SAN ANGELO LANDFILL

TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

CELL 11A CONSTRUCTION
GEOSYNTHETICS CONSTRUCTION

Specifications, SLQCP, and Drawings

Prepared for

City of San Angelo

April 2014

Prepared by

BIGGS & MATHEWS ENVIRONMENTAL

1700 Robert Road, Suite 100 ◆ Mansfield, Texas 76063 ◆ 817-563-1144

TEXAS BOARD OF PROFESSIONAL ENGINEERS

FIRM REGISTRATION NO. F-256

TEXAS BOARD OF PROFESSIONAL GEOSCIENTISTS

FIRM REGISTRATION NO. 50222

CONTENTS

SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

PROJECT QUANTITIES

CITY OF SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION (GEOSYNTHETICS)
PROJECT QUANTITIES

Bid Items			
Item #	**Description**	**Quantity**	**Unit**
1	Non-Reinforced Geosynthetic Clay Liner Supply*		SF
2	Non-Reinforced Geosynthetic Clay Liner Installation	280,840	SF
3	Reinforced Geosynthetic Clay Liner Supply*		SF
4	Reinforced Geosynthetic Clay Liner Installation	18,430	SF
5	Smooth Geomembrane Liner Supply*		SF
6	Smooth Geomembrane Liner Installation	280,840	SF
7	Textured Geomembrane Liner Supply*		SF
8	Textured Geomembrane Liner Installation	18,430	SF
9	Single-Sided Drainage Geocomposite Supply*		SF
10	Single-Sided Drainage Geocomposite Installation	280,840	SF
11	Double-Sided Drainage Geocomposite Supply*		SF
12	Double-Sided Drainage Geocomposite Installation	18,430	SF
13	Geotextile for Leachate Collection System Supply	27,000	SF

* Bidder to calculate the lap/scrap factor for supply of geosynthetic clay liner, geomembrane liner, and drainage geocomposite and fill in the quantities, unit price, and total for these line items.

The quantity shall provide the amount of material required to be delivered to the site to complete installation in the project area.

The installed area is calculated by Engineer as 3D surface area and includes material to be placed in the anchor trench. The supplied material must cover the given installed area with allowance for scrap and overlaps typical to each material type. No additional payment will be made if supplied material does not cover given installed area and Contractor may be liable for time delay in getting additional material delivered to the project site.

SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

TECHNICAL SPECIFICATIONS

SECTION 01010
SUMMARY OF WORK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Project site location and access.
B. Scope of work.
C. Construction sequence.
D. Access to the site by authorized agencies of the Owner.
E. This section supplements the requirements specified in the General Conditions, Supplementary Conditions, and Construction Plans. If the requirements of this section and conditions noted above conflict, the Contractor shall adhere to the more stringent requirement as determined by the Owner/Engineer.

1.02 PROJECT SITE LOCATION AND ACCESS

A. The Site (also referred to in the Contract Documents as Project Site) is the City of San Angelo Landfill. The site is located about 3 miles northeast of the City of San Angelo on Old Ballinger Highway in Tom Green County, Texas.
B. Access to the work areas is via the existing entrance on Old Ballinger Highway.

1.03 SCOPE OF WORK

A. Principal features of the work may include:
   1. Supply and installation of non-reinforced and reinforced geosynthetic clay liner
   2. Supply and installation of smooth and textured geomembrane liner
   3. Supply and installation of single-sided and double-sided drainage geocomposite
   4. Supply of geotextile for leachate collection system
B. The above description of the work is for general information only, and does not limit the responsibility of the Contractor to accomplish the work in strict accordance with the Contract Drawings and Specifications.
C. Environmental Observations: The Work shall be performed in strict accordance with the applicable requirements of the state and local agencies having jurisdiction, and in accordance with the requirements of the General Conditions, the Supplementary Conditions, and these Specifications.

1.04 CONSTRUCTION SEQUENCE

A. Meetings may be conducted between the Owner/Engineer and Contractor prior to starting each sequence of construction. The intent of these meetings is to review and discuss specification requirements for that particular sequence of construction. During these meetings, the Contractor shall present a construction plan for each construction sequence as applicable outlining and detailing the equipment, personnel, schedule and materials required, including source, transportation, excavation, placement, and compaction of materials proposed.
B. The Contractor may be required to attend and participate in construction progress meetings. The purpose of these meetings is to bring to the attention of the Contractor, the Specification requirements, including quality control, as well as safety considerations of a particular phase of the Work prior to initiation of the activities.

1.05 ACCESS TO WORK

A. The authorized representatives of the Texas Commission on Environmental Quality will also have the right of access to inspect the Work covered by these Contract Documents during the performance of this Contract.
B. These inspections will be performed in the presence of the Owner/Engineer.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01019
MOBILIZATION AND DEMOBILIZATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Mobilization of all construction equipment, materials, supplies, appurtenances, and the like, manned and ready for commencing and performing the work. Assembly and delivery to the site or plant, equipment, materials, and supplies necessary for the performance of the work but which are not intended to be incorporated in the work; preparation of the Contractor's work area; complete assembly, and in working order, of equipment necessary to perform the required work; personnel services preparatory to commencing actual work; and all other preparatory work required to permit commencement of actual work on construction items for which payment is provided under the Contract.

B. Demobilization of all construction, equipment materials (excluding surplus materials specified to remain on site), supplies, appurtenances, and the like; and cleaning and restoration of the site upon completion of the work.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01190
HEALTH AND SAFETY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General requirements for the protection of Health and Safety of personnel involved in the construction of the Project.
B. General requirements for furnishing services of a Safety Monitor.
C. Preparation of Safety Program.

1.02 RELATED SECTIONS

A. Section 01010 - Summary of Work
B. Section 02315 – Excavating, Backfilling, and Compacting

1.03 REFERENCES

A. The CONTRACTOR shall be familiar with the Safety Guidelines as prepared by the Solid Waste Association of North America (SWANA) National Landfill Gas Committee in August 1991. Copies may be obtained by writing to SWANA, 1100 Wayne Avenue, Suite 650, Silver Spring, Maryland 20910, telephone number 301-585-2898.

1.04 QUALITY ASSURANCE

A. Nothing in this Section shall preclude the CONTRACTOR from complying with the more stringent requirements of the applicable Federal, State, County, OWNER and Industry Standards, rules, and regulations.

1.05 HAZARDOUS SITE CONDITIONS

A. The CONTRACTOR is advised that the construction of this project is being performed over and adjacent to buried wastes and refuse. As these buried materials decompose anaerobically, they will generate landfill gas (LFG), which normally consists of carbon dioxide (CO_2), methane (CH_4), and occasionally hydrogen sulfide (H_2S) and other gases, depending on the composition of the buried materials. These gases usually vent to the atmosphere through the cover soil, but may migrate laterally over 1,000 feet to adjacent areas depending on site and weather conditions.

B. The following landfill and LFG related information is included to assist the CONTRACTOR in developing his Safety Program and is not intended to encompass all steps that may be necessary to protect the workers or to comply with applicable regulations. A copy of the Safety Program shall be submitted to the OWNER and to the ENGINEER for their information.

1. Landfill gases usually vent to the atmosphere through the cover soils, but may migrate laterally to adjacent areas depending on site and weather conditions.
2. Landfills have the potential to create hazardous conditions if working conditions are not controlled or recognized. Some of the hazards are:
   a. Fires may start spontaneously from exposed and/or decomposing refuse.
   b. Fires and explosions may occur from the presence of methane gas.
   c. Landfill gases may cause an oxygen deficiency in underground trenches, vaults, conduits, and structures.
   d. Hydrogen sulfide, a highly toxic and flammable gas, or other toxic gas may be present.

e. Possible caving of trenches and excavations when working over or in refuse fills.
f. Splash hazards associated with landfill leachate and LFG condensate.

1.06 SAFETY MONITOR

A. The CONTRACTOR shall provide a person who will be designated as the LFG Safety Monitor. The Safety Monitor shall be thoroughly trained in rescue procedures, and in the use of safety equipment and gas detectors. He shall be present at all times during working hours whenever open trenches or excavations are greater than 2 feet in depth, when refuse is exposed, or when LFG is likely to be present.

B. The Safety Monitor shall have appropriate instruments (detector[s]) to test for oxygen deficiency and for the presence of methane gas and hydrogen sulfide gas. A personal gas monitor (such as Lumidor Safety Products PGM13, Gas Tech GX-82, Model 1641, or similar unit[s]) shall be available for this purpose. The Safety Monitor shall periodically calibrate his instruments and regularly test the excavation areas and other work space for safe working conditions and ensure that appropriate safety equipment is available at the site.

C. The Safety Monitor shall have the delegated authority to order workers on the project site to comply with the LFG safety requirements. Failure to observe his order shall be cause for removal of the worker from the project.

1.07 SAFETY PROGRAM

A. Supplemental to the CONTRACTOR's regular safety program, the CONTRACTOR shall develop and institute procedures to inform all workers and site visitors of the potential for the presence of methane and other landfill gases emanating from the natural decomposition of refuse buried at or near the job site and the importance of safety precautions to ensure the safety of workers and the public. The CONTRACTOR shall also instruct all workers and maintain strict control of construction activities to protect and maintain the integrity of the work features as they are installed.

1.08 SAFETY PRECAUTIONS

A. In addition to conforming to the safety rules and regulations of governmental authorities having jurisdiction, the CONTRACTOR shall take the following precautionary measures:

1. Periodically during construction, the work space should be monitored for concentrations of methane and hydrogen sulfide. Workers shall not be permitted to enter a workspace where there is an oxygen deficiency or a combustible mixture of gases without appropriate protection. Positive fan-forced ventilation to dilute gas mixtures and avoid oxygen deficiency should be provided when work is necessary in any workspace.
2. Smoking shall be strictly prohibited in all areas of the landfill.
3. In the event toxic gases are present at concentrations hazardous to the workers or the general public, the CONTRACTOR shall immediately evacuate all persons from the area until the area is determined safe by the Safety Monitor.
4. Soil shall be stockpiled adjacent to the work space in areas of exposed refuse for fire-fighting purposes.
5. The use of explosives or firearms shall not be permitted on the site.
6. If refuse is exposed during construction activities, it shall be covered as soon as possible after exposure with at least a 6-inch layer of soil. In no event shall the refuse remain exposed overnight, unless otherwise approved by the OWNER/ENGINEER and/or the local health authorities.
7. If refuse is excavated during construction activities, it shall be disposed of at the Site, as directed by the OWNER/ENGINEER. Contractor to comply with Texas Commission on Environmental Quality rules and site operating practices for covering any excavated or exposed refuse to control odors while performing this project. Refuse stockpiles shall be removed from the work site before the end of work each day.
8. The Site will accept refuse that results from the construction of the work specified in the Contract Drawings and Specifications.

9. Arrangements for waste disposal must be coordinated with the Site Manager. The cost of handling and hauling refuse spoils shall be considered as included in the contract price for the pay item with which they are included. The OWNER will waive the cost associated with disposal of the refuse spoils at the working face.
10. No welding shall be permitted in trenches, enclosed areas, or over refuse unless performed in areas of the site tested and approved by the Safety Monitor.
11. Combustion engine powered construction equipment used in excavating activities and/or refuse removal operations shall be equipped with vertical exhaust and spark arrestors.
12. Electric motors and controls utilized in excavation areas and in below ground work spaces shall be explosion-proof.
13. As construction progresses, all pipe openings and valves shall be closed as soon as installed to prevent the migration of gases through the pipeline systems.

B. Trench and Site Safety. If not already included in the standard safety practices, the CONTRACTOR should include Occupational Health and Safety Act (OSHA) training (29 CFR 1910) and the following measures in his safety program:

1. For all excavations and trenches, the CONTRACTOR shall comply with all federal, state and local requirements for trench safety.
2. The trench excavation safety system shall be used for all trench excavations deeper than five (5) feet. The *Excavation and Trenching Operation Manual* of OSHA shall be the minimum governing requirement of this item and is hereby made a part of this specification. The design of the trench excavation safety protection system shall be performed by or under the supervision of a professional engineer licensed to practice in the state of Texas.
3. Any personnel working near the edge of excavations, manholes, or similar construction should wear a parachute-type harness securely attached to a lanyard. The lanyard should be made as short as possible and securely fastened to a safe object such as a parked vehicle or drill rig.
4. Shoring shall be installed for all trenches over 5 feet in depth. Safe and suitable ladders that project at least 3 feet above the top of the trench should be provided for all trenches. A minimum of one ladder should be provided for each 100 feet of open trench, or fraction thereof, and be so located that workers in the trench need not move more than 50 feet to a ladder.
5. Workers shall not be allowed to work alone at any time in an excavation. Work parties of at least three workers shall be mandatory, with one worker outside of the hazard area and another worker within hailing distance to assist in an emergency.
6. Inhalation of landfill gases shall be avoided. Such gases or oxygen-deficient air may cause nausea and dizziness, which could lead to accidents. Work upwind of the excavation where possible, unless the excavation is constantly monitored and declared safe.
7. Workers shall avoid contact with exposed refuse, condensate, or leachate. Irritants or hazardous materials may be present.
8. No excavation or drilled hole greater than 2 feet deep shall be left unattended or left open at any time unless it is securely covered in a safe manner acceptable to the regulatory agency having jurisdiction.
9. Fire extinguishers with a rating of at least “B” shall be available at all times on the site.
10. Startup and shutdown of equipment shall be avoided in areas of exposed refuse.
11. Personnel, when in an open excavation or in the presence of landfill gas, shall be fully clothed with non-sparking cloth, wear shoes with non-metallic soles, and wear a hard hat and safety goggles or glasses. The excavation shall be monitored continuously in a manner satisfactory to the Safety Monitor for the presence of methane, hydrogen sulfide, and oxygen for the duration that personnel are in an excavation. Workers should immediately vacate an excavation if methane, hydrogen sulfide, or oxygen deficiency is detected therein, and shall not be permitted to re-enter the excavation unless satisfactory precautionary measures for a safe work environment are implemented.

