every 500 linear feet of field seam or major fraction thereof. The total footage of individual repairs of leaks of more than 10 feet and individual repairs of more than 10 feet of failed seams must also be counted and destructively tested using the same frequency of testing described above.
- A maximum frequency shall be agreed upon by the Installer, Design Engineer, Owner/Project Manager and CQA personnel;
- Test locations shall be determined during seaming at the CQA personnel's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding; and
- At a minimum, a destructive test must be done for each welding machine used for seaming or repairs.

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

4.3.9.2 Sampling Procedure

Two types of samples shall be obtained at each test location. Two seam specimens one inch wide by 12 inches long with the weld centered across the length shall be taken 42 inches apart. These samples shall be tested in the field by the contractor using a tensiometer capable of quantitatively measuring shear and peel strengths. If a double fusion weld is to be tested, then both tracks of the weld should be tested, if possible. This test shall be observed by the CQA personnel.

Once the field tests have passed, a sample shall be recovered between the passing field sample locations for laboratory testing. The sample shall be 42 inches long by 12 inches wide, with the weld centered along the length. The sample shall be divided and distributed as stated below:

- One 12-inch by 12-inch section shall be given to the construction contractor(s);
- Field Testing shall include at least 2 peel test specimens (4 when possible for testing both tracks on dual-track fusion welded seams) and 2 shear test specimens;
- One 12-inch by 18-inch sample shall be sent to the laboratory for testing;
- Independent Laboratory Testing shall consist of at least 5 peel test specimens (10 when possible for testing both tracks on dual-track fusion welded seams) and 5 shear test specimens; and
- One 12-inch by 12-inch sample shall be given to the Owner for archive storage.

Samples shall be cut by the Installer as the seaming progresses in order to have laboratory test results before completion of liner installation. The CQA personnel shall:

- Observe sampling;
- Assign a number to each sample, and mark it accordingly;
- Record sample location on layout drawing; and
- Record reason for taking the sample at this location (e.g. statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 4.4. The continuity of the new seams in the repaired area shall be tested according to Section 4.3.8.

4.3.9.3 Destructive Test

The CQA personnel shall be responsible for maintaining proper labeling and documentation of all FML samples. All test samples shall be numbered by the CQA personnel. Information contained on the master log shall include:

- Sample number;
- CQA personnel who obtained the sample;
- Location of testing (onsite or offsite);
- Date sample collected and sent off to be tested or date tested in the field;
- Date results received or test completed at site;

- Test(s) performed on sample; and
- Test(s) results, indication of failing or passing, and additional comments when appropriate.

The samples shall be numbered the same as they are on the master log. The CQA monitor shall mark the sample immediately upon sampling, and shall be responsible for timely processing of test samples. The CQA personnel shall reserve the decision of the location of where samples shall be obtained or tested, and allow which samples shall be sent to the laboratory.

4.3.9.4 Laboratory Testing

The destructive test samples to be sent to an independent testing laboratory shall be packaged and shipped under the responsibility of the CQA personnel in a manner which will not damage the test sample. The Owner/Project Manager shall verify that packaging and shipping conditions are acceptable. The Owner/Project Manager will be responsible for packaging and storing the archive samples.

Test samples shall be forwarded to an Independent Testing Laboratory selected by the Owner/Project Manager with concurrence of the CQA Officer. Testing shall include "Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods" as referenced in ASTM D 6392. ASTM D 6392 is recommended for destructive seam testing since it has replaced ASTM D 4437.

Five test specimens shall be tested for each test method (ten for peel when testing both tracks on dual-track fusion welded seams where possible). The Independent Testing Laboratory shall provide test results no more than 24 hours after they receive the samples. The destructive test results shall meet or exceed the following specifications, and shall not have any visible sign of failure in the weld (see Table III-I).

The CQA personnel shall immediately notify the Design Engineer and construction contractor(s) of failing test results. The CQA Officer shall review Independent Laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

4.3.9.5 Procedure for Destructive Test Failure

The following procedures shall apply whenever a sample fails the destructive test. If laboratory test results indicate failure, then these procedures shall be followed using only the laboratory tests. The Installer has two options:

- The Installer can cap strip between the failed location and any passed test location; or
- The Installer can retrace the welding path to an intermediate location (at a 10 ft. minimum spacing from the location of the failed test) and take a small sample for an additional field test. If this additional sample passes the test, then the seam is reconstructed between that location and the original failed location. If this sample fails, then process is repeated to establish the zone in which the seam should be reconstructed.

The seam must be reconstructed in both directions from the original failed location and either one or both of the above procedures can be used to reconstruct the seam.

TABLE III-1
FML TEST SPECIFICATIONS – 60 MIL HDPE
City of Laredo
Webb County, Texas

TEST	TYPE OF TEST	STANDARD TEST METHOD	FREQUENCY OF TESTING
Resin	Density	ASTM D 1505	per 100,000 ft^2 and every resin lot
	Melt Flow Index	ASTM D 1238 (90/2.16 and 190/21.6)	
Manufacturer's Quality Control	Testing per GRI Standard GM13[A]		
Conformance Testing by 3rd Party Independent Laboratory	Thickness	ASTM D 5199 (smooth HDPE) or D 5994 (textured HDPE)	per 50,000 ft^2 and every resin lot
	Specific Gravity/Density	ASTM D 1505/D 792	per 100,000 ft^2 and every resin lot
	Carbon Black Content	ASTM D 1603	
	Carbon Black Dispersion	ASTM D 5596	
	Tensile Properties	ASTM D 6693 Type IV Dumbbell, 2 ipm, GL=2.0 in	
Destructive Seam Field Testing	Shear & Peel	ASTM D 6392	varies for field, lab, and archive
Non-destructive Seam Field Testing	Air Pressure	GRI GM6	all dual-track fusion
	Vacuum	ASTM D 4437	all non-air pressure tested seams when possible
	Other		concurrence of TCEQ

Notes:
A- UV Resistance testing not required for HDPE which is to be immediately covered.

TABLE III-2
FML DESTRUCTIVE TEST SPECIFICATIONS – 60 MIL HDPE
City of Laredo
Webb County, Texas

PROPERTY	TEST METHOD	SPECIFIED MINIMUM VALUE [1]			
		SMOOTH (lb/in)		TEXTURED (lb/in)	
		EXTRUSION WELD	FUSION WELD	EXTRUSION WELD	FUSION WELD
Peel Adhesion [2][3] (Peel) [2]	ASTM D 6392	FTB and 78	FTB and 91	FTB and 78	FTB and 91
Bonded Seam [2][3] Strength (Shear) [3]	ASTM D 6392	120		120	

To be considered passing: (a) all specimens tested in peel must fail in FTB; (b) at least 4 of the 5 specimens tested must meet the minimum specified value for peel and shear; (c) the 5th specimen can be as low as 80% of the listed values; (d) adhesion cannot be greater than 25%.

FTB: Film Tear Bond

[1] At least 4 of 5 specimens tested in the peel mode must fail in FTB.