12. Assembly of construction work shall be performed outside of trenches or excavations. Prefabricated items shall be lowered into excavations. Only final connections may be made within trenches with the necessary precautions stated.

PART 2 PRODUCTS

(Not Used)

PART 3 EXECUTION

(Not Used)

END OF SECTION

SECTION 01302
MEASUREMENT AND PAYMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

The "Bid Price" for each and every item, as set forth in the Proposal, shall include the furnishing of all labor, tools, materials, machinery, appliances, plant, and equipment appurtenant to and necessary for the construction and completion in a first class, workmanlike manner of all work as herein specified in strict accordance with these Specifications and accompanying Plans. The "Bid Price" shall also include any and all kinds, amount, or class of excavation, backfilling, pumping, or drainage; sheeting, shoring, and bracing; disposal of any and all surplus materials; protection of all overhead, surface, or underground structures; removal and replacement of any poles, conduits, pipelines, appurtenances, and connections; cleaning up, overhead expense, bond, public liability and compensation and property damage insurance, patent fees, royalties, risk due to the elements, and profits, unless otherwise specified.

The bid price shall also include all other incidentals not specifically mentioned above that may be required to fully construct each and every item complete in place in accordance with the true intent and meaning of the Specifications and accompanying Plans.

The actual installed amount for each item, including underages and overages from the initial bid amount, will be paid for based upon the original unit price amount in the bid proposal.

The CONTRACTOR shall take all measures necessary to protect existing structures on the areas adjacent to the work, and if damaged, shall replace them in as good condition or better than previously existed at his own cost and expense without additional compensation from the OWNER.

Listed below are descriptions of items as listed in the Proposal and the manner in which payment shall be awarded for each. If there is not a specific measurement and/or payment section, paragraph, or item associated with each Technical Specification contained in this Contract Document, then the following descriptions shall be used to describe measurement and payment.

PART 2 BASE BID ITEMS

2.01 ITEMS NO. 1 AND 2 – NON-REINFORCED GEOSYNTHETIC CLAY LINER

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Non-Reinforced Geosynthetic Clay Liner within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.02 ITEMS NO. 3 AND 4 – REINFORCED GEOSYNTHETIC CLAY LINER

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Reinforced Geosynthetic Clay Liner within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.03 ITEMS NO. 5 AND 6 – SMOOTH GEOMEMBRANE LINER

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Smooth Geomembrane Liner within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.04 ITEMS NO. 7 AND 8 – TEXTURED GEOMEMBRANE LINER

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Textured Geomembrane Liner within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.05 ITEMS NO. 9 AND 10 – SINGLE-SIDED DRAINAGE GEOCOMPOSITE

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Single-Sided Drainage Geocomposite within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.06 ITEMS NO. 11 AND 12 – DOUBLE-SIDED DRAINAGE GEOCOMPOSITE

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Double-Sided Drainage Geocomposite within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

2.07 ITEM NO. 13 – GEOTEXTILE FOR LEACHATE COLLECTION SYSTEM

The unit price bid on the per square foot basis shall be full compensation for all parts, labor, materials, and incidentals required for the Geotextile for Leachate Collection System within the project area as specified in the Specifications and shown on the Plans or as directed by the OWNER.

END OF SECTION

SECTION 02070
GEOTEXTILES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials and installation of geotextiles in leachate collection system.

1.02 RELATED SECTIONS

A. Section VIII – Soil and Liner Quality Control Plan (SLQCP)

1.03 QUALITY ASSURANCE

A. Quality Assurance shall be performed in accordance with Section VIII.
B. CQA monitor shall be present at all times during geotextile installation activities.

1.04 REFERENCES

A.	ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
B.	ASTM D 4716	Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
C.	ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
D.	ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
E.	ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
F.	ASTM D 3786	Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics - Diaphragm Bursting Strength Tester Method
G.	ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon ARC Type Apparatus
H.	ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles

1.05 SUBMITTALS

A. The geotextile manufacturer will test the geotextile prior to shipment to ensure that the physical properties of the finished product are in accordance with these Specifications. Test results shall be forwarded to the CQA Monitor with each shipment of material. In addition, a letter of certification from the geotextile manufacturer stating that the material is in compliance with the Contract Specifications will accompany the Manufacturer's test results.

PART 2 PRODUCTS

2.01 MATERIALS

A. Geotextile "A" shall be placed over and around the leachate collection system drainage aggregate as shown on the Plans, and shall be a non-woven, needle-punched, continuous filament, polyester or polypropylene material.
B. Geotextile "B" shall be bonded to the drainage geonet in accordance with Section 02071 – Drainage Geocomposite and shall be a non-woven, needle-punched, continuous filament, polyester or polypropylene material.

C. All geotextile shall be free of oil, grease, and other foreign materials.
D. Properties:

Geotextile "A"
(Needlepunched Nonwoven)

Properties And Requirements	Qualifier	Units	Specified Values[1]	Test Method
Type	---	---	Nonwoven	---
Fabric Weight	Minimum	oz/yd^2	16	ASTM D 5261
Apparent Opening Size	Maximum	Sieve	100	ASTM D 4751
Grab Strength[2]	Minimum	lb	300	ASTM D 4632
Tear Strength[2]	Minimum	lb	120	ASTM D 4533
Puncture Strength[2]	Minimum	lb	180	ASTM D 4833
Burst Strength[2]	Minimum	psi	600	ASTM D 3786
UV Resistance[3]	Minimum	%	70	ASTM D 4355

NOTES:

[1]All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

[2]Minimum value measured in machine and cross machine direction.

[3]Ultraviolet Resistance requirement is at 500 hours of exposure.

Geotextile "B"
(Needlepunched Nonwoven)

Properties And Requirements	Qualifier	Units	Specified Values[1]	Test Method
Type	---	---	Nonwoven	---
Fabric Weight	Minimum	oz/yd^2	6	ASTM D 5261
Apparent Opening Size	Maximum	Sieve	70	ASTM D 4751
Grab Strength[2]	Minimum	lb	160	ASTM D 4632
Tear Strength[2]	Minimum	lb	60	ASTM D 4533
Puncture Strength[2]	Minimum	lb	80	ASTM D 4833
Burst Strength[2]	Minimum	psi	270	ASTM D 3786

NOTES:

[1]All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table).

[2]Minimum value measured in machine and cross machine direction.

2.02 DELIVERY, STORAGE, AND HANDLING

A. All geotextiles shall be sealed in plastic at the factory prior to shipment to the job site.
B. All geotextiles shall be protected from precipitation, inundation, ultraviolet exposure, dirt, puncture, cutting, and other damaging or deleterious condition.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Geotextiles shall be installed with a minimum 2 inch overlap between edges and shall be field sewn or heat bonded.
B. Until sewn, the loose edges of the geotextiles shall be temporarily secured with sand bags or other methods approved by the Engineer.

C. Holes or tears in the geotextile shall be repaired by placing a patch of equivalent filter or cushion geotextile over the defective area. The patch shall extend a minimum of 8 inches beyond the edges of the hole or tear and shall be secured in place by sewing to the parent geotextile.

3.02 FIELD QUALITY CONTROL

A. The CQA monitor will observe for holes, tears, and other visible defects. These defects will be noted and marked on the geotextile for identification of necessary repairs.
B. Material found to be unusable due to holes and tears shall be removed prior to final placement.

END OF SECTION

SECTION 02071
DRAINAGE GEOCOMPOSITE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials and installation of single-sided drainage geocomposite.
B. Materials and installation of double-sided drainage geocomposite.

1.02 RELATED SECTIONS

A. Section VIII – Soil and Liner Quality Control Plan (SLQCP)

1.03 QUALITY ASSURANCE

A. Quality assurance shall be performed in accordance with Section VIII.
B. CQA Monitor shall be present at all times during drainage geocomposite installation activities.

1.04 REFERENCES

A. ASTM D 638 Standard Test Method for Tensile Properties of Plastics
B. ASTM D 792 Standard Test Methods for Density and Specific Gravity of Plastics by Displacement
C. ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique
D. ASTM D 1603 Test Method for Carbon Black Content in Olefin Plastics
E. ASTM D 1621 Test Method for Compressive Properties of Rigid Cellular Plastics
F. ASTM D 1682 Test Methods for Breaking Load and Elongation of Textile Fabrics
G. ASTM D 1777 Measuring Thickness of Textile Materials
H. ASTM D 4716 Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

1.05 SUBMITTALS

A. The Contractor shall submit, prior to delivery, a certification with test data signed by a legally authorized representative from the Manufacturer. The certification shall demonstrate compliance and attest that the drainage geocomposite being furnished meets the requirements stated in these Specifications.

PART 2 PRODUCTS

2.01 MATERIALS

A. Drainage Geocomposite: Comprised of non-woven, needle-punched, continuous or staple filament, polyester or polypropylene geotextile, heat-bonded to top side (single-sided) or both sides (double-sided) of an integrally formed, solid rib, extruded, high density polyethylene (HDPE) or polyethylene (PE) strands or mesh net structure (geonet or drainage net).
B. The bonding process shall not introduce adhesives or other foreign products.
C. The drainage geocomposite shall have uniform channels and open areas to provide uniform flow of water.
D. The drainage geocomposite shall be resistant to normal compressive loads up to 10,000 psf.
E. The drainage geocomposite shall be resistant to ultraviolet degradation.

Property	Test Method	Requirement
Specific Gravity	ASTM D 1505	Minimum 0.935 g/cm^3
Thickness	ASTM D 1777	Minimum 0.20 inch
Percent Carbon Black	ASTM D 1603	Minimum 2% Maximum 3%

F. The geotextile portion of the drainage geocomposite shall conform to Geotextile "B" as provided in Section 02070 - Geotextiles.
G. The drainage geocomposite shall have a hydraulic transmissivity greater than or equal to $5x10^{-4}$ m^2/sec at a hydraulic gradient of 0.1 and a normal pressure of 5,000 psf when tested in accordance with ASTM D 4716.

2.02 SOURCE QUALITY CONTROL

A. Measure product thickness at a minimum of once every 100,000 square feet of product.
B. Measure specific gravity and percent carbon black at a minimum of once every 100,000 square feet of product.
C. Measure geotextile properties at a minimum of once every 100,000 square feet of product.
D. Provide quality control test data with certification per paragraph 1.05 of this Specification.
E. Provide quality control certificates for each lot and each shift's production. Certificates shall include roll numbers and identification.

PART 3 EXECUTION

3.01 PLACEMENT OF DRAINAGE GEOCOMPOSITE

A. Place the drainage geocomposite in locations shown on the Plans.
B. The surface to receive the drainage geocomposite shall be smooth, free from obstructions, depressions, and sharp objects.
C. Place the drainage geocomposite with the long dimension down the slope.
D. The drainage geocomposite shall be laid smooth and free of tension, stress, folds, wrinkles, or creases.
E. Any damage to underlying materials caused by placement of the drainage geocomposite shall be repaired by the Contractor at no additional cost to the Owner.

3.02 SEAMING GEOCOMPOSITE ROLLS

A. Adjacent rolls of drainage geocomposite shall be tightly butted together and securely tied.
B. Tie geocomposite with plastic fasteners at a minimum of every 4 feet longitudinally and every 6 inches at end seams.
C. Overlap geotextile at least 6 inches and heat bond or sew the seams.

3.03 REPAIRS

A. Any holes or tears in the drainage geocomposite shall be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
B. The patch shall be secured to the originally installed drainage geocomposite by tying every 6 inches.
C. If the hole or tear width across the roll is more than 50% of the width of the roll, the damaged area shall be cut out across the entire roll and the 2 portions of the drainage geocomposite shall be joined.

END OF SECTION

SECTION 02072
HDPE GEOMEMBRANE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials and installation of smooth HDPE geomembrane.
B. Material and installation of textured HDPE geomembrane.

1.02 RELATED SECTIONS

A. Section 02076 – Geosynthetic Clay Liner
B. Section VIII – Soil and Liner Quality Control Plan (SLQCP)

1.03 QUALITY ASSURANCE

A. Quality assurance shall be in accordance with Section VIII.
B. CQA Monitor shall be present at all times during HDPE geomembrane installation activities.