[2] At least 4 of 5 specimens from each peel and shear determination must meet the following minimum specified values; peel strength minimum requirement for HDPE is 62% of the manufacturer's parent sheet strength but not less than 78 pounds per inch (ppi) and exhibit FTB; shear strength minimum requirement for HDPE is 95% of the manufacturer's parent sheet strength but not less than 120 ppi; and

[3] The average value from all 5 specimens from each peel and shear determination must meet the minimum specified value.

[4] The above criteria must be met by both tracks from each dual-track fusion welded seam before it is considered as passing.

Destructive seam testing locations shall be cap-stripped and the cap completely seamed by extrusion welding to the parent geomembrane. Capped sections shall be non-destructively tested. Additional destructive test samples may be taken if deemed necessary by the geotechnical professional or his representative. If a destructive test does not meet the passing criteria, additional destructive tests must be conducted at least 10 feet on both sides of the failed destructive test. If either of these destructive tests fails, the sampling and testing process must be repeated until the failed seam is bracketed by passing destructive tests. The failed seam must then be capped between the passing tests. Alternatively, all seams done by the welder/machine within the time period (between passing destructive tests or trial welds) represented by the failed destructive test may be capped. All field tested specimens from a destructive test location must be passing both shear and peel for the seam to be considered passing. Field tested specimens are determined as passing if the specimen tested in peel fails in film tear bond (FTB) and all test specimens meet the passing criteria for independent laboratory testing. Independent laboratory testing must confirm field results.

All acceptable seams must be bounded by two locations from which samples passing destructive tests have been taken. In all cases, to approve a reconstructed seam, a sample taken from the zone in which the seam has been reconstructed must pass destructive testing. Any seam or portion of seam in the zone reconstructed by the first of the above procedures, between the location which originally passed the destructive test and location which, after reconstruction, passes the second destructive test, is acceptable. Seams or portions of seams reconstructed by the second procedure are acceptable if an additional sample, located outside of, but adjacent to, the reconstructed seam, also passes destructive testing.

The CQA personnel shall document all actions taken in conjunction with destructive test failures.

4.4 Defects and Repairs

4.4.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the CQA personnel for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed by the Installer if the amount of dust or mud inhibits examination.

4.4.2 Evaluation

Each suspect location both in seam and non-seam areas shall be non-destructively tested using the methods described in Section 4.3.8 as appropriate. Each location which fails the non-destructive testing shall be marked by the CQA personnel and repaired by the Installer.

4.4.3 Repair Procedures

Repair procedures should be agreed upon between the Owner/Project Manager, Installer and CQA personnel. Unless otherwise agreed, the procedures shall be as follows:

- Defective seams shall be repaired by reconstruction;
- Pinholes shall be repaired by seaming or patching;
- Tears, larger holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches;
- Surfaces of HDPE geomembrane which are to be patched shall be abraded no more than one hour prior to the repair; and
- All seams used in repairing procedures must be approved extrusion welded seams and shall be subjected to the same non-destructive test procedures as outlined for all other seams.
- All seam leaks and destructive test locations shall be repaired for a distance of at least 6 inches on each side of the faulty spot or area detected. At a minimum, these repairs shall be non-destructively retested and possibly destructively tested.

Each patch shall be numbered and logged. Patches shall be round or oval in shape, made of the same geomembrane, and extend a minimum of 6 inches beyond the edge of defects. Patches shall be applied using approved methods only.

4.4.4 Seam Reconstruction Procedures

Seam reconstruction shall be achieved by grinding the existing seam and rewelding a new seam.

4.4.5 Verification of Repairs

Each repair shall be non-destructively tested using the methods described in Section 4.3.8 as appropriate. Repairs which pass the non-destructive test shall be taken as an indication of an adequate repair and the repair will be considered completed. Failed tests indicate that the repair shall be redone and retested until a passing test is obtained. The CQA personnel shall observe all non-destructive testing of repairs and shall record the number of each patch, date, and test outcome.

4.4.6 Excessive Wrinkles

When seaming of the geomembrane liner is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing materials on top of it, the CQA personnel shall observe the geomembrane wrinkles when the geomembrane is in a cool state. Wrinkles which can be folded over and creased by weight shall be repaired. The CQA personnel shall indicate to the Project Manager which wrinkles should be cut and reseamed by the Installer. The seam thus produced shall be tested like any other seam.

4.5 Backfilling of Anchor Trench

The anchor trench, if any, shall be backfilled and compacted by the Earthwork Contractor or the Installer in accordance with the construction specifications and/or drawings, and contractual agreements.

Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane. The CQA personnel shall observe the backfilling operation and advise the Project Manager of any problems.

4.6 Geomembrane Acceptance

Certificates of acceptance shall be used by the Design Engineer and/or CQA Officer to establish the acceptability of the installed FML. These certificates shall state that the FML has been installed in accordance with the construction drawings and specifications.

The Installer and Geomembrane Manufacturer shall retain all ownership and responsibility for the geomembrane until acceptance by the Owner.

The geomembrane liner shall be accepted by the Owner/Project Manager when:

- The installation is finished;
- All seams have been inspected and approved;
- All required laboratory tests have been completed and approved;
- All required documentation has been received from the construction contractor(s) and has been approved;
- All record drawings have been completed and approved; and
- The SLER and FMLER have been accepted by the TCEQ

The lining Manufacturer shall furnish a written lining material warranty on a prorated basis for a period of 5 years. The warranty shall be against manufacturing defects or workmanship and against deterioration due to ozone, ultraviolet, or other normal weather aging. The warranty shall be limited to replacement of material only, and shall not cover installation of said material. It shall not· cover damage due to vandalism, acts of animals or unusual acts of God.

The Installer shall furnish a written guarantee stating the entire lining work constructed by said contractor is free of defects in material and workmanship, and was installed pursuant to the CQA Manual for a period of one (l) year following the date of acceptance of the work by the Owner. The installer shall agree to make any repairs or replacements made necessary by defects in materials or workmanship in the work which become evident within said guarantee period. The Installer shall make repairs and/or replacements promptly. If the Owner secures the repair work, the Installer shall be liable to the Owner for the cost of such repairs and/or replacements.

4.7 Materials in Contact with the Geomembrane

The quality assurance procedures indicated in this section are only intended to assure that systems built with these materials would be constructed in such a way to enable proper performance.

4.7.1 Granular Materials

A copy of the specifications prepared by the Design Engineer for placement of granular materials shall be given to the CQA Officer by the Owner/Project Manager. The CQA personnel shall verify that these specifications are consistent with the state of the art such as:

- Placement of granular materials on the geomembrane shall not proceed at an ambient temperature below 5° (40°F) nor above 40°C (104°F) unless otherwise specified;
- A geotextile may be installed between angular aggregate and the geomembrane;
- Equipment used for placing granular material shall not be driven directly on the geomembrane;
- A minimum thickness of 1 foot of granular material is specified between a light dozer (such as a D-6 LPG or lighter which exerts a maximum contact pressure of 5 psi) and the geomembrane;
- A minimum thickness of 3 feet of granular material is specified between a rubber-tired vehicle and the geomembrane;
- In heavily trafficked areas such as access ramps, granular material thickness should be at least 3 feet; and
- The CQA personnel shall verify that placement of granular material is done in such a manner that geomembrane damage is unlikely.

The CQA personnel shall inform the Owner/Project Manager if the above conditions are not fulfilled.

4.7.2 Sumps and Appurtenances

A copy of the specifications prepared by the Design Engineer for sumps and appurtenances shall be given by the Owner/Project Manager to the CQA Officer. The CQA personnel shall review these specifications and verify the use of geosynthetic layers between concrete and geomembranes, if necessary.

The CQA personnel shall verify that:

- Installation of the geomembrane in sump and appurtenance areas, and connection of geomembrane to sumps appurtenances have been made according to the specifications;
- Extreme care is taken while welding around appurtenances since both non-destructive and destructive testing might not be feasible in these areas; and
- The geomembrane has not been visibly damaged while making connections to sumps and appurtenances.
- The CQA personnel will observe and record destructive testing and welding around the sumps and appurtenances.

The CQA personnel shall inform the Owner/Project Manager if the above conditions are not fulfilled.

SECTION IV: GEOTEXTILES AND GEONETS CQA

1.0 INTRODUCTION

Any geotextile and geonet (or geocomposite) materials used in conjunction with construction of the composite liner will be documented by the Manufacturers and CQA personnel. The following sections outline the quality assurance for geotextile and geonet materials.

2.0 MANUFACTURING

The Geotextile and geonet (or geocomposite) manufacturers will provide the Owner/Project Manager with a list of guaranteed "minimum average roll value" properties for the type of geotextile and geonet (or geocomposite) to be delivered. The manufacturer shall also provide a written quality control certification, signed by a responsible party employed by the Manufacturer, that the material delivered has properties that meet or exceed the guaranteed "minimum average roll value" properties. The contractor shall provide the material property data to the Owner/Project Manager when the product is delivered to the site.

Quality control certificates shall include the following:

- Roll identification numbers;
- Sampling procedures; and
- Results of quality control testing.

The Manufacturer of the geotextile shall provide, as a minimum, the following test results:

- Mass per unit area;
- Tear strength;
- Puncture strength;
- Permeability; and
- Apparent opening size.

The Manufacturer of the geonet (or geocomposite) shall provide, as a minimum, test results for the following:

- Transmissivity;
- Density;
- Mass per unit area;
- Carbon black content;
- Tensile strength; and
- Thickness.

The Manufacturers shall also provide a written certification that the geotextile and geonet is continuously inspected and, in the case of geotextile, found to be needle-free. The CQA Officer shall examine all the certifications to ensure that the property values listed meet or exceed those specified for that particular material.

The Manufacturers shall identify all rolls of geotextile and geonet with the following:

- Manufacturer's name;
- Product identification;
- Lot number;
- Roll number; and
- Roll dimensions.

The CQA personnel shall examine the rolls upon delivery, and will document each roll received and any damage to the rolls. Any deviation from the above requirements shall be reported to the Owner/Project Manager.

3.0 SHIPMENT AND STORAGE

During shipment and storage, the geotextile and geonet shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, the geotextile and geonet rolls shall be shipped and stored in relatively opaque and watertight wrappings.

The wrapping protecting the geotextile and geonet shall be removed less than one hour prior to placement. After the wrapping has been removed, the material shall not be exposed to sunlight for more than 15 days prior to placement of soil or waste material, unless otherwise specified and guaranteed by the Manufacturer.

4.0 HANDLING AND PLACEMENT

The Installer shall handle all geotextile and geonets in such a manner as to ensure that they are not damaged in any way. As necessary, the material shall be securely anchored in anchor trenches and rolled down slopes. In the presence of wind, the material shall be appropriately weighted with sandbags or the equivalent. Special care shall be taken during cutting to protect other materials from damage and not to entrap stones, excessive dust or moisture that could damage the underlying materials, generate clogging potential, or hamper subsequent seaming.

5.0 SEAMING AND OVERLAPS

At a minimum, all geotextile shall be properly overlapped and continuously sewn or heat bonded. For sewing purposes, the geotextile shall be overlapped approximately 4 inches. No horizontal scams will be allowed on side slopes, except as part of a patch. All sewing shall be done using polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile.

At a minimum, the geonet/geotextile composite shall be overlapped by at least 4 inches and secured by tying the geonet and sewing or heat bonding the geotextile. The tying of the geonet can be achieved by plastic fasteners or polymer braid. Tying devices shall be white or yellow for inspection purposes. Tying shall be conducted as a minimum of every 5 feet of seam on the slope and the every 8 feet on the seam bottom. The geotextile shall be sewn or heat bonded.

6.0 REPAIRS

Any holes or tears in the geotextile shall be repaired as follows:

- On slopes: A patch made from the same geotextile shall be sewn or heat bonded into place. A minimum overlap of 2 feet will be maintained.
- Non-slopes: A patch made from the same geotextile shall be spot sewn or heat bonded into place with a minimum of 2 feet overlap in all directions.

Any holes or tears in the geonet/geotextile composite shall be repaired by placing a patch extending 2 feet beyond edges of the hole or tear. The patch shall be secured to the original composite by tying at 1 foot intervals. If the hole or tear is more than 50% of the width of the roll, the damaged areas shall be cut out and replaced.

7.0 PLACEMENT OF SOIL MATERIALS

The Earthwork Contractor and/or the Installer shall place all soil materials located on top of the geotextile and geonet in such a manner as to ensure the following:

- No dumping directly on the geotextile;
- No damage to the material;
- Minimal slippage of the geotextile and geonet on underlying layers;
- No excess tensile stresses in the geotextile; and
- Protective cover shall be placed on sidewalls beginning at the bottom of the slope

proceeding to the top of the slope.

Unless otherwise specified by the Design Engineer, all lifts of material shall, in no case, be less than 12 inches, measured loose to provide adequate protection to the geotextile from heavy equipment.

SECTION V: LEACHATE COLLECTION SYSTEM CQA

1.0 INTRODUCTION

The purpose of the leachate collection system (LCS) in a MSWLF is to minimize the leachate head on the liner during operation and through the postclosure monitoring period. The LCS shall consist of the following:

- Collection pipe network;
- Granular drainage layer;
- Synthetic drainage layer; and
- Geotextiles (filter fabric).

2.0 DOCUMENTATION

The inspection and testing results of the LCS materials shall be recorded in the daily construction report and on other appropriate forms.

2.1 Collection Pipe Network

2.1.1 Pipe Specifications

The collection pipes shall be 6-inch diameter Schedule 80 PVC pipe or as required in the construction specifications. All pipes shall be of structural integrity to withstand the overburden pressures that will result from placement of solid waste into the landfill.

2.1.2 Construction Monitoring During Installation

The pipe network shall be placed as specified in the construction drawing and specifications. The pipe network installation shall be monitored to ensure the following:

- The pipes are placed at the specified locations and in the correct configurations;
- The pipes are placed at the proper grades as stated in the construction specifications; and
- The pipes are properly connected.