1.04 REFERENCES

A. ASTM D 0638 Standard Test Method Tensile Properties of Plastics
B. ASTM D 0746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
C. ASTM D 0792 Standard Test Methods for Density and Specific Gravity of Plastics by Displacement
D. ASTM D 1004 Test Method for Tear Resistance of Plastic Film and Sheeting
E. ASTM D 1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
F. ASTM D 1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
G. ASTM D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
H. ASTM D 1593 Specification for Nonrigid Vinyl Chloride Plastic Film and Sheeting
I. ASTM D 1603 Test Method for Carbon Black Content in Olefin Plastics
J. ASTM D 3015 Standard Practice for Microscopic Examination of Pigment Dispersion in Plastic Compounds
K. ASTM D 3083 Standard Specification for Flexible Plastic Sheeting for Pond, Canal, and Reservoir Lining
L. ASTM D 3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Thermal Analysis
M. ASTM D 4437 Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes
N. Federal Test Method Standards: 101C Puncture Resistance
O. Geosynthetic Research Institute (GRI):
    1. Test Method GM-4 – Multiaxial Burst Test
    2. Test Method GM-5 – Notched Constant Tensile Load Test

1.05 SUBMITTALS

A. Prior to installation, the manufacturer shall submit quality control certificates signed by a responsible party employed by the manufacturer in accordance with Section VIII.
B. Two weeks prior to installation of geomembrane, submit drawings showing the panel layout indicating details not conforming to the Contract Drawings. Upon acceptance, use these drawings for installation of geomembrane.

C. Qualifications
   1. Submit, two weeks prior to installation, name of installer, and resume of Installation Supervisor/Field Engineer to be assigned to the project.
   2. Submit, two weeks prior to installation, resume of master seamer.
   3. Submit, two weeks prior to installation, resumes of installation seamers performing seaming operations.
   4. Submit, two weeks prior to installation, equipment list and list of personnel to perform field seaming operations.

D. Field Quality Control Documents
   1. Submit quality control documentation prepared during installation.
   2. Submit daily prior to the start of installation, subgrade acceptance certificate signed by the installation supervisor for each area to be covered by the geomembrane.
   3. Submit upon completion of the installation, certificate stating the liner has been installed in accordance with the plans and specifications.
   4. The warranty obtained from the manufacturer/fabricator and the installation warranty.
   5. As-built drawings showing location of panels, seams, repairs, patches, and destructive samples including measurements.

PART 2 PRODUCTS

2.01 GEOMEMBRANE RESIN

A. High Density Polyethylene (HDPE), new, first quality, compounded, and manufactured specifically for producing HDPE geomembrane.
B. Do not mix resin types during manufacturing.
C. Do not use recycled materials or seconds in manufacturing.

2.02 TEXTURED AND SMOOTH HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

A. The HDPE geomembrane shall have the properties listed in Section VIII.

2.03 EXTRUDATE ROD OR BEAD

A. Meet the geomembrane requirements.
B. Made from same resin as the geomembrane.
C. Thoroughly disperse additives throughout rod or bead, containing 2 to 3 percent carbon black.
D. Free of contamination by moisture or foreign matter.

2.04 WELDING EQUIPMENT

A. Maintain sufficient operational seaming apparatus to continue work without delay.
B. Use power source capable of providing constant voltage under combined line load.
C. Provide protective lining and splash pad large enough to catch spilled fuel under electric generator, if located on liner.
D. Tensiometers capable of measuring seam strength, calibrated and accurate within 2 pounds.
E. Dies for cutting seam samples.

2.05 CONFORMANCE TESTING

A. Conformance testing shall be in accordance with Section VIII.

2.06 HANDLING AND STORAGE

A. Geomembrane handling and storage shall comply with the requirements of Section VIII.

PART 3 EXECUTION

3.01 PREPARATION OF SUBGRADE

A. Verify in writing to the Engineer that the surface on which the geomembrane will be installed is acceptable. Installation without written acceptance means acceptance.
B. Round sharp grade changes to 6-inch radius.

3.02 PREPARATION

A. Repair damage caused to subgrade during deployment.
B. Round edges of anchor trenches.
C. Perform trial seam welds in accordance with the requirements of Section VIII.
    1. A trial weld sample is considered passing when all specimens pass peel and shear tests.
    2. When repeated trial welds fail, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are achieved.

3.03 INSTALLATION

A. Deployment shall be in accordance with Section VIII.
    1. Assign each panel a unique identifying code number or letter consistent with the Contractors submitted panel layout drawing. The coding is subject to approval by the CQA Monitor.
    2. Deploy no more panels in one shift than can be welded or secured during that same day.
    3. Do not deploy in the presence of excessive moisture, precipitation, ponded water, or high winds.
    4. Do not damage geomembrane by handling, by trafficking, or leakage of hydrocarbons or any other means.
    5. Do not wear damaging shoes or engage in activities that could damage the geomembrane.
    6. Unroll geomembrane panels using methods that will not damage, stretch or crimp geomembrane. Protect underlying surface from damage.
    7. Use methods that minimize wrinkles and differential wrinkles between adjacent panels.
    8. Place ballast on geomembrane that prevents uplift from wind. Use ballast that will not damage geomembrane.
    9. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.
    10. Do not allow vehicle traffic directly on the flexible membrane.
    11. Remove heavily wrinkled or folded material.
    12. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.
    13. Before wrinkles fold over, attempt to push them out. For wrinkles that cannot be pushed out, cut them out and repair cuts prior to burial or at the direction of the CQA Monitor.
B. Seam Layout.
    1. Orient seams parallel to line of a maximum slope (i.e., orient down not across slope).
    2. Minimize number of field seams in corners, odd-shaped geometric locations, and outside corners.
    3. Keep horizontal seams at least 5 feet away from toe or crest of slope.
    4. Use seam numbering system compatible with panel number system. Each seam must have a unique number.
    5. Shingle panels on slopes and grades so that upgradient panel is on top.
C. Seam Welding Personnel.
    1. Provide at least one master welder at site.
    2. Qualify personnel performing welding operations by experience and by successfully passing field-welding tests performed on site.
    3. Master welder will provide direct supervision over other welders.

D. Seam Welding Equipment.
   1. Extrusion welder must be equipped with gauges showing temperatures in extruder apparatus and at nozzle. Temperature at nozzle may be measured by external temperature gauges.
   2. Hot wedge welder shall be automated variable speed vehicular mounted devices with pressure controlled by spring, pneumatic, or other system that allows for variation in sheet thickness. Rigid frame fixed position equipment is not acceptable.
   3. Maintain adequate quantity of welding apparatus in order to avoid delaying the project.
   4. Use power source capable of providing constant voltage under combined line load.

E. General Welding Procedures.
   1. Do not commence welding until trial weld test sample, made by that equipment, passes test.
   2. Clean surface of grease, moisture, dust, dirt, debris, or other foreign material.
   3. Overlap panels a minimum of 4 inches.
   4. Do not use solvents or adhesives unless product is approved in writing by the Engineer.
   5. Provide adequate material on weld to allow peel testing of both sides of double wedge weld.
   6. Extend welding to the outside edge of all panels.
   7. If required, provide a firm substrata by using a flat board, a conveyor belt, or similar hard surface directly under the weld overlap to achieve firm support.
   8. Provide adequate illumination if welding operations are carried out at night.
   9. Cut fishmouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion weld the cut fishmouths or wrinkles where the overlap is more than 3 inches. When there is less than 3 inches overlap, patch with an oval or round patch extending a minimum of 6 inches beyond the cut in all directions.
   10. Weld only when ambient temperature, measured 6 inches above the geomembrane is between 40^{o}F and 104^{o}F unless other limits are accepted, in writing, by the Engineer.

F. Defects and Repairs.
   1. Examine all weld areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the flexible membrane shall be clean at the time of the examination.
   2. Repair and non-destructively test each suspect location. Do not cover geomembrane at locations which have been repaired until test results with passing values are available.

G. Extrusion Welding.
   1. Use procedures to tack bond adjacent panels together that do not damage flexible membrane.
   2. Purge welding apparatus of heat-degraded extrudate before welding.
   3. Bevel top edges of geomembrane a minimum of 45^{o} and full thickness of flexible membrane before extrusion welding.
   4. Clean seam welding surfaces of oxidation by disc grinder or equivalent not more than one hour before extruding weld.
   5. Do not remove more than 4 mils of material when grinding.
   6. Cover entire width of grind area with extrudate.
   7. When restarting welding, grind ends of all welds that are more than one hour old.

H. Interface Extrudate Welding.
   1. Mount components necessary to weld on mobile unit.
   2. Include the following accessories on mobile unit:
      a. Variable speed control.
      b. Wheels with non-skid surface.
      c. Directional control.
      d. Automatic hot air system for preheating welding surfaces.
      e. Extruder system with appropriate die.
      f. Adjustable contact pressure rollers.
   3. Test and set “hot air system” using scrap material each day prior to commencing welding.
   4. Adjust hot air velocity to preclude wind effects.

5. Adjust contact pressure rollers to prevent surface ripples in panels.
6. Protect against moisture build-up between panels.

I. Hot Wedge Welding.
1. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.
2. Protect against moisture build-up between panels.
3. Bevel edges of top and bottom panels on cross seams.
4. Do not weld on flexible membrane until equipment has passed trial weld test.
5. Extrusion-weld a patch over or spot weld all seam intersections as described in paragraph 3.05.

3.04 FIELD QUALITY CONTROL AND QUALITY ASSURANCE

A. Nondestructive Testing (Performed by Installer).
1. Nondestructively test all field seams over their full length using a vacuum test unit, air pressure, or other approved methods. Perform testing as the seaming progresses and not at the completion of all the field seaming. Complete all required repairs in accordance with this Specification.
2. Test procedures and weld acceptance criteria shall be in accordance with Section VIII.

B. Destructive Testing (performed by CQA Monitor and the Installer).
1. Collect destructive test samples at a minimum frequency of one test location per 500 feet of seam length.
2. Determine test locations during welding. Locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or suspected defect. CQA Monitor will be responsible for choosing the locations. The CQA Monitor will not notify the installer in advance of selecting locations where weld samples will be taken.
3. Test Procedures and weld acceptance criteria shall be in accordance with Section VIII.

C. Failed Weld Procedures.
1. Procedures apply when test failure is determined by the Construction Quality Assurance Laboratory, the installer, or by field tensiometer. Follow one of the following two options:
a. First Option.
1) Reconstruct the seam between any two passing test locations.
b. Second Option.
1) Trace the weld at least 10 feet minimum in both directions from the location of the failed test, or to the end of the welds in question.
2) Obtain a small sample at both locations for an additional field test.
3) If these additional test samples pass field tests, then take laboratory samples.
4) If the laboratory samples pass, then reconstruct the weld or cap between the two test sample locations that bracket the failed test location.
5) If any sample fails, then repeat the process to establish the zone in which the weld must be reconstructed.

D. Acceptable Welded Seams.
1. Bracketed by two locations from which samples have passed destructive tests.
2. For reconstructed seams exceeding 50 feet, a sample taken from within the reconstructed weld passes destructive testing.
3. Whenever a sample fails, provide additional testing for seams that were welded by the same welder and welding apparatus or welded during the same time shift.

E. Seams That Cannot Be Non-Destructively Tested.
1. If the weld is accessible to testing equipment prior to final installation, non-destructively test the weld prior to final installation.
2. If the weld cannot be tested prior to final installation, cap strip the weld. The welding and cap-stripping operations must be observed by the CQA Monitor and installer for uniformity and completeness.

3.05 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.
B. Repair, removal, and replacement are at Contractor's expense if the damage results from the Contractor's, Installer's, or the Contractor's subcontractor activities.
C. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test. Agreement upon the appropriate repair method will be determined between the Owner and CQA Monitor. Do not commence welding on liner until trial weld test sample, made by that equipment and operator, passes trial test. Repair procedures available include:
    1. Patching: Used to repair large holes (over 3/8-inch diameter), tears (over 2 inches long), undispersed raw materials and contamination by foreign matter.
    2. Abrading and re-welding: Used to repair small sections of seams.
    3. Spot welding or seaming: Used to repair small tears (less than 2 inches long), pin holes or other minor, localized flaws.
    4. Capping: Used to repair large lengths of failed seams.
    5. Removing the seam and replacing with a strip of new material.
D. In addition, satisfy the following procedures:
    1. Abrade flexible membrane surfaces to be repaired (extrusion welds only) no more than one (1) hour prior to the repair.
    2. Clean and dry all surfaces at the time of repair.
    3. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.

3.06 GEOMEMBRANE ACCEPTANCE

A. Contractor retains all ownership and responsibility for the flexible membrane until acceptance by the Owner.
B. The Owner will accept flexible membrane installation when:
    1. All required documentation from the manufacturer, fabricator, and installer has been received and accepted.
    2. The installation is finished.
    3. Test reports verify completion of all field seams and repairs.
    4. Written certification documents and drawings have been received by the Owner.

END OF SECTION

SECTION 02076
GEOSYNTHETIC CLAY LINER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials and installation of Non-Reinforced Geosynthetic Clay Liner (GCL)
B. Materials and installation of Reinforced Geosynthetic Clay Liner (GCL)

1.02 RELATED SECTIONS

A. Section VIII – Soil and Liner Quality Control Plan (SLQCP)

1.03 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Section VIII.
B. CQA monitor shall be present at all times during GCL installation activities.