Once the collection pipe network is installed, the pipes shall be flushed to remove sedimentation and debris and to verify that the pipes are open. Standard sewer cleaning equipment can be used to remove objects and debris remaining in the pipes after simple flushing.

2.1.3 Gravel Packing Around Pipes

Gravel packing shall be placed around the collection pipes to ensure sufficient flow of leachate into the pipes. The gravel packing around the leachate collection pipes shall consist of rounded granular soils meeting the requirements of ASTM C 33 for coarse aggregate and Size No.4 graduation requirements or the requirements stated in the construction specifications, and shall have a permeability of 1 x 10^{-2} cm/s or greater as determined by ASTM D 2434. The gravel shall not have a calcium carbonate or calcium sulfate content that exceeds 15 percent by weight as determined by procedures set forth in the ASTM D 3042 modified method, since a calcium carbonate or calcium sulfate concentration above this value may induce clogging of the pipes when subjected to leachate.

The installation of the gravel packing shall be monitored to ensure the following:

- Gravel packing is properly placed around the collection pipes and meets the graduation requirements stated in the CQA manual of the construction specifications; and
- The gravel packing is properly wrapped and completely enclosed with a geotextile.

2.1.4 Sumps and Collection Trenches

Sumps and collection trenches should be constructed to the appropriate dimensions and grades. The thickness of day liner in the area of sumps and collection trenches shall be verified.

2.2 Granular Drainage Layer

This site may utilize a granular LCS drainage layer instead of using a geocomposite drainage layer with protective cover. The granular LCS drainage layer shall be constructed of rounded granular soils meeting the requirements of ASTM C 33 for coarse aggregate and Size No. 67 gradation requirements, or smaller, or the requirements stated in the construction specifications. These granular soils shall be selected on the basis of their permeability, grain size distribution, and calcium carbonate content. Once delivered at the site, the granular soils shall be tested to ensure that they meet the gradation and permeability specifications and are free from excessive amounts of fines or organic materials. The gravel shall be rounded and properly graded, and have a permeability, of 1 x 10^{-2} cm/s or greater as determined by ASTM D 2434. The percent of calcium carbonate or calcium sulfate shall not exceed 15 percent by weight, as determined by procedures set forth in the Concrete Handbook or the X-Ray Fluorescent technique respectively, to minimize clogging potential.

The granular drainage layer shall be a minimum 1-foot thick continuous granular blanket and the CQA personnel shall monitor the installation of the drainage layer to ensure the following:

- The thickness of the drainage layer meets the specified requirements; and
- The transport of fines by runoff into the LCS is prevented by barriers or filters.

Placement of the granular-material shall be conducted such that the material is not dumped or pushed directly on the geomembrane. The material shall be placed outside of the construction area,

and a staging area will be developed where the granular material can be pushed over the staging area with low ground pressure equipment and slowly spilled over the leading edge of the layer. This method of placement will ensure that the minimum thickness of one foot is maintained under the equipment, and the FML under the granular layer is not pushed to create wrinkles or possible tears.

At a minimum, the granular drainage layer shall be sampled and tested for gradation (ASTM D 422 or 1140) at a frequency of one test per 50,000 square feet of area.

2.3 Synthetic Drainage Layer

The synthetic drainage layer shall consist of a geonet specifically designed to have high permeability and sufficient strength characteristics (see Section V). This layer along with geotextile may be substituted on the slopes and floors for the granular drainage layer.

Upon delivery of the geonet/geotextile at the site, the CQA personnel shall observe the material to ensure that it contains no deficiencies or is not damaged during unloading. Any damaged rolls shall be rejected and removed from the site. At a minimum, the Manufacturer shall furnish certification with appropriate documentation that the geonet meets the design specifications. During geonet placement, the CQA personnel shall:

- Document all defects and actions implemented to repair or remove the defects;
- Verify that the geonet is not damaged during handling and placement;
- Verify that the geonet is appropriately anchored to prevent movement by wind; and
- Verify that the geonet is properly overlapped and joined in accordance with the specifications.

The CQA personnel shall inform both the construction contractor and the Owner/Project Manager if the above conditions are not met. All deficiencies with the geonet shall be repaired in accordance with this manual and the project specifications.

2.4 Geotextile Filter Fabric

The filter fabric, also referred to as a geotextile, is a synthetic product specifically designed to have high permeability and sufficient strength characteristics (see Section V).

Upon delivery at the site, the CQA personnel shall observe the geotextile to ensure that it contains no deficiencies or is not damaged during unloading. Any damaged rolls shall be rejected and removed from the site. At a minimum, the supplier shall furnish certification with appropriate documentation that the geotextile meets the design specifications.

Prior to geotextile installation, the CQA personnel shall verify that the supporting surface does not contain debris or have objects protruding which could damage the geotextile.

During geotextile placement, the CQA personnel shall:

- Document all defects and corrective measures implemented to repair or eliminate the defects;
- Verify that equipment used does not damage the geotextile by equipment transit, leakage of hydrocarbons, or other means;
- Verify that people working on the geotextile do not smoke, wear shoes that could damage the geotextile, or engage in activities that could damage the geotextile;
- Verify that the geotextile are anchored to prevent movement by the wind;
- Verify that seams are overlapped in accordance with the specifications; and
- Verify that the panels are being joined in accordance with the specifications.

The CQA personnel shall inform both the construction contractor(s) and the Owner/Project Manager if the above conditions are not met.

All deficiencies with the geotextile shall be repaired in accordance with the construction specifications. The CQA personnel shall document all repairs on the daily construction report. Repair procedures may include the following:

- Patching- Used to repair large holes, tears, large defects, and destructive sample locations; and
- Removal- Used to replace areas with large defects where the preceding method is not appropriate.

3.0 PROTECTIVE COVER

A minimum 2-foot thick protective cover (2 feet on slopes using a geocomposite drainage layer) shall be placed over the LCS. The thickness of the protective cover shall be verified through subsequent surveys. The protective cover shall consist of onsite soils resulting from landfill excavation which will possess a permeability of approximately 1×10^{-4} cm/sec or greater after minimal compaction. The protective cover in conjunction with the LCS shall provide a minimum of 2 feet of protection to the FML. Care shall be implemented during placement of the protective cover to avoid damage to the LCS. The protective cover will be tested every 20,000 cy for permeability (ASTM D2434). If the protective cover does not meet the permeability criteria, gravel-filled leachate drains tied into the underlying drainage layer may be constructed.

The protective cover will be placed with low ground pressure equipment (< 5psi). In areas of heavy traffic (such as access ramps) the thickness should be at least 2 to 3 feet (< 16 psi equipment).

SECTION VI: SURVEYING CQA

1.0 INTRODUCTION

Surveying of lines and grades shall be conducted on an ongoing basis during the construction of the composite liner system. Thorough CQA of the surveying is essential to ensure that slopes and base gradients are properly constructed to promote proper drainage to the sumps.

2.0 SURVEY CONTROL

If not available, a permanent benchmark shall be established for the site in a location convenient for daily tie-in. The vertical and horizontal control for this benchmark shall be established within normal land surveying standards.

3.0 SURVEYING PERSONNEL

The survey crew shall consist of a senior field surveyor and as many survey technicians as are required to satisfactorily undertake the requirements of the work. All surveying personnel shall be experienced in the provision of these services, including detailed accurate documentation. All surveying shall be performed under the direct supervision of a registered Professional Land Surveyor in the State of Texas. This licensed surveyor shall seal all survey drawings prepared showing in-place elevations.

4.0 SURVEYING PROCESS

4.1 Precision and Accuracy

The survey instruments used for this work should be sufficiently precise and accurate to meet the needs of the project. All survey equipment should be capable of reading to a precision of 0.001 foot and with a setting accuracy of ±0.8 seconds.

4.2 Lines and Grades

The following surfaces shall be surveyed to verify that proper lines and grades were achieved during the liner construction:

- Original subgrade surface;
- Top of the compacted clay liner;
- Top of the completed leachate collection system; and
- Top of the completed protective cover system.

During each subsequent survey, the crest and toe of each slope and the limits of each component shall be defined.

4.3 Frequency and Spacing

All surveying should be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. In addition, spot checks during construction will be necessary to assist the Earthwork Contractor in compliance with the required grades.

A grid should be established across the construction site to maintain point locations in the construction area for survey control. The grid should be established so that elevation points are present for at least every 5,000 square feet of surface area. The cross points of the grid should be utilized during each successive survey to maintain dimension control. The corresponding successive cross point locations should not vary by more than 0.3 feet horizontally with appropriate adjustments on side slopes. The subsequent surveys will be used to determine the constructed thickness of each component.

5.0 DOCUMENTATION

All field survey notes should be retained by the Surveyor. The findings from the field surveys should be documented on a set of as-built drawings. These drawings should, at least, show the final surface elevations (and thickness) of each liner system component.

SECTION VII: SOIL AND GEOSYNTHETIC EVALUATION REPORTS

1.0 INTRODUCTION

Upon completion of the field inspection laboratory testing and engineering evaluation an evaluation report for the earthwork portion and the geosynthetic portion of the liner system construction will be provided by the CQA Consultant. The following sections briefly describe the contents of those reports. Brief outlines for each report are contained in Appendix C to illustrate the contents of the reports, at a minimum.

2.0 SOIL LINER EVALUATION REPORT (SLER)

Upon completion of the clay liner portion of the liner system, a Soil Liner Evaluation Report (SLER) will be presented to document the activities associated with the earthwork. The SLER will contain, at a minimum, the soil and liner evaluation form developed by the TCEQ, and a construction quality assurance report. In this report, all relevant data and drawings will also be provided to present a full documentation of the activities. Upon completion of the SLER, the report and all attachments will be submitted to the TCEQ in triplicate.

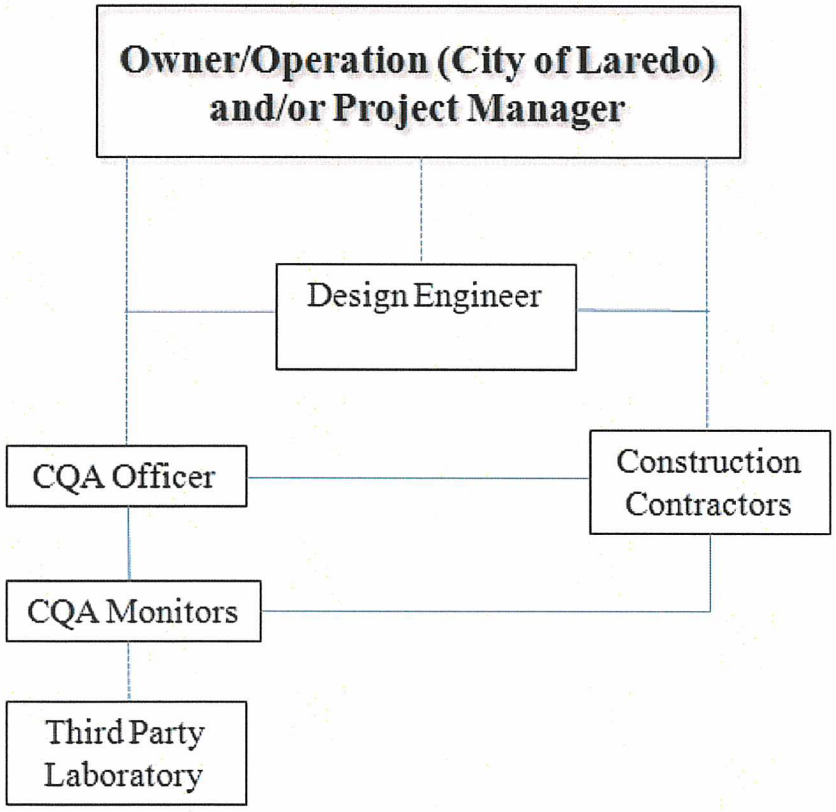
3.0 FLEXIBLE MEMBRANE LINER EVALUATION REPORT (FMLER)

A Flexible Membrane Liner Evaluation Report (FMLER) will be provided upon completion of the geosynthetic portion of the composite liner system to document the activities associated with the construction of the geosynthetics. The FMLER will contain, at a minimum, the flexible membrane liner evaluation form developed by the TCEQ, and a construction quality assurance

report. The report will present all relevant data and as-built drawings to fully document the construction activities. The FMLER will be submitted to the TCEQ, in triplicate, upon completion.