1.04 REFERENCES

A.	ASTM D 2216	Determination of Moisture Content of Soil
B.	ASTM D 5084	Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (modified)
C.	ASTM D 5321	Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
D.	ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
E.	ASTM D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
F.	ASTM D 3786	Test Method for the Mullen Burst Strength of Textiles
G.	USP-NF-XV11	Test Method for the Free Swell of Bentonite Clay
H.	GRI-GCL-I	Test Method for the Confined Swell of Geosynthetic Clay Liners

1.05 SUBMITTALS

A. Pre-installation: Submit the following to the Engineer for approval prior to GCL deployment.
   1. Manufacturer's specification for GCL, which includes properties, contained in Section 2.01 of this Specification and in Section VIII.
   2. Written certification that the GCL meets the properties listed in Section 2.01 of this Specification and in Section VIII.
   3. Written certification that GCL manufacturer has continuously inspected GCL for the presence of needles and found GCL to be needle-free.
   4. Quality control certificates signed by a responsible entity of the GCL manufacturer. Each quality control certificate shall include roll identification numbers and results of quality control tests. At a minimum, results shall be given for tests and corresponding methods specified in Section 2.01 of this Specification and in Section VIII.
B. Installation: As installation proceeds, submit subgrade surface acceptance documentation, signed by the Contractor, for each area that will be covered directly by GCL.

1.06 DELIVERY, STORAGE, AND HANDLING

A. GCL shall be supplied in rolls wrapped individually in relatively impermeable and opaque protective covers.

B. GCL rolls shall be marked and tagged with the following information:
   1. Manufacturer's name.
   2. Product identification.
   3. Roll number.
   4. Roll dimensions.
   5. Roll weight.

C. Store and protect GCL from dirt, water, ultraviolet light exposure, and other sources of damage.

PART 2 PRODUCTS

2.01 MATERIALS

A. The active ingredient of the GCL shall be natural sodium bentonite.

B. The GCL product shall have the following properties:

PROPERTY	TEST METHOD	FREQUENCY, ft^2 (m^2)	REQUIRED VALUE	
			Reinforced	Non-Reinforced
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tons	24 mL/2g min.	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tons	18 mL max.	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2	0.80 lb/ft^2	0.80 lb/ft^2
GCL Grab Strength[3]	ASTM D 4632	200,000 ft^2	90 lbs	100 lbs
GCL Peel Strength[3]	ASTM D 4632	40,000 ft^2	15 lbs	N/A
GCL Index Flux[4]	ASTM D 5887	Weekly	1×10^{-8} $m^3/m^2/sec$	1×10^{-8} $m^3/m^2/sec$
GCL Permeability[4]	ASTM D 5084	Weekly	5×10^{-9} cm/sec	5×10^{-9} cm/sec
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321	Periodic	500 psf typical	50 psf typical

Notes:

[1] Bentonite property tests performed at Bentonite processing facility before shipment to manufacturer's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

[4] Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of $5x10^{-9}$ cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless the gradients 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 the end of the production date of the supplied GCL may be provided.

[5] Peak value measured at 200 psf (10 kPa) normal stress. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

C. The bentonite sealing compound or bentonite granules used to seal penetrations and make repairs shall be made of the same natural sodium bentonite as the GCL and shall be as recommended by the GCL manufacturer.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. The subgrade shall be prepared in a manner consistent with proper subgrade preparation techniques for the installation of geosynthetic materials.
B. The subgrade shall be properly compacted so as not to settle and cause excessive strains in the GCL or other synthetic liner materials.
C. Ensure that rutting or raveling is not caused by installation equipment.
D. Ensure a surface free of debris, roots, or angular stones larger than 3/4-inch diameter.
E. Prior to installation, ensure that the subgrade has been rolled to provide a smooth surface.

3.02 INSTALLATION

A. Handle GCL in a manner to ensure it is not damaged. At a minimum, comply with the following:
   1. Cut GCL with a geotextile cutter (hook blade), scissors, or other approved device. Protect adjacent materials from potential damage due to cutting of GCL.
   2. Prevent damage to underlying layers during placement of GCL.
   3. During GCL deployment, do not entrap in or beneath the GCL any stones, trash, or moisture that could damage GCL.
   4. Visually examine entire GCL surface. Ensure that no potentially harmful foreign objects, such as needles, are present.
   5. Do not place GCL in the rain or at times of impending rain.
   6. Do not place GCL in areas of ponded water.
   7. Overlap GCL to the manufacturer's match line.

3.03 DEFECTS AND REPAIRS

A. Repair all flaws or damaged areas by placing a patch of the same material extending at least 1 foot beyond the flaw or damaged area.

END OF SECTION

SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

SOIL AND LINER QUALITY CONTROL PLAN (SLQCP)

SAN ANGELO LANDFILL
TOM GREEN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 79

PERMIT MODIFICATION

PART III - SITE DEVELOPMENT PLAN
ATTACHMENT 3
SOILS AND LINER QUALITY CONTROL PLAN

Prepared for

City of San Angelo

March 1994
July 1994
July 2007
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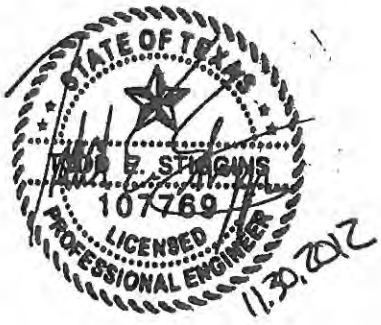


Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road • Mansfield, Texas 76063 • 817-563-1144

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

1 INTRODUCTION

1.1 PURPOSE

This Soils and Liner Quality Control Plan (SLQCP) has been prepared in accordance with Chapter 330, Subchapter H: Liner System Design and Operation to establish procedures to assure compliance with Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Rules (MSWR). This SLQCP also provides guidance for the design, construction, testing and documentation of the liner and leachate collection system construction.

1.2 DEFINITIONS

Specific terms and acronyms that are used in this SLQCP are defined below.

ASTM

This means the American Society for Testing and Material.

Construction Quality Assurance (CQA)

CQA is a planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. CQA includes the observations, evaluations, and testing necessary to assess and document the quality of the constructed facility. CQA includes measures taken by the CQA organization to assess whether the work is in compliance with the plans, specifications, and permit requirements for a project.

Construction Quality Assurance (CQA) Monitors

CQA monitors are representatives of the GP who work under direct supervision of the GP. The CQA monitor is responsible for quality assurance monitoring and performing on-site tests and observations. The CQA monitor must be NICET-certified at level 2 for soils and geosynthetics, an engineering technician with a minimum of four years directly related experience, or a graduate engineer or geologist with one year of directly related experience.

Geomembrane Liner (GM)

This is an essentially impermeable geomembrane synthetic lining material, also referred to as geomembrane, membrane liner, or sheet.

Geomembrane Liner Evaluation Report (GLER)

This is a construction report for geomembrane liner that is submitted to the TCEQ for approval.

Geosynthetic Materials

Manufactured materials that include geomembranes, geogrids, geofilters, geocomposites, geodrainage nets, and geotextiles.

Geosynthetic Clay Liner (GCL)

A synthetic liner material that consists of bentonite encapsulated between two geotextiles.

Geosynthetic Clay Liner Evaluation Report (GCLER)

This is a construction report for geosynthetic clay liner that is submitted to the TCEQ for approval.

Geotechnical Professional (GP)

The GP is the authorized representative of the owner who is responsible for all CQA activities for the project. The GP must be registered as a professional engineer in Texas. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The GP must also have competency and experience in certifying similar projects. The GP may also be known in applicable regulations and guidelines as the CQA engineer, resident project representative, geotechnical quality control/quality assurance professional (GQCP), or professional of record (POR).

Geotechnical Professional's (GP's) Representative

The GP's Representative is a person who works under the supervision of the GP. The GP's Representative may include the CQA Monitor and third party testing laboratory, but excludes employees of the manufacturer and contractor.

Panel

This is a unit area of the GM or GCL, which will be seamed in the field.

Quality Assurance

Quality assurance is a planned program, or system of activities that is designed to assure that the work meets the requirements of plans, specifications, and permit for a construction project. Quality assurance includes procedures, quality control activities and documentation that are performed by the GP and CQA monitor.

Quality Control

Quality control is a planned system of inspections and activities that implement, monitor and control the quality of a construction project. The GP, CQA monitor, and contractor will perform quality control.

1.3 SITE CONDITIONS

1.3.1 Geology

The site geology and subsurface conditions are summarized below.

The San Angelo Landfill is located on the western edge of the Eastern Shelf of the Permian Basin. Permian age formations dip westerly into the Midland Basin at about 50 feet per mile. The Permian formations occur as redbeds and consist of silty and clayey clastic deposits with thin interbeds of limestone, dolomite, and sandstone. The Concho River valley occurs in a southeast–northwest trend across the area and is the erosional edge of the Edwards Plateau. The Edwards Plateau consists of Lower Cretaceous limestones and sandstones.

Quaternary aged alluvial and colluvial sediments shed from the Edwards Plateau and fill the Concho River valleys and lowland areas. Thicknesses of these sediments range from 0 to 150 feet and consist of caliche, clay, silt, sand, gravel, and conglomerate. The gravel is typically found at the base of the unit.

Quaternary sediments occur at the surface of the site. These sediments are alluvial in nature and consist of various lithologies of sand, silt, and clay and range in thickness from about 27 feet on the west side of the site to 55 feet on the far northeast corner of the site. Off-site to the south and southeast, the Quaternary alluvial strata occur in similar thicknesses, ranging from about 70 feet to about 62 feet. Occasional uncorrelatable lenses of limestone and caliche also occur within the alluvial section.

At the base of the alluvial section is a unit that consists of basal gravels and gravelly clays in communication with cemented fractured conglomerates and fractured limestones and dolomites from the upper portions of the Choza Formation. The conglomerate, limestone, and dolomite sections appear to be the same lithologic variation. The conglomerate is likely to be made up of eroded Paleozoic limestone and dolomite deposited as part of the Leona alluvial depositional event. In any event, the limestone, dolomite and conglomerates, which appear to be cemented, are fractured and in communication with the gravel and sandy portions of the overlying Leona. This assemblage of lithologies is identified collectively as the Leona Gravel and serves as the uppermost aquifer. The combined lithologies of the Leona Gravel interval range in thickness, where present on the site, from 2 feet to 32 feet. Clean gravel materials appear more frequently on the western side of the site. Over most of the site, the gravel occurs as clayey gravel. Occasional isolated and uncorrelateable, relatively thin interbeds of clay occur within the Leona Gravel interval. The unit occurs over most of the site but is absent from the north central portion of the site.

Beneath the Leona Formation is the Permian-aged Choza Formation. The Choza in the area is primarily a shale to clayey shale red-bed formation that contains occasional isolated and uncorrelatable interbeds of limestone and/or dolomite. The Choza dolomites that occur more than 10 feet into the Choza shale are not immediately hydraulically connected to the Leona Gravel interval. Where dolomite, limestone, and conglomerates of limestone and dolomite occur near the top of the Choza, they are often in communication with the overlying Leona and are considered to be a part of the

Leona unit. The Choza shale is a widespread correlateable unit that underlies the Leona Gravel throughout the area. The Choza shale serves as the aquiclude beneath the uppermost aquifer beneath the site, which is the Leona Gravel.

1.3.2 Hydrogeology

The major aquifer of the region is found in the basal gravels of the Quaternary alluvium and is known as the Leona Aquifer. Maximum yields have been reported in the Lipan Flats area, about 20 miles south of the site, of 500 gallons per minute (gpm). Typical yields in the area of the site range from a few gpm up to about 100 gpm. Typical well depths range from 30 to about 100 feet. The Leona Aquifer is occasionally commingled with the underlying Permian aquifers. The regional gradient of the Leona Aquifer is toward the Concho River.

There are minor Permian age aquifers underlying the Leona which produce highly mineralized groundwater. Almost all of the groundwater producing wells located in Tom Green County, regardless of which zone, are completed above 300 feet because of the poor water quality (brine conditions) found below that depth.

2 LINER SYSTEM

2.1 LINER AND LEACHATE COLLECTION SYSTEMS

Two liner systems are permitted for installation at the San Angelo Landfill. An alternate liner design permit modification was approved by TCEQ on January 15, 1999 and is included as Appendix 3D. The components for the two liner systems are listed from bottom to top in Table 3-1.

Table 3-1
Components of the Liner Systems

	Liner System Component	Description	Thickness
Option 1	Compacted Clay Liner	Compacted soil with a maximum coefficient of permeability of less than 1×10^{-7} cm/sec.	24 inches
	Geomembrane Liner (GM)	Smooth HDPE geomembrane on floor. Textured HDPE geomembrane on sidewalls.	60 mils
Option 2	Geosynthetic Clay Liner (GCL)	Unreinforced GCL on the floor. Reinforced GCL on the sidewalls. GCL with a maximum coefficient of permeability of less than 5.0×10^{-9} cm/sec.	Varies
	Geomembrane Liner (GM)	Smooth HDPE geomembrane on floor. Textured HDPE geomembrane on sidewalls.	60 mils

In addition to the two liner system options, there are several leachate collection system configurations permitted for use at the San Angelo Landfill. The components of the leachate collection systems are listed from bottom to top in Table 3-2.