APPENDIX A
FIGURES

Figure 1
Project Organization



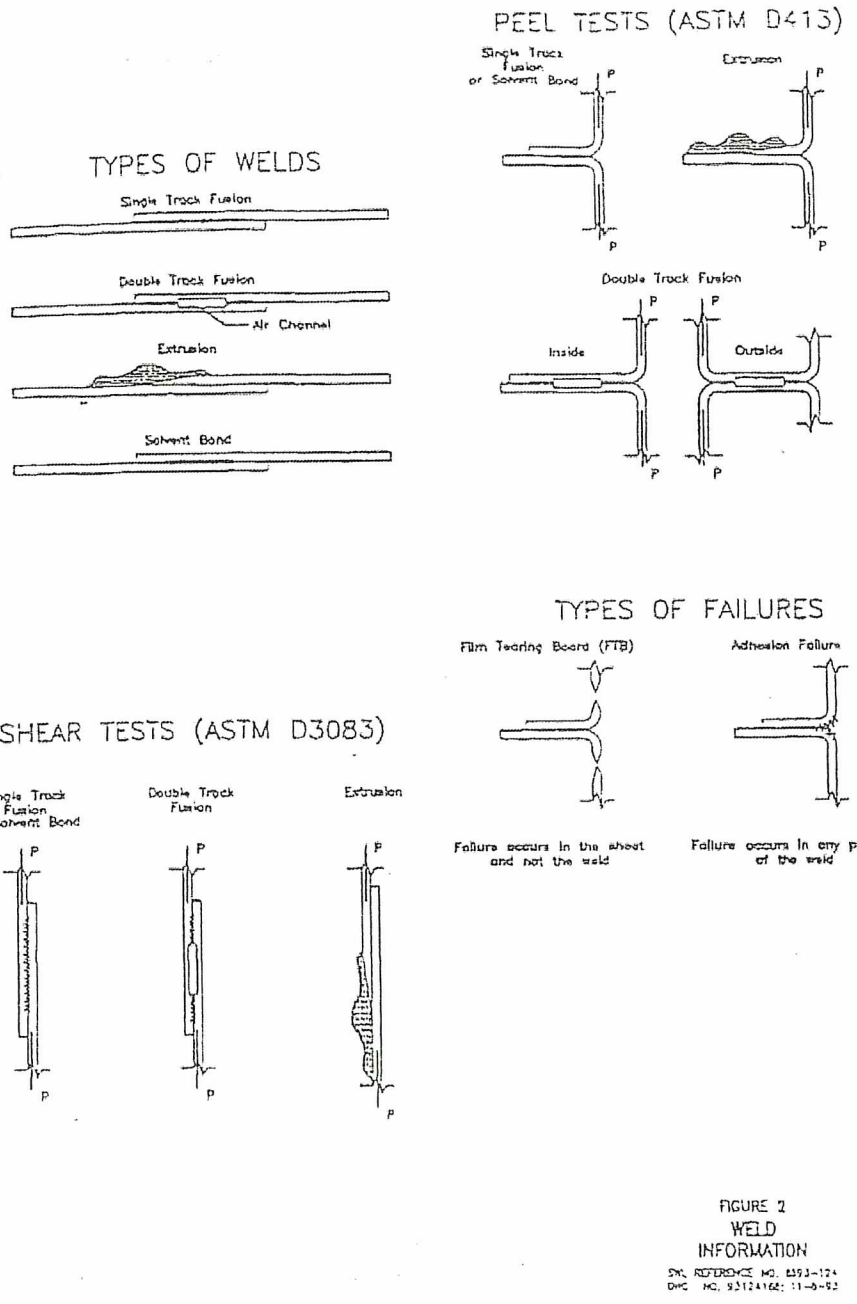


FIGURE 2
WELD
INFORMATION

APPENDIX B
CQA FORMS

Summary of Field Density Test Results
ASTM D 2922

Terracon

25809 Interstate 30 South
Bryant, AR 72022
(501) 847-9292

Project No: _____
Date of Report: _____

Client Name: _____
Contractor: _____
Project Name: _____
Location: _____
Reviewed by: _____
Technician: _____
Test Location: _____

Depart Lab: _____ Depart Site: _____
Arrive Site: _____ Arrive Lab: _____

MATERIAL INFORMATION			
Mat'l. No.	Material Description	Maximum Dry Density (pcf)	Optimum Moisture (%)

Test No.	Lift or Elev.	Test Location		Shelby Tube Sample	Mat'l. No.	Wet Density, pcf	Dry Density, pcf	Lab Max. Dry Density, pcf	Percent Compaction %	Pecent Compaction Required	Moisture Content %	Optimum Moisture %	PASS or FAIL
		Northing	Easting										

CERTIFICATE OF ACCEPTANCE OF SOIL SUBGRADE

Geosynthetic Installer _____ Project _____

Address _____ Location _____

_____ Owner _____

I, the Undersigned, the duly authorized representative of _____ do hereby accept the soil subgrade surface bounded by _____

_____

_____ as an acceptable surface on which to install and shall be responsible for maintaining its integrity and suitability in accordance with the project specifications from this date to the completion of the installation.

_____	_____	_____	_____
Name	Signature	Title	Date

Certificate accepted by QA/QC Manager:

_____	_____	_____	_____
Name	Signature	Title	Date

Certificate accepted by Owner:

_____	_____	_____	_____
Name	Signature	Title	Date

Geosynthetics Inventory

Terracon
25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

Terracon Project No:

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Manufacturer: _____
Transportation: _____
Date of Arrival: _____
Material Type: _____
Condition of Material: _____

ROLL COUNT	ROLL NUMBER	RESIN OR LOT NO.	MATERIAL DIMENSIONS				QC/QA CERT.	CONF. SAMPLE	REMARKS
			LENGTH (FEET)	WIDTH (FEET)	SQUARE FEET	THICK (MILLS)			

TOTAL THIS PAGE: ft^2
TOTAL ACCUMULATED: ft^2

Material Type Legend:

40S = 40 Mil Smooth HDPE Geomembrane
40T = 40 Mil Textured HDPE Geomembrane
60S = 60 Mil Smooth HDPE Geomembrane
60T = 60 Mil Textured HDPE Geomembrane

DSG - Double Sided Geocomposite
SSG - Single Sided Geocomposite
6oz Geo - 6 ounce Geotextile
12oz Geo - 12 ounce Geotextile

Geosynthetics Daily Deployment Log

Terracon

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

Date	Panel ID	Roll Number	Weather Conditions		Material Type	Approximate Panel Dimensions		Panel Visually Inspected (Y or N)	CQA Monitor
			Amb. Temp. (°F)	Weather/ Wind		Length (Feet)	Width (Feet)		

Material Type Legend:

60S - 60-Mil Smooth HDPE Geomembrane
60T - 60-Mil Textured HDPE Geomembrane
40S - 40-Mil Smooth HDPE Geomembrane
40T - 40-Mil Textured HDPE Geomembrane
DSGC - Double Sided Geocomposite
SSGC - Single Sided Geocomposite
8oz Geo - 8 ounce Geotextile
12oz Geo - 12 ounce Geotextile

Geomembrane Trial Weld Summary

Terracon
25809 Interstate 30 South
Bryant, Arkansas 72022
Phone: 501.847.9292
Fax: 501.847.9210

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

Specification for Trial Welds	
Peel Extrusion =	
Shear Extrusion =	
Peel Fusion =	
Shear Fusion =	

Date	Time	Ambient Temp °F	Sample ID	QC Initials	Machine Number	Seamer Initials	Weld Type	Fusion Weld		Extrusion Weld		Test Values lbs/inch	Pass or Fail
								Wedge Temp °F	Speed ft/hr	Temp °F	Preheat Setting		

Geomembrane Panel Seaming Summary

Terracon
25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

Client Name: _____
Contractor: _____
Project Name: _____
Address _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

[X] Primary
[ ] Secondary
[ ] Other: _____

Machine No. _____

Carry Over: _____ ft

PRODUCTION SEAM			LOCATION AND DISTANCE					DESTRUCTIVE TESTING			
Date	Time	Seamer Initials	Seam Number	Seam Length (ft)	QA ID	Location From - To	Accum. Seam Length (ft)	Destruct No.	Location From - To	Field Test Pass/Fail	Lab Test Pass/Fail

Seam Length this Machine:
Note: _____

This Page: _____ ft
Accumulated: _____ ft

Geomembrane Repair Log Summary

Terracon

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

Liner System
[X] Primary
[ ] Secondary
[ ] Other: _____

25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

DATE	LOCATION				REPAIR NO. AND CODE		REPAIR TYPE (3)	SIZE			WELDER ID		QA ID	NON-DESTRUCTIVE TESTING				
	PANEL	SEAM	DIST (ft)	OFFSET (ft)	(1)	(2)		LENGTH (ft)	WIDTH (ft)	DIA (ft)	MACH NO	OPER ID		DATE	OPER ID	PASS/ FAIL	ACTION	QA ID

NOTES: (1) Repair No.: Repairs should be numbered sequentially
(2) Repair Codes.: P = Patch, C = Cap, S = Anchor Trench Ext., DS = Destructive Sample, G = Grind and Weld, T = Topping along Fusion Seam
(3) Repair Types: E = Extrusion and F = Fusion

ABBREVIATIONS:
GV = Gas Vent
AT = Anchor Trench
EXT = Existing
PP = Pipe Penetration

Geomembrane Non-Destructive Test Log Summary

Terracon
25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

Date	Seam Number	Seam Length (ft)	Tester Initials	Air Testing						Vacuum Box P/F	Seam Section
				Pressure			Time		P/F		From - To
				Start	End	+/-	Start	End			

Key: AT = Anchor Trench P1 = Panel Number 1
EOS = End of Seam OBB = Overbuild Berm

Geomembrane Destructive Test Log Summary

Terracon

25809 Interstate 30 South
Bryant, AR 72022
Phone: 501.847.9292
Fax: 501.847.9210

Client Name: _____
Contractor: _____
Project Name: _____
Address: _____
Location: _____

Project Number: _____
CQA Monitor: _____
Reviewed By: _____
Approved By: _____
Liner Installer: _____

Destructive Testing Specifications	
Peel Extrusion =	
Shear Extrusion =	
Peel Fusion =	
Shear Fusion =	

Date	Sample ID	Seam Number	Machine Number	Seamer Initials	Test Values lbs/inch	Field Pass/Fail	Lab Pass/Fail	Comments

APPENDIX C
REPORT OUTLINES

SOIL LINER EVALUATION REPORT (SLER) OUTLINE

COVER LETTER
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1.0 SLER FORM
2.0 CQA REPORT
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  - 2.1.1 Scope
  - 2.1.2 Referenced Documents
  - 2.1.3 Parties to Construction
  - 2.1.4 CQA Personnel
- 2.2 Construction Information
- 2.3 CQA Activities
  - 2.3.1 Field Activities
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3.0 SUMMARY

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FLEXIBLE MEMBRANE LINER EVALUATION REPORT (FMLER) OUTLINE

COVER LETTER
TABLE OF CONTENTS

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- 2.2 Construction Information
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  - 2.2.2 Geotextile
  - 2.2.3 Geonet
  - 2.2.4 Anchor Trenches
  - 2.2.5 Leachate Collection System
  - 2.2.6 Protective Cover
- 2.3 CQA Activities
  - 2.3.1 Subgrade Acceptance
  - 2.3.2 FML Construction
  - 2.3.3 LCS Construction
  - 2.3.4 Protective Cover

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APPENDIX D
GEOSYNTHETIC CLAY LINER CQA

GEOSYNTHETIC CLAY LINER QUALITY ASSURANCE

1.0 INTRODUCTION

This document includes the requirements for selection, installation and protection of the Geosynthetic Clay Liner (GCL) as used in conjunction with the FML as the primary liner.

The overall goal of the GCL quality assurance program is to assure that proper construction techniques and procedures are implemented, and that the GCL is installed in accordance with construction drawings and specifications. The GCL portion of the liner system shall be installed and tested in accordance with the construction drawings and specifications, and this CQA document. To monitor compliance, the quality assurance program shall include:

- A review of the construction contractor's quality control submittals;
- Material conformance testing on samples collected prior to installation; and
- On-site construction monitoring.

2.0 MATERIALS

The GCL material to be used for this construction shall be an approved GCL, as either bentonite sandwiched between two geotextiles, such as Claymax produced by the James Clem Corporation, or bentonite bonded to a geomembrane, such as Gundseal produced by Gundle Lining Systems. The contractor shall provide the material property data to the Owner/Project Manager when the product is delivered to the site. The bentonite shall be natural sodium bentonite. The GCL shall meet the minimum specification for this project of a hydraulic conductivity of 5×10^{-9} cm/sec and an internal friction angle of 9° for unreinforced GCL in a hydrated state. A reinforced GCL shall be utilized on all cell side slopes. The material must exhibit an internal friction angle of 9° for the bottom liner system and 18° for the final cover system. The Manufacturer shall provide "minimum specifications" for the GCL and its components (bentonite and geotextile/FML facing) prior to construction to verify conformity with project specifications. The Manufacturer shall also provide a written certification that the GCL and its components meet the "minimum specifications", that the GCL has been continuously inspected and found to be needle-free, and that the bentonite will not shift during transportation or installation.

Quality control certificates shall also be submitted by the Manufacturer, which will be signed by a responsible party of the Manufacturer, and shall contain roll identification numbers and results of quality control rests. The GCL Manufacturer quality control tests shall include, at a minimum, clay mass per unit area (minimum of 0.75 lbs/sq.ft., oven dried at 105°), water content of bentonite (maximum of 25%), free swell (minimum of 24 ml), permeability, fluid loss (maximum 18 ml), and internal shear resistance. The bentonite manufacturer quality control tests shall include, at a minimum, water content, free swell, and liquid limit (minimum of 500%) or plate water absorption (minimum of 800%). The geosynthetic manufacturer tests shall include at a minimum, mass per unit area and strength properties (e.g., grab and Mullen burst strength) for geotextiles or density, thickness, melt flow index, tensile properties, tear resistance, and puncture resistance for FMLs, depending on the material provided for use. The Owner and Engineer reserve the right to reject any material which is deemed unsuitable, at no cost to the Owner.

The GCL manufacturer shall provide information in regards to granular bentonite to be applied at the seam overlap to provide permeability less than or equal to the parent material (i.e. spread rate, supporting test data, etc.)

3.0 SHIPPING AND HANDLING

The GCL shall be supplied in rolls which are individually wrapped in relatively opaque (plastic) protective covers. Each roll shall be marked with the Manufacturer's name, product identification, roll number, roll dimensions and roll weight. The Installer shall store the GCL in an area selected by the Owner and shall protect the GCL from damage by the environment and during handling. The rolls must be stored off the ground, covered with a tarp, and kept dry. Upon delivery at the site, CQA personnel shall document the arrival of the materials and obtain samples for subsequent laboratory testing, as specified in Section 4.0.

4.0 CONFORMANCE TESTING

The samples collected by the CQA personnel from the delivered rolls of GCL shall be forwarded to an independent laboratory for testing to ensure conformance with the specifications and the list of guaranteed properties. As a minimum, tests to determine the following characteristics shall be performed on the GCL:

- Mass per Unit Area (ASTM D 5993);
- Permeability (ASTM D 5887); and
- Direct Shear (ASTM D 6243) per GCL adjoining material type.

Test method ASTM D 5887 is recommended for permeability in the proceeding list since this method has replaced ASTM D 5084 modified or GRI GCL-2 as the preferred method. Test method ASTM D 6243 is recommended for direct shear since this method has replaced ASTM D 5321.