Table 3-2
Components of the Leachate Collection Systems

	Leachate Collection System Component	Description	Thickness	Chimneys
Option A	Granular Drainage Layer	Granular drainage layer consisting of rock drainage aggregate with a permeability of 1×10^{-2} cm/sec or greater.	12 inches	Chimneys required
	Soil Protective Cover	Soil protective cover with a maximum coefficient of permeability of less than 1×10^{-4} cm/sec.	12 inches	
Option B	Granular Drainage Layer	Granular drainage layer consisting of rock drainage aggregate with a permeability of 1×10^{-2} cm/sec or greater.	12 inches	Chimneys not required
	Soil Protective Cover	Soil protective cover with a maximum coefficient of permeability of greater than 1×10^{-4} cm/sec.	12 inches	
Option C	Granular Drainage Layer	Granular drainage layer consisting of rock drainage aggregate with a permeability of 1×10^{-2} cm/sec or greater.	12 inches	Chimneys not required
	Shredded Tires or Shredded Waste Protective Cover	Shredded tires or shredded waste protective cover consisting of tires or waste shredded to pieces having a nominal size of 2 to 4 inches with a permeability of 1×10^{-2} cm/sec or greater.	12 inches	
Option D	Drainage Layer	Single-sided drainage geocomposite on the floor, and double-sided drainage geocomposite on the sidewalls.	Varies	If the protective cover has a coefficient of permeability greater than 1×10^{-4} cm/sec, then chimneys are not required. If the protective cover has a maximum coefficient of permeability less than 1×10^{-4} cm/sec, then chimneys are required.
	Soil Protective Cover	Soil protective cover with a maximum coefficient of permeability of less than 1×10^{-4} cm/sec.	24 inches	

As shown in Table 3-1, there are two liner systems currently permitted for use at the San Angelo Landfill. The two liner system options are permitted to be interchangeable with the leachate collection system options shown in Table 3-2.

The leachate collection layer will drain to collection trenches along the centerline of each cell. The leachate collection trenches will consist of perforated HDPE pipes encased in aggregate filled trenches. The leachate collection trenches will convey leachate to sumps located along the toe of the sideslopes. Details of the leachate collection system are provided in Appendix 3A.

2.2 CONSTRUCTION MONITORING

Continuous on-site monitoring is necessary to assure that all the components of the liner and leachate collection system are constructed in accordance with this SLQCP. At a minimum, the CQA monitor shall provide continuous on-site observation during all construction activities including the following:

- Subgrade preparation
- Compacted clay liner placement, compaction, and testing (if required)
- Geosynthetic clay liner (GCL) deployment, seaming, and repairing (if required)
- Geomembrane liner deployment, trial welds, seaming, testing, and repairing
- Anchor trench backfill
- Leachate collection layer deployment and seaming
- Protective cover layer placement
- Any work that could damage the installed components of the liner system

The GP will document and certify that the liner system was constructed in accordance with this SLQCP. The GP will generally be on site once weekly during periods when construction activities are occurring and the GP will be on site for all extraordinary construction events to provide adequate direct observation of the installation and testing of the liner system.

3 CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

3.1 GENERAL

The top of liner plan for the San Angelo Landfill (see Appendix 3A, Attachment 3A.1) provides for the landfill floor to slope at 0.5 percent to the perimeter sidewalls, which will slope at 3H:1V. The landfill floor will be divided into approximate 200-foot wide areas, which will each have a 2 percent cross slope from the ridge of each cell to a leachate collection trench along the centerline of the cell. Collection trenches will slope at 0.5 percent to sumps located along the east perimeter of the landfill. The excavation will range from ground surface to about 20 feet deep. Earthwork activities and testing will be documented in the SLER or GCLER and the GLER in accordance with Section 9.

3.2 MATERIALS

The following material classifications will be encountered in excavations, or will be required for landfill construction.

General Fill and Liner Subgrade

General fill consists of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than 4 inches in diameter. The top 6 inches of liner subgrade will consist of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than ¾-inch in diameter.

Protective Cover

Protective cover materials shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, solid waste, organic materials, and meets the requirements of Section 7.2.4.

Daily and Intermediate Cover

Daily and intermediate cover materials consist of soils that have not been previously mixed with solid waste.

Topsoil

Topsoil consists of soil that is capable of sustaining vegetation and is free of debris, rubbish, and solid waste.

Drainage Aggregate

Drainage aggregate consists of natural or manufactured granular material meeting the gradation that is required by the specifications. Drainage aggregate shall have a

coefficient of permeability of 1.0×10^{-2} cm/sec or greater. Additional requirements for drainage aggregate that is used in the leachate collection system are provided in Section 7.2.1.

Anchor Trench Backfill

Anchor trench backfill consists of general fill that is free of particles larger than 1 inch in diameter.

Unsuitable Materials

Unsuitable materials consist of any material that is determined by the Engineer to not be suitable for use as classified above.

3.3 EXCAVATION

Based on the subsurface exploration, it is anticipated that the excavation can be achieved with excavation equipment such as dozers with rippers and trackhoes.

3.4 GENERAL FILL AND LINER SUBGRADE

Areas to receive general fill shall be stripped of vegetation and debris. Prior to placement of general fill, either the GP or the CQA monitor shall observe the subgrade. Soft areas shall be undercut to firm material then be backfilled with compacted general fill. General fill consists of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than 4 inches in diameter. The top 6 inches of liner subgrade will consist of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than ¾-inch in diameter.

3.5 TESTING AND VERIFICATION

A minimum of one standard Proctor test (ASTM D 698) shall be performed on each representative soil used as general fill material. Atterberg limits tests (ASTM D 4318) and percent passing the 1-inch and No. 200 sieve (ASTM D 422) shall be performed with each Proctor test. Moisture-density testing shall be performed by the CQA monitor at a rate of one field density test per lift for each 20,000 square feet of lift area.

4 CONSTRUCTION QUALITY ASSURANCE FOR COMPACTED CLAY LINER

4.1 GENERAL

The compacted clay liner layer consists of a 24-inch-thick layer of compacted, relatively homogeneous, cohesive material. The CQA monitor shall generally be on site during compacted clay liner layer placement, processing, compaction, and testing. The GP shall make sufficient site visits during compacted clay liner layer construction to document the construction activities, testing, and thickness verification in the Soils and Liner Evaluation Report (SLER), in accordance with Section 9.

4.2 MATERIALS

Compacted clay liner layer material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material. The required compacted clay liner layer material properties are summarized in Table 3-3.

Table 3-3
Compacted Clay Liner Material Properties

Test	Standard	Required Property
Plasticity Index	ASTM D 4318	15 or greater
Liquid Limit	ASTM D 4318	30 or greater
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	30 or greater
Percent Passing 1-inch Sieve	ASTM D 422	100
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1×10^{-7} cm/sec or less

Preconstruction testing procedures and frequencies for compacted clay liner layer materials are listed in Section 4.8.1.

4.3 SUBGRADE PREPARATION

Prior to placing compacted clay liner layer material, the subgrade should be proofrolled with heavy, rubber-tired construction equipment to detect soft areas. The GP or CQA monitor must observe the proof-rolling operation. Soft areas should be undercut to firm

material then be backfilled with compacted general fill in accordance with the requirements for general fill.

The subgrade elevations shall be verified in accordance with the requirements of Section 4.8.3 prior to the placement of compacted clay liner layer. Low areas should be brought to the design grades with general fill that is placed in accordance with the requirements of Section 3.4.

4.4 PLACEMENT AND PROCESSING

The compacted clay liner subgrade and surface of each lift should be scarified prior to placement of the next lift of compacted clay liner. The compacted clay liner layer material should be placed in maximum 8-inch loose lifts to produce compacted lift thickness of approximately 6 inches. The material should be processed to a maximum particle size of 1 inch or less before water is added. Rocks and clods less than 1 inch in diameter should not total more than about 10 percent by weight. The surface of the top lift shall contain no material larger than $\frac{3}{8}$ inch. Compacted clay liner material should be processed with a disc or soil pulverizer.

If additional water is necessary to adjust the moisture content, it should be applied after initial processing, but prior to compaction. Water should be applied evenly across the lift and be worked into the material. Water used for the clay liner compaction must not be contaminated by waste or any objectionable material.

4.5 COMPACTION

The compacted clay liner layer shall be compacted with a pad/tamping-foot or prong-foot roller. A footed roller is necessary to bond the lifts, to distribute the water, and to blend the soil matrix through kneading action. The compacted clay liner layer shall not be compacted with a bulldozer, rubber-tired roller, flat-wheel roller, scrapers, or any track equipment unless it is used to pull a footed roller. The compactor should weigh at least 40,000 pounds. The Caterpillar 815 and 825 are examples of equipment typically used to achieve satisfactory results. The lift thickness shall be controlled to achieve total penetration into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. Cleaning devices on the roller must be in place and be maintained to prevent the prongs or pad feet from becoming clogged to the point that they cannot achieve full penetration.

The compactor shall make approximately four passes across the area being compacted. A pass is defined as one pass of the compactor, front and rear drums. The material should be compacted to a minimum of 95 percent of the maximum dry density determined by standard Proctor (ASTM D 698) at a moisture content at or above optimum moisture. Areas with failing tests shall be reworked and recompacted, and then retested with passing tests before another lift is added.

After a lift is compacted, it must be watered to prevent drying and desiccation until the next lift can be placed. If desiccation occurs, the GP must determine if the lift can be

rehydrated by surface application of water or if the lift must be scarified, watered, and then recompacted. Following compaction and fine grading of the final lift, the surface of the compacted clay liner layer shall be smooth drum rolled.

4.6 PROTECTION

The completed compacted clay liner layer must be protected from drying, desiccation, rutting, erosion and ponded water until the geomembrane liner is installed. Areas that undergo excessive desiccation or damage shall be reworked, recompacted and retested as directed by the GP.

4.7 TIE-IN TO EXISTING LINERS

The edge of existing compacted clay liner layers shall be cut back on either a slope or stair steps to prevent the formation of a vertical joint. Details of approved tie-in methods to existing liners are shown in Appendix 3A.

4.8 TESTING AND VERIFICATION

4.8.1 Preconstruction Testing

Table 3-4 lists the minimum testing required for material proposed for use as the compacted clay liner layer.

Table 3-4
Compacted Clay Liner Layer Material Preconstruction Tests

Test	Standard	Frequency
Plasticity Index	ASTM D 4318	1 per material type
Liquid Limit	ASTM D 4318	1 per material type
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	1 per material type
Percent Passing 1-inch Sieve	ASTM D 422	1 per material type
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1 per material type

After the moisture density relationship has been determined for a material type, a soil sample should be remolded to about 95 percent of the maximum dry density at the optimum moisture content. This sample will be tested to determine if the soil can be compacted to achieve a suitable coefficient of permeability. Either falling head or constant head laboratory permeability tests may be performed to determine the coefficient of permeability. The permeant fluid for testing must be tap water or

0.005N calcium sulfate solution. Distilled or deionized water shall not be used as the permeant fluid.

4.8.2 Construction Testing

All quality control testing will be performed during construction of the liner, except for testing which is required after individual lifts are constructed. Table 3-5 lists the minimum testing required for material used as the compacted clay liner layer.

Table 3-5
Compacted Clay Liner Layer Material Construction Tests

Test	Standard	Frequency
Field Density	ASTM D 2922 ASTM D 3017	1/8,000 sf per 6-inch lift
Plasticity Index	ASTM D 4318	1/100,000 sf per 6-inch lift
Liquid Limit	ASTM D 4318	1/100,000 sf per 6-inch lift
Percent Passing 1-inch and No. 200 Mesh Sieve	ASTM D 1140 ASTM D 422	1/100,000 sf per 6-inch lift
Standard Proctor Test	ASTM D 698	1 per material type
Coefficient of Permeability	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1/100,000 sf per 6-inch lift

The Atterberg limits of the in-place compacted clay liner layer must be continually compared to the Atterberg limits of the Proctor curve sample to assure that the proctor curve accurately represents the in place material. Any variance of more than 10 points between the liquid limit or plasticity index of the in-place soil and those of the Proctor curve sample will require that a new Proctor curve be developed. Permeability testing will be performed as described in Section 4.8.1 and all test data will be reported.

4.8.3 Thickness Verification

The as-built thickness of the compacted clay liner layer shall be determined by standard survey methods. Prior to the placement of compacted clay liner layer material the subgrade elevations will be determined at a minimum rate of 1 survey point per 5,000 square feet of lined area. After the compacted clay liner layer is completed, the top of compacted clay liner layer elevations will be determined at the same locations as the subgrade elevations. The as-built thickness will be the difference between the subgrade elevations and the top of compacted clay liner layer elevations, reported to the nearest 0.1 foot, and shall not be less than 2 feet.

5 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETIC CLAY LINER

5.1 GENERAL

The geosynthetic clay liner (GCL) consists of a sodium bentonite contained between two geotextiles that is placed over the liner subgrade. Reinforced GCL will be placed over the sidewalls, and nonreinforced GCL will be placed on the landfill floor. The CQA monitor shall provide continuous on-site observation during GCL deployment, seaming, and repairing. The GP shall make sufficient site visits during the GCL installation to document the installation in the GCLER, in accordance with Section 9.

5.2 MATERIALS

5.2.1 Properties

The GCL shall consist of sodium bentonite contained between two geotextiles. A certificate of analysis for each clay lot shall be submitted as part of the quality control documentation. The finished GCL must have a permeability no greater than 5×10^{-9} cm/sec (test method ASTM D 5084 or GRI GCL-2), have a free swell (test method ASTM D 5890) of at least 24 mL/2g, and a fluid loss (test method ASTM D 5891) no greater than 18 mL. The manufacturer shall provide recommended seaming procedures.

Manufacturer quality control testing procedures and frequencies for GCL are listed in Section 5.5.1. Conformance samples may be taken at the manufacturing plant or at the project site by the GP or his representative and will be forwarded to a third party laboratory for testing. Third party conformance testing procedures and frequencies for GCL are listed in Section 5.5.2.

5.2.2 Delivery and Storage

The GCL shall be shipped in rolls, which are wrapped individually in relatively impermeable and opaque protective covers. The rolls may be stacked only as allowed by manufacturer's recommendations. The GCL rolls must be stored above ground and protected from moisture.

Upon delivery of the GCL, the CQA monitor will observe that:

- Equipment used to unload and store the rolls or pallets does not damage the GCL.
- The GCL is stored in an acceptable location and not stacked more than five rolls high.

- The GCL is protected from puncture, dirt, grease, water, moisture, and excessive heat, or other damage.

- All manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications.

5.3 PREPARATION

Prior to installation of the GCL, the liner subgrade shall be surveyed and verified. Surveying will be performed to verify that the finished subgrade is to the lines and grades specified in the design with a vertical tolerance of ±0.1 feet.

Before installation of GCL, the CQA monitor or geosynthetics contractor will observe the following:

- All lines and grades of the prepared subgrade have been verified.
- The prepared subgrade is free of irregularities and protrusions.
- The top six inches of prepared subgrade shall be free of particles larger than ¾-inch in diameter.
- The prepared subgrade has been smooth-drum rolled.
- The prepared subgrade is not saturated and no standing water is present.
- The geosynthetics contractor has certified in writing that the prepared subgrade on which the GCL will be installed is acceptable.

5.4 INSTALLATION

5.4.1 Deployment and Placement

Equipment used to deploy GCL over soil shall not cause rutting of the subgrade. The GCL should be unrolled, not dragged, across the subgrade. Where the GCL cannot be unrolled, a geosynthetic rub sheet must be placed under the GCL to protect it during deployment. Deployed GCL panels shall contain no folds or excessive slack. Generators, gasoline or solvent cans, tools, or supplies shall not be placed directly on GCL. Installation personnel shall not smoke or wear damaging shoes when working on GCL.

GCL on sideslopes shall not be unrolled perpendicular (across) to the slope. No horizontal seams will be allowed on side slopes unless the full roll length is too short to extend from the anchor trench to 5 feet past the toe of the slope. If horizontal seams are necessary, they will be constructed only in the lower half of the slope with a minimum end lap of 3 feet, shingled in the down slope direction, and staggered at least 20 feet apart vertically. GCL will be temporarily anchored at the top of the slope and then be unrolled downslope with appropriate construction equipment to prevent wrinkles and folds.

During GCL placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe the condition of the liner subgrade and note any deficiencies. All deficiencies shall be repaired and be approved by the CQA monitor.
- Observe the condition of the GCL and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.
- Observe that people working on the GCL do not smoke, wear shoes that could damage the GCL, or engage in activities that could damage the GCL.
- Observe that no more panels are deployed than can be covered on the same day.
- Observe that overlaps are constructed in accordance with the manufacturer's recommendations, but in no case will the overlaps be less than 6 inches on the edges (longitudinal) and 2 feet on the ends.
- Observe that seams are constructed per manufacturer's recommendations. Horizontal and vertical seams for reinforced and unreinforced GCLs will be amended with granular dry bentonite between the overlapped panels in accordance with the manufacturer's recommendations. In absence of other guidelines, a rate of ¼ pound per linear foot will be used where bentonite amendment is required.
- Observe that defects are patched and overlapped properly.
- Observe that on sideslopes, the GCL is anchored at the top and then unrolled.
- Observe the GCL for premature hydration. All GCL that has prematurely hydrated shall be removed and replaced with new GCL.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and be repaired in accordance with Section 5.4.4 or be removed and replaced by the installer.

5.4.2 Protection

Construction equipment on the GCL shall be minimized to reduce the potential for damage or puncture. Small equipment such as generators shall be placed on scrap GM material (rub sheets). Vehicle and equipment traffic other than only low contact pressure vehicles must not be allowed on the deployed GCL. The CQA monitor will verify that GCL (or overlying geosynthetics) are not displaced or damaged while overlying materials are being placed. Drainage aggregates and protective cover shall be placed in lifts using low ground pressure equipment.

5.4.3 Anchor Trenches

The top corner of the anchor trenches shall be rounded to prevent crimping the GCL. The bottom of the anchor trench shall be dry, stable and be free of loose particles and rocks. Anchor trenches shall be backfilled with compacted general fill that is free of particles larger than 1 inch in diameter. General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture density tests will be taken at the discretion of the CQA monitor to evaluate the quality of the backfill.

5.4.4 Repairs

Repairs shall be constructed in accordance with the manufacturer's recommendations. Damaged unreinforced GCL (landfill floor) will be repaired by completely exposing the affected area, removing all foreign objects or soil, and placing a patch cut from unused GCL over the damaged area with a minimum overlap of 12 inches on all edges. Dry bentonite will be placed between the patch edges and the repair material at a rate of a quarter pound per linear foot. Reinforced GCL material damaged on the side slopes will be repaired by the same procedure as the unreinforced GCL.

5.5 TESTING AND VERIFICATION

5.5.1 Manufacturer's Quality Control Testing

The manufacturer shall test the GCL and raw materials in accordance with the most current GRI Standard GCL3 and Table 3-6 to assure the quality of the GCL. The current GRI Standard GCL3 (as of the date of this SLQCP) is provided in Appendix 3C.

Table 3-6
GCL Manufacturer Tests

Test	Type of Test	Standard Test Method	Frequency of Testing
Bentonite[1]	Free Swell	ASTM D 5890	per 50 tons and every truck or railcar
	Fluid Loss	ASTM D 5891	
Geotextile	Mass Unit/Unit Area	ASTM D 5261	per 200,000 ft^2
	Grab Tensile Strength	ASTM D 4632	
GCL Product	Clay Mass/Unit Area @0% moisture	ASTM D 5993	per 40,000 ft^2
	Bentonite Moisture Content	ASTM D 5993	
	Grab Tensile Strength	ASTM D 4632	per 200,000 ft^2
	Permeability[2]	GRI GCL-2 or ASTM D 5084	per week for each production line
	Lap Joint Permeability	Flow box or other suitable device	per GCL adjoining material and lap type

[1] Tests to be performed on bentonite before incorporation into GCL.
[2] Report last 20 permeability values, ending on production date of supplied GCL.

5.5.2 Conformance Testing

Conformance testing requirements are provided in Table 3-7.

Table 3-7
GCL Conformance Tests

Property	Standard Test Method	Frequency of Testing
Clay Mass/Unit Area @ 0% moisture	ASTM D 5993	per 40,000 ft^2
Permeability[1]	GRI GCL-2 or ASTM D 5084	per 100,000 ft^2
Internal Shear Strength	ASTM D 6243	per 100,000 ft^2

[1]Test at confining/consolidating pressures simulating field conditions for ASTM D 5084.

5.5.3 Required Manufacturer's Specifications

Table 3-8
Manufacturer's Specifications for Unreinforced and Reinforced GCL Materials

Property	Required Values	
	Unreinforced GCL	Reinforced GCL
Free Swell (millimeters)	24 (minimum)	24 (minimum)
Fluid Loss (millimeters)	18 (minimum)	18 (minimum)
Bentonite Mass per Unit Area (lb/sf)	0.75 (minimum)	0.75 (minimum)
Grab Tensile Strength (lbs)	80 (minimum)	90 (minimum)
GCL Hydrated Internal Shear Strength (psf)	50 (minimum)	500 (minimum)
GCL Permeability (cm/s)	5×10^{-9} (maximum)	5×10^{-9} (maximum)
Lap Joint Permeability (cm/s)	5×10^{-9} (maximum)	5×10^{-9} (maximum)

6 CONSTRUCTION QUALITY ASSURANCE FOR GEOMEMBRANE LINER

6.1 GENERAL

The geomembrane liner (GM) consists of a 60-mil-thick HDPE geomembrane placed over the geosynthetic clay liner or the compacted clay liner. Smooth GM will be placed on the floor and GM that is textured on both sides will be placed over the sidewalls. The CQA monitor shall provide continuous on-site observation during GM deployment, trial welds, seaming, testing, and repairing. The GP shall make sufficient site visits during the GM installation to document the installation and testing in the GLER, in accordance with Section 9.

6.2 MATERIALS

6.2.1 Properties

GM shall consist of smooth and textured high-density polyethylene (HDPE) geomembrane produced from virgin raw materials. Recycled materials are not acceptable. The GM shall not be manufactured from resin from differing suppliers. The GM shall meet the requirements of the Geosynthetics Research Institute (GRI) Standard GM13. A copy of GRI Standard GM13 (as of the date of this SLQCP) is included in Appendix 3B for informational purposes and will be superseded as newer versions are adopted. This SLQCP incorporates the most current version of GRI Standard GM13.

Third party conformance testing procedures and frequencies for GM are listed in Section 6.5.2.

6.2.2 Delivery and Storage

GM shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site.

Upon delivery of the geomembrane, the CQA monitor will observe that:

- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location and not stacked more than five rolls high.
- The geomembrane is protected from puncture, dirt, grease, water, moisture, and excessive heat, or other damage.

- All manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications.

- The geomembrane receipt log form has been completed for all materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane.

6.3 PREPARATION

The surface of the compacted clay liner or the GCL shall be protected in accordance with Section 5.4.2 until the GM is installed. Prior to installation of any geomembrane, the installed GCL or compacted clay liner surface shall be inspected by the CQA monitor and the geosynthetics contractor. Before installation of the GM, the GP or CQA monitor will observe the following:

- The GCL or compacted clay liner surface is free of surface irregularities and protrusions.

- The anchor trenches are free of sharp objects and stones.

- The GCL is not saturated, and no water is present above the GCL (if required).

- The geosynthetics contractor has certified in writing that the GCL or compacted clay liner surface on which geomembrane will be installed is acceptable.

6.4 INSTALLATION

6.4.1 Deployment and Placement

The following activities must take place prior to GM deployment:

- The manufacturer's quality control and third party conformance tests will be completed and approved by the GP in accordance with the requirements of Section 6.5.

- The GP and geosynthetics installer shall approve the subgrade in accordance with the requirements of Section 6.3.

- The geosynthetic installer shall sign the subgrade acceptance form.

GM shall be deployed by equipment that will unroll the GM without damaging, crimping or stretching it and deployment equipment must not damage the underlying geosynthetic clay liner (GCL) or compacted clay liner. Only low contact pressure equipment shall be allowed on the GCL or compacted clay liner. GM must not be deployed during periods

of rain, freezing temperatures, or high winds. The installer must only deploy the amount of GM that can be seamed on the same day.

Upon deployment, each panel shall be assigned a unique identification number. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and damaging shoes shall not be permitted on the GM and only low-ground pressure supporting equipment shall be allowed on the GM. Textured GM shall be placed on sideslopes and shall extend to a minimum of 5 feet beyond the toe of the slope.

During GM placement, the CQA monitor must:

- Provide full-time observation.
- Record panel numbers, panel dimensions, and roll numbers on the panel layout drawing.
- Record weather conditions.
- Observe the condition of the GM and note any defects. All defects must be repaired in accordance with the requirements of Section 6.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the deployment method minimizes wrinkles and that the GM is anchored to prevent movement from wind.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that there are no horizontal seams on sideslopes and that the textured material extends a minimum of 5 feet past the toe of the slope.
- Observe that the underlain GCL or compacted clay liner is not damaged by geomembrane installation equipment or activities. These observations will be visual and when the GM deems it necessary other testing methods may be used.
- Observe that the geomembrane panels are deployed only by low ground pressure equipment to prevent damage to the underlain GCL or compacted clay liner.
- Observe that the geomembrane is not dragged across a surface that could damage the geomembrane.
- Observe that the geomembrane panel is placed in a manner to ensure direct and uniform contact between GM and GCL or compacted clay liner. The geomembrane panels will be observed for crimping, stretching, and wrinkling to ensure uniform contact.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and be repaired in accordance with Section 6.4.4 or be removed and replaced by the installer.

6.4.2 Seaming

Only welding apparatus and operators that have completed approved trial welds, in accordance with Section 6.5.3, shall be allowed to weld panel seams. Each seam shall be assigned a unique number, which is preferably consistent with the panel numbering system. Sidewall seams shall be oriented downslope. Prior to welding, the proper panel overlap shall be provided. Dirt, grease, and free moisture shall be cleaned from the panel contact area, and wrinkles shall be removed as much as practical. For extrusion welds, oxidation shall be ground from the seam area within one hour of the welding operation and the extrudiate shall be purged from the extrusion welding apparatus. Seaming operations shall not be allowed when the ambient temperature is below 40° F or above 104° F unless trial welds have demonstrated that adequate welds can be achieved outside these limits.

During GM seaming operations, the CQA monitor must:

- Provide full-time observation.
- Record seam numbers on the panel layout drawing.
- Record weather conditions.
- Observe that only approved welding apparatus and operators are allowed to weld seams.
- Observe the condition of the seams and note any defects. All defects must be repaired in accordance with the requirements of Section 6.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the seams are free of grease, dirt, moisture and wrinkles.
- Observe that welding operations take place within the approved ambient temperature range.
- Observe that seam grinding has been completed less that one hour before extrusion welding and the extrudiate has been purged from extrusion welders.