Samples shall be taken across the entire width of the roll and shall not include the first three feet. Samples shall be three feet long by the roll width. The CQA personnel shall mark the machine direction on the samples with an arrow.

Samples shall be taken at a minimum rate of one per lot or batch number, or one per 100,000 ft^2, whichever is least.

The CQA Officer shall examine all results from the laboratory conformance testing and shall report any non-conformance in accordance with Section 5.1.3 of Section I: General of the SLQCP.

5.0 INSTALLATION

The GCL Installer shall submit a copy of their quality control procedures prior to installation for review and concurrence with the Engineer. The GCL shall be handled in a manner to ensure it is not damaged during placement.

Prior to GCL installation, the CQA personnel and Installer shall inspect the sub grade soils and provide written certification that these soils are suitable for placement of the GCL. This certification shall be provided in the form of a Subgrade Acceptance sheet. The surface of the subgrade shall be smooth-drum rolled, such that loose soil, exposed rocks, or other foreign material are not protruding from the surface. Also, the surface shall be kept free from standing water.

CQA personnel shall provide 100 percent on-site monitoring of the GCL installation. Documentation of the roll numbers along with other pertinent data will be obtained as deployment of the GCL proceeds. The GCL shall be properly anchored at the top of the slope and deployed down the slope in a controlled manner. No horizontal seams shall be allowed on the slope. The edges of the GCL shall be weighted with sandbags in the presence of wind. The GCL shall be cut with a textile cutter or other approved device. During placement of the GCL, care shall be taken not to entrap stones or other deleterious material under the GCL. Equipment used to deploy the GCL must not cause rutting of the subgrade. Geomembrane-backed GCL must be placed with the bentonite side up. The GCL shall not be placed during or prior to impending inclement weather, or in areas of ponded water. GCL material that is hydrated prior to placement of the geomembrane shall be replaced at no cost to the Owner. Only that amount of GCL which can be covered with FML during the day shall be placed.

The GCL edges shall be overlapped a minimum of six inches on the sides or per the manufacturer's recommended overlap distance. Panel ends shall be overlapped a minimum of one foot on the floor. End laps on the sidewalls are to be avoided whenever possible. Written approval from TCEQ is required for sidewall end laps, and a minimum lap of 3 feet is required. For GCL with non-woven geotextile facing, granular bentonite must be applied to the overlapped area at a rate in accordance with the manufacturer's recommendations. In areas of repairs or sample locations, a patch of the same material shall be placed with a minimum overlap of one foot in all directions. If areas of shifted bentonite are encountered, a patch of the same material shall be placed and shall extend a minimum of one foot beyond the area of shifting. If flaws such as cuts, rips, shifted bentonite, etc., in excess of 50 percent of the width of the roll are found, the entire roll width shall be replaced at no cost to the Owner. In the area of a clay liner tie-in, the GCL shall extend a minimum of two feet beyond the tie-in area.

6.0 GCL ACCEPTANCE

Certificates of acceptance may be used by the Engineer and/or CQA Officer to establish the acceptability of the installed GCL. The Installer and Manufacturer shall retain all ownership and responsibility for the GCL until acceptance by the Owner.

TABLE D-1
LABORATORY TEST STANDARDS
FOR GCL MATERIALS
City of Laredo, Webb County, Texas

Manufacturer's Quality Control				**(Reinforced/Non-Reinforced)**
Test	Method (1)	Testing Freq.	Units	Min. Requirements
Bentonite Swell Index[2]	ASTM D 5890	1 per 100,000 lbs	mL/g	≥24/2 (min)
Bentonite Fluid Loss[2]	ASTM D 5891	1 per 100,000 lbs	mL	≤18 (max)
Bentonite Mass per Area[3]	ASTM D 5993	40,000 ft^2	lb/ft^2	≥0.75 (min)
Bentonite Moisture Content	ASTM D 4643 ASTM D 2216	1 per 100,000 lbs	%	≤12%
Geotextile Mass per Area	ASTM D 5261	200,000 ft^2	oz/yd^2	≥3 oz MARV
Geotextile Grab Tensile Strength	ASTM D 4632 ASTM D 6768	200,000 ft^2	lbs/ft	N/A
Geomembrane Mass/Unit Area[8]	ASTM D 5261 ASTM D 1525	200,000 ft^2	g/cm^3	≥94
Geomembrane Thickness[8]	ASTM D 5199 (Smooth) ASTM D 5944 (Textured)	200,000 ft^2	mil	20 avg./18 min.
Geomembrane Tensile Properties[8] (Strength / Elongation)	ASTM D 638 ASTM D6693	200,000 ft^2	lbs./in. / %	30 MARV / 100% MARV
GCL Grab Strength[4]	ASTM D 4632 ASTM D 6768	200,000 ft^2	lbs/in	≥30 MARV
GCL Peel Strength[4]	ASTM D 6496	40,000 ft^2	lbs/in	≥3.5 MARV
GCL Index Flux[5]	ASTM D 5887	1 per week	m^3/m^2/s	≤1 x 10^{-8} (max)
GCL Permeability[5]	ASTM D 5887	1 per week	cm/sec	≤5 x 10^{-9} (max)
Lap Joint Permeability	Flow box or other suitable device	(7)	_/_	N/A
Conformance Testing by CQA Engineer				**(Reinforced/Non-Reinforced)**
Bentonite Mass per Area[3]	ASTM D 5993	100,000 ft^2	lb/ft^2	0.75 (min)
GCL Grab Strength[4]	ASTM D 4632 ASTM D 6768	100,000 ft^2	lbs/in	≥30 MARV
GCL Peel Strength[4] (reinforced only)	ASTM D 4632/6496	100,000 ft^2	lbs/in	≥3.5/NA MARV
GCL Permeability[5]	ASTM D 5887	100,000 ft^2	cm/sec	5 x 10^{-9} (max)
GCL Hydrated Internal Shear Strength[6]	ASTM D 5321 ASTM D 6243	Periodic (6)	psf	≥500 typical @ 200 psf (min) / ≥100 typical @ 200 psf (min)

(See Table D-1 notes on next page)

Notes:

1. Test to be performed according to the latest test method as approved by the certifying engineer.
2. These parameters are for the bentonite incorporated into the GCL and do not necessarily reflect the properties of the bentonite in the finished product.
3. Bentonite mass per area is exclusive of the average weight of the geotextiles and is normalized by 0 percent moisture content per ASTM D 5993.
4. All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.
5. Index flux and permeability testing with deaired distilled/deionized water at 80 psi cell pressure, 77 psi headwater pressure and 75 psi tail water pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5×10^{-9} cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless gradient used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior to end of the production date of the supplied GCL may be provided.
6. ASTM D 5321·08 (geosynthetics) or D 6243 (GCLs) internal direct shear performed on GCL sample hydrated under 200 psf normal load and then sheared at 0.2 in./min. max for Procedure A and 0.04 in/min for Procedure B. Use wet conditions as per ASTM D 5321. The testing is required prior to construction of the first ECS Cell.
7. GCL Panels will be installed using the manufacturer's recommended overlap distances.
8. The use of geomembrane backed GCL's must be approved by the POR and TCEQ prior to use.