6.4.3 Anchor Trenches

The GM anchor trench shall be left open until the seaming is completed. Expansion and contraction of the GM will be accounted for during deployment. The top corner of the anchor trenches shall be rounded to prevent crimping the GM. The bottom of the anchor trench shall be dry, stable and be free of loose particles and rocks. Anchor

trenches shall be backfilled with compacted general fill that is free of particles larger than 1 inch in diameter. The anchor trenches shall be backfilled and compacted in a manner that does not damage or induce stress to the GM.

6.4.4 Repairs

Defects in the GM, defects in seams, failing destructive tests, failing nondestructive tests, holes from nondestructive tests, and destructive test sample locations shall be repaired by one of the following repair techniques:

- Patching - used to repair large holes, tears, large GM defects, and destructive test locations.
- Extrusion - used to repair small GM defects, cuts, holes from nondestructive tests, and seam defects less than ½ inch long.
- Capping - used to repair failed seams or seams where nondestructive tests cannot be performed.
- Removal - used to replace areas with large defects where other repair techniques are not appropriate.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry all surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.

Destructive and non-destructive testing will be performed on all repairs in accordance with Section 6.5.4.

6.5 TESTING AND VERIFICATION

6.5.1 Manufacturer's Quality Control Testing

The GM manufacturer shall test the geomembrane and raw materials in accordance with the most current GRI Standard GM13 to assure the quality of the GM. The GRI Standard GM13 (as of the date of this SLQCP) is provided in Appendix 3B.

6.5.2 Conformance Testing

Conformance samples of the GM shall be cut across the full width of selected rolls in accordance with the test frequency specified in Table 3-9. Conformance samples may

be taken at the manufacturing plant or at the project site by the GP or his representative and will be forwarded to a third party laboratory for testing. Minimum conformance testing requirements are provided in Table 3-9 and criteria are provided in GRI GM13.

Table 3-9
GM Conformance Tests

Test	Standard	Frequency
Sheet Thickness[1]	ASTM D 5199 (smooth) ASTM D 5994 (textured)	1 per 50,000 sf and every resin lot
Specific Gravity	ASTM D 1505	1 per 100,000 sf and every resin lot
Carbon Black Content	ASTM D 1603	1 per 100,000 sf and every resin lot
Carbon Black Dispersion	ASTM D 3015 ASTM D 5596	1 per 100,000 sf and every resin lot
Tensile Properties	ASTM D 638/GRI GM13	1 per 100,000 sf and every resin lot
Direct Shear	ASTM D 5321	Per GM/adjoining material type

[1]The average thickness shall be no less than the specified thickness and no individual measurement shall be less than 90 percent of the specified thickness.

6.5.3 Trial Welds

Each operator and welding apparatus must be tested to verify that seam welds that meet the specifications can be achieved under the site conditions. Trial welds, must be performed at the beginning and midpoint of each day for each operator and apparatus used that day. If welding continues past 6:00 p.m., additional trial welds may be required.

The trial weld samples shall be 3-feet long and 12-inches wide, with the seam centered lengthwise. At least four one-inch wide coupons will be cut from each trial weld sample.

Two coupons from each sample will be tested for shear and two samples will be tested for peel. Peel test coupons for dual-track welds shall be tested on both sides of the air channel. Each coupon must meet the minimum strength requirements listed in Table 3-10 and exhibit a Film Tear Bond (FTB). If the trial weld fails, two more trial seams must be welded and tested. This process will continue until passing trial welds are achieved.

The CQA monitor must observe the trial welding operations and document the operator's initials, apparatus number, time, date, air temperature, apparatus temperature, and peel and shear test results. If the CQA monitor believes that an operator or apparatus is not functioning properly, or if the weather conditions have substantially changed since the trial welds were performed, new trial welds must be performed.

6.5.4 Construction Testing

Nondestructive Tests

Nondestructive seam tests include vacuum testing and air pressure testing. Nondestructive testing shall be performed for the entire length of each seam by the GM installer.

Vacuum testing shall be used to test extrusion-welded seams and fusion welded seams that cannot be tested by air pressure methods. The vacuum box shall be placed over a seam section, which has been thoroughly saturated with a soapy water solution. The rubber gasket on the bottom of the vacuum box must seal against the GM to prevent leaks. The vacuum box pressure shall be reduced to about 3 to 5 inches of Hg. Soap bubbles will indicate the presence of holes or non-bonded seams. The vacuum box dwell time shall be at least 10 seconds.

Air pressure testing shall be used to test fusion-welded seams that have an air channel. Both ends of the air channel shall be sealed and air shall be pumped into the channel to at least 30 psi or ½ psi per mil of thickness, whichever is greater. With the air pump shut off, the air channel must sustain the pressure for at least five minutes, without more than a 4-psi pressure drop. Following a passing pressure test, the pressure shall be released from the end of the seam that is opposite of the pressure gauge. The pressure gauge must return to zero, if not, the seam is probably blocked. After the blockage has been located, the seam shall be pressure tested on both sides of the blockage. If the pressure drop is greater than 4 psi after 5 minutes this indicates a seam leak which must be isolated and repaired. All penetration holes shall be sealed after the air pressure testing is completed.

During the nondestructive testing, the CQA monitor must:

- Observe that equipment and operators are performing the tests properly.
- Observe that the entire length of each seam is tested and record the results of the test on the appropriate log.
- Identify failed seams and inform the installer of any required repairs.
- Record all completed and tested repairs on the repair log.

Destructive Tests

Destructive testing shall be performed at a frequency of one test location per 500 linear feet of seam. Repairs over 10-feet long shall be included in the total seam length. Destructive test samples will be 45-inches long by 12-inches wide with the seam centered along the length of the sample. At a minimum, a destructive test must be done for each welding machine used for seaming or repair.

Two coupons will be cut from each end of the sample and the installer must test these coupons with a tensiometer capable of measuring the seam strength. The installer shall

test two coupons in shear and two coupons in peel. For double wedge-welded seams, both sides of the air channel shall be tested in peel. The CQA monitor must observe the tests and record the results on the destructive testing log. The minimum requirements for destructive testing are provided in Table 3-10. If one of the coupons fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established.

If the field test results are satisfactory, the remaining sample shall be divided into three parts: one third for the installer, one third for third party laboratory testing, and one third for the owner to archive. The laboratory shall test five coupons from each sample in shear and test five coupons from each sample in peel (10 when testing both inner and outer welds of dual-track fusion welds). The minimum requirements for destructive testing are provided in Table 3-10. If the laboratory test fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established. All seams shall be bracketed by passing laboratory tests; field tests results shall not be used for final acceptance.

Table 3-10
Geomembrane Seam Properties

Test	Standard	Frequency	Minimum Criteria
Shear	ASTM D 4437/ NSF 54 or ASTM D 6392/ GRI-GM19	1 sample per 500 feet of seam	4 of 5 specimens from each sample must have a shear strength greater than or equal to 95% of sheet strength but not less than 120 ppi. The average shear strength value of all 5 specimens must be greater than or equal to 95% of sheet strength but not less than 120 ppi. 4 of 5 specimens shall exhibit Film Tear Bond.
Peel	ASTM D 4437/ NSF 54 or ASTM D 6392/ GRI-GM19	1 sample per 500 feet of seam	4 of 5 specimens from each sample must have a peel strength greater than or equal to 62% of sheet strength but not less than 78 ppi. The average peel strength value of all 5 specimens must be greater than or equal to 62% of sheet strength but not less than 78 ppi. Both sides of dual track seams shall meet the minimum criteria. Each track is considered a separate sample. 4 of 5 specimens shall exhibit Film Tear Bond.

[1] The manufacturer's sheet strength valves must be provided in order to determine if the test result is adequate.

During destructive seam testing, the CQA monitor must:

- Select sample locations and observe sample cutting.
- Assign sample numbers and label samples.
- Observe installer-performed tests.
- Record sample locations, sample number, sample purpose, and field test results.

7 CONSTRUCTION QUALITY ASSURANCE FOR THE LEACHATE COLLECTION LAYER AND PROTECTIVE COVER

7.1 GENERAL

As detailed in Table 3-2, the San Angelo Landfill is permitted for several leachate collection system configurations. The leachate collection system consists of the leachate collection layer, collection trenches, piping, and the sumps. This section includes information regarding the leachate collection layer (granular drainage layer, geocomposite) and protective cover (shredded tires/shredded waste protective cover, soil protective cover). Section 8 discusses the leachate collection system (geotextiles, pipes, aggregates). Details of the leachate collection layer design are provided in Appendix 3A. Material properties are described in Section 7.2. The CQA monitor shall provide on-site observation during leachate collection layer installation. The GP shall make sufficient site visits during the leachate collection layer installation to document the installation in the GLER, in accordance with Section 9.

The protective cover consists of either a 12-inch or 24-inch-thick layer of soils or a 12-inch-thick layer of shredded tires/shredded waste. Where leachate chimneys are provided, the drainage aggregate or shredded tires/shredded waste around the leachate collection pipes will extend through the protective cover to form a chimney drain for the leachate collection system. The CQA monitor shall provide continuous on-site observation during protective cover placement to assure that protective cover placement does not damage underlying geosynthetics. The GP shall make sufficient site visits during protective cover placement to document the construction activities, testing, and thickness verification in the GLER in accordance with Section 9.

7.2 MATERIALS

7.2.1 Granular Drainage Layer

The leachate collection layer may consist of 12 inches of granular soils installed above the liner system. The granular soils are selected on the basis of grain size and permeability. The permeability of the granular soils will be 1 x 10^{-2} cm/sec or greater. The granular drainage layer shall have the minimum properties listed in Table 3-11.

Table 3-11
Granular Drainage Layer Properties

Test	Standard	Required Property	
Gradation	ASTM D 422	Sieve 2" 1 1/2" 3/4" 3/8" No. 4	% Passing 100 90 – 100 10 – 70 0 – 10 0 – 5
Hydraulic Conductivity	ASTM D 2434	$\geq 1.0 \times 10^{-2}$ cm/sec	
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	Maximum 15% or less	

[a]Use an HCL solution having a pH of 5 or lower.

Conformance testing procedures and frequencies for granular drainage layer are listed in Section 7.5.1.

7.2.2 Geocomposite (Drainage Layer)

The leachate collection layer may consist of a drainage geocomposite installed above the liner system. Single-sided geocomposite (nonwoven geotextile bonded to the top of HDPE drainage net) will be installed on the floor, and double-sided geocomposite (nonwoven geotextile bonded to the top and bottom of HDPE drainage net) will be installed on the sidewalls. The geocomposite shall have the minimum properties listed in Table 3-12.

Table 3-12
Geocomposite Properties

Material	Test	Standard	Required Property
Geotextile	Material		Nonwoven polypropylene or polyester
	Apparent Opening Size	ASTM D 4751	70 sieve maximum
	Unit Weight	ASTM D 5261	6 oz/yd^2
	Grab Strength	ASTM D 4632	160 lb
HDPE Drainage Net	Specific Gravity	ASTM D 1505	0.935 g/cm^3
	Thickness	ASTM D 5199	0.20 inch
	Carbon Black	ASTM D 1603	Minimum 2%; Maximum 3%
Geocomposite	Transmissivity	ASTM D 4716	5.0×10^{-4} m^2/sec

Manufacturer quality control testing procedures and frequencies for geocomposite are listed in Section 7.5.1.

7.2.2.1 Delivery and Storage

Geocomposite shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping

damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected.

The geocomposite shall be unloaded and handled with equipment that does not cause damage. Rolls will not be pushed, slid, or be dragged to the storage location. The geocomposite must not be stored on wet, soft, or rocky subgrade but must be stored on a stable subgrade. Geocomposite must not be stacked more than five rolls high to avoid crushing the roll cores. The stored geocomposite must be protected from puncture, grease, dirt, excessive heat, or other damage.

7.2.2.2 Preparation

Prior to installation of the leachate collection layer the GM shall be tested and verified in accordance with Section 6.5. The CQA monitor shall observe that the surface to receive the granular drainage layer or geocomposite is free of debris, stones and dirt. Also, the CQA monitor will verify that the geocomposite conformance documentation has been submitted and approved, if geocomposite is to be installed.

Prior to placing the protective cover material, the liner subgrade elevations shall be verified in accordance with the requirements of Section 4.3 and all testing on the underlying geosynthetics shall be completed.

7.2.3 Shredded Tires/Shredded Waste Protective Cover

Shredded tires/shredded waste may be used as a 12-inch leachate collection/protective cover layer. The 12-inch leachate collection/protective cover layer consisting of shredded tires/shredded waste will be placed over the 12-inch granular drainage layer in accordance with the project plans and specifications. The shredded tires/shredded waste shall have a nominal size of 2 to 4 inches and shall be free of organics, angular rocks, foreign objects, or other deleterious materials. The physical characteristics of the shredded tires/shredded waste shall be evaluated through visual observation before and during construction. The shredded tires/shredded waste will be placed using low ground pressure equipment. The shredded tires/shredded waste shall be placed by spreading in front of the spreading equipment with a minimum of 12 inches of granular drainage layer between the spreading equipment and the installed geosynthetics. Under no circumstances shall the construction equipment, or shredded tires/shredded waste come in direct contact with the installed geosynthetics.

The thickness of the shredded tires/shredded waste shall be verified with surveying procedures of a minimum of one survey point per 5,000 square feet of constructed area. A minimum of two survey points shall be used for all constructed areas regardless of size. Surveying will verify that the finished shredded tires/shredded waste layer minimum thickness is as specified in the SLQCP. The test results for the shredded tires/shredded waste layer will be included in the GLER.

7.2.4 Soil Protective Cover

Soil protective cover material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, solid waste, and organic material, or any material that could

damage the underlying geosynthetics. If the protective cover has a maximum coefficient of permeability of greater than 1.0×10^{-4} cm/sec, then chimneys are not required. If the protective cover has a maximum coefficient of permeability of less than 1.0×10^{-4} cm/sec, then chimneys are required.

7.3 INSTALLATION/PLACEMENT

7.3.1 Granular Drainage Layer

A 12-inch-thick granular drainage layer shall be installed on the floors and sidewalls. The granular drainage layer shall be placed to the lines and grades shown on the plans. The granular drainage layer shall be placed in a manner that minimizes the potential to damage the underlying geosynthetics. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geosynthetics. The granular drainage layer material shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geosynthetics. On sidewalls, the granular drainage layer shall be placed from the bottom to the top, not across or down. Bridge slope transitions occur when cold weather causes the geomembrane to contract. The granular drainage layer shall not be placed over geosynthetics until the geosynthetics expand to maintain contact with the liner subgrade. The minimum separation distance between construction equipment and the geosynthetics are listed in Table 3-13.

Table 3-13
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
<4	10
4 – 8	18
8 – 16	24
>16	36

During the granular drainage layer placement, the CQA monitor must:

- Observe that the granular drainage layer is placed in accordance with the plans and specifications.
- Observe that the granular drainage layer is consistent with the conformance test samples.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the granular drainage material is spread in a way to minimize wrinkles in the GM.

Any geosynthetic material that in the opinion of the CQA monitor has been damaged by the granular drainage layer placement must be repaired and retested in accordance with Sections 5.4.4 and 6.4.4.

7.3.2 Geocomposite

Single-sided geocomposite shall be installed on the floor, and double-sided geocomposite shall be installed on the sidewalls. Geocomposite shall be deployed by equipment that will unroll the geocomposite without damaging, crimping or stretching it and deployment equipment must not damage the underlying GM. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and damaging shoes shall not be permitted on the geocomposite and only low-ground pressure supporting equipment shall be allowed on the geocomposite or GM. Adjacent rolls of geocomposite shall be securely tied through the drainage net with plastic fasteners every 5 feet along the length of the panel and every 6 inches along the ends of the panels. The top geotextile of adjacent rolls shall be overlapped and be sewn or heat bonded together.

During geocomposite placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe the condition of the geocomposite and note any defects. All defects must be repaired or replaced.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the deployment method minimizes wrinkles in the GM and the geocomposite.
- Observe that the geocomposite panels have been properly tied and seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be removed and replaced by the installer.

7.3.3 Shredded Tires/Shredded Waste Protective Cover

Shredded tires/shredded waste shall be placed in the collection trenches and sumps to the lines and grades shown on the plans. During shredded tires/shredded waste placement, the CQA monitor must:

- Observe that the shredded tires/shredded waste is placed in accordance with the plans and specifications.
- Verify that grade control construction staking is performed prior to work.

- Verify that the shredded tires/shredded waste have no protruding steel or metal components.

- Verify that underlying geosynthetic installations are not damaged during placement operations. Mark damaged geosynthetics and verify that damage is repaired.

- Monitor haul road thickness over geosynthetic installations and verify that equipment hauling and material placement meet equipment specifications.

- The GP will coordinate with the project surveyor to perform a thickness verification survey of the shredded tires/shredded waste materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey.

7.3.4 Soil Protective Cover

The soil protective cover shall be placed in a manner that minimizes the potential to damage the underlying geosynthetics. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geosynthetics. The soil protective cover shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geosynthetics. On sidewalls, soil protective cover shall be placed from the bottom to the top, not across or down. Bridge slope transitions occur when cold weather causes the geomembrane to contract. Soil protective cover shall not be placed over geosynthetics until the geosynthetics have expanded to maintain contact with the liner subgrade. The minimum separation distance between construction equipment and the geosynthetics are listed in Table 3-13.

Any geosynthetic material that in the opinion of the CQA monitor has been damaged by the soil protective cover placement must be repaired and retested in accordance with Sections 5.4.4 and 6.4.4.

7.4 TESTING AND VERIFICATION

7.4.1 Manufacturer's Testing

The granular drainage layer shall be tested at the source to assure that the granular drainage layer meets the specifications. Material property requirements are provided in Section 7.2.1. Minimum source testing requirements are provided in Table 3-14.

Table 3-14
Granular Drainage Layer Source Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per source
Hydraulic Conductivity	ASTM D 2434	1 per source
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per source

[a]Use an HCL solution having a pH of 5 or lower.

Geocomposite property requirements are provided in Section 7.2.2. Minimum manufacturer's testing requirements are provided in Table 3-15.

Table 3-15
Geocomposite Manufacturer's Tests

Material	Test	Standard	Frequency
Geotextile	Weight	ASTM D 5261	1 per 100,000 SF
	Apparent Opening Size	ASTM D 4751	1 per 100,000 SF
	Grab Strength	ASTM D 4632	1 per 100,000 SF
HDPE Drainage Net	Specific Gravity	ASTM D 1505	1 per 100,000 SF
	Thickness	ASTM D 5199	1 per 100,000 SF
	Carbon Black	ASTM D 1603	1 per 100,000 SF
Geocomposite	Transmissivity	ASTM D 4716	1 per 100,000 SF

7.4.2 Thickness Verification

The as-built thickness for both thicknesses of protective cover or drainage layer shall be determined by standard survey methods. Prior to the placement of geosynthetics, the top of liner subgrade elevations will be determined at a minimum rate of one survey point per 5,000 square feet of lined area. After the protective cover is completed, the top of the protective cover elevations will be determined at the same locations as the top of liner subgrade elevations. The as-built vertical thickness will be the difference between the top of liner subgrade elevations and the top of protective cover elevations, reported to the nearest 0.1 foot.

8 CONSTRUCTION QUALITY ASSURANCE FOR THE LEACHATE COLLECTION SYSTEM

8.1 GENERAL

The leachate collection system consists of the leachate collection layer, collection trenches, piping, and the sumps. This section includes information regarding the leachate collection system (geotextiles, pipes, aggregates). Details of the leachate collection system design are provided in Appendix 3A. Material properties are described in Section 8.2. The CQA monitor shall provide on-site observation during leachate collection system and piping installation. The GP shall make sufficient site visits during the leachate collection system installation to document the installation in the GLER, in accordance with Section 9.

8.2 MATERIALS

8.2.1 Geotextile

The leachate aggregate that is placed in the collection trenches and sumps shall be wrapped in a geotextile filter fabric. The geotextile shall have the minimum properties listed in Table 3-16.

Table 3-16
Geotextile Properties

Test	Standard	Required Property
Material		Nonwoven polypropylene or polyester
Apparent Opening Size	ASTM D 4751	100 sieve maximum
Unit Weight	ASTM D 5261	16 oz/yd^2
Grab Strength	ASTM D 4632	300 lb

Manufacturer quality control testing procedures and frequencies for geotextile are listed in Section 8.5.1.

8.2.2 Leachate Pipe

The leachate piping includes perforated collection trench pipes and the solid sidewall riser pipes. The leachate piping shall meet the cell classification PE 345434C in accordance with ASTM D 3350. The pipe shall have the minimum SDR rating and perforation schedule shown on the plans and specifications.

8.2.3 Leachate Aggregate

Leachate aggregate will be placed in the collection trenches and in the sumps. The leachate aggregate shall consist of manufactured or natural materials having the properties listed in Table 3-17.

Table 3-17
Leachate Aggregate Properties

Test	Standard	Required Property	
Gradation	ASTM D 422	Sieve	% Passing
		1 1/2"	95 – 100
		1/2"	20 – 50
		3/8"	<15
Hydraulic Conductivity	ASTM D 2434	$\geq 1.0 \times 10^{-2}$ cm/sec	
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	Maximum 15% loss	

[a] Use an HCL solution having a pH of 5 or lower.

Conformance testing procedures and frequencies for leachate aggregate are listed in Section 8.5.1.

8.2.4 Delivery and Storage

Geotextile shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected.

Pipe shall be shipped in bundles labeled with the manufacturer's name and cell classification number.

The geotextile and pipe shall be unloaded and handled with equipment that does not cause damage. Rolls will not be pushed, slid, or dragged to the storage location. The geotextile must not be stored on wet, soft, or rocky subgrade, but must be stored on a stable subgrade. Geotextile must not be stacked more than five rolls high to avoid crushing the roll cores. The stored geotextile and pipe must be protected from puncture, grease, dirt, excessive heat, or other damage.

8.3 PREPARATION

Prior to installation of the leachate collection system, the geomembrane shall be tested and verified in accordance with Section 6.5. The CQA monitor shall observe that the surface to receive the leachate collection system is free of debris, stones, and dirt. Also, the CQA monitor will verify that the geotextile conformance documentation has been submitted and approved, if geotextile is to be installed.

8.4 INSTALLATION/PLACEMENT

8.4.1 Geotextile

Geotextile shall be placed around the leachate aggregate in the collection trenches and the sumps in accordance with the plans. Geotextile shall be deployed by equipment that will unroll the geotextile without damaging or stretching it and deployment equipment must not damage the underlying geosynthetics. Smoking and damaging shoes shall not be permitted on the geotextile and only low-ground pressure supporting equipment shall be allowed on the geotextile. Adjacent rolls shall be overlapped and be sewn or heat bonded together.

During geotextile placement, the CQA monitor must:

- Provide full-time observation.
- Observe the condition of the geotextile and note any defects. All defects must be repaired or replaced.
- Observe that people working on the geocomposite and GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.

- Observe that the deployment method minimizes wrinkles in the GM and the geocomposite.

- Observe that the geotextile panels have been properly seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be removed and replaced by the installer.

8.4.2 Leachate Pipe

Leachate pipe shall be placed to the lines and grades shown on the plans. The pipe shall be joined in accordance with the manufacturer's recommendations and the project specifications.

Construction equipment shall not be allowed to travel directly over the leachate pipes to prevent crushing or excessive deflection until aggregates and protective cover have been placed. Minimum equipment separation distances listed in Section 7.4.1, Table 3-13 shall be observed.

During leachate pipe placement, the CQA monitor must:

- Provide full-time observation.

- Observe the condition of the pipes and note any defects. All defective pipes must be replaced.

- Observe that people working on the geocomposite and GM do not smoke, wear shoes that could damage the GM or geocomposite, or engage in activities that could damage the GM or geocomposite.

- Observe that construction equipment does not damage pipes.

- Observe that the perforations and pipe orientation are in accordance with the plans and specifications.

- Observe that the pipes and fittings are joined in accordance with the project specifications and the manufacturer's recommendations.

Any pipes that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or be removed and replaced by the installer.

8.4.3 Leachate Aggregate

Leachate aggregate shall be placed in the collection trenches and sumps to the lines and grades shown on the plans. During leachate aggregate placement, the CQA monitor must:

- Observe that leachate aggregate is placed in accordance with the plans and specifications.

- Observe that the leachate aggregate is consistent with the conformance test samples.

- Observe that leachate aggregate placement activities do not dislodge or damage leachate pipes or underlying geosynthetics.

8.5 TESTING AND VERIFICATION

8.5.1 Manufacturer's Testing

Geotextile property requirements are provided in Section 8.2.1. Minimum manufacturer's testing requirements are provided in Table 3-19.

Table 3-19
Geotextile Manufacturer's Tests

Test	Standard	Frequency
Weight	ASTM D 5261	1 per 100,000 SF
Apparent Opening Size	ASTM D 4751	1 per 100,000 SF
Grab Strength	ASTM D 4632	1 per 100,000 SF

The leachate piping manufacturer shall provide a certification that the pipe meets the cell classification PE 345434C in accordance with ASTM D 3350, and the minimum SDR rating and perforation schedule shown on the plans and specifications.

The leachate aggregate shall be tested at the source to assure that the aggregate meets the specifications. Material property requirements are provided in Section 8.2.3. Minimum source testing requirements are provided in Table 3-20.

Table 3-20
Leachate Aggregate Source Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per source
Hydraulic Conductivity	ASTM D 2434	1 per source
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per source

[a] Use an HCL solution having a pH of 5 or lower.

8.5.2 Construction Testing

The leachate aggregate shall be tested to assure that it meets the specifications. Material property requirements are provided in Section 8.2.3. The CQA monitor will collect the leachate aggregate for conformance testing onsite. Conformance testing requirements are provided in Table 3-21.

Table 3-21
Leachate Aggregate Conformance Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per 3,000 cy
Hydraulic Conductivity	ASTM D 2434	1 per 3,000 cy
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per 3,000 cy

[a] Use an HCL solution having a pH of 5 or lower.

8.5.3 Verification

The as-built location of the leachate piping shall be determined and reported in the GLER. All aspects of the leachate collection system will be documented in the GLER as stated in Section 9.

9 DOCUMENTATION

After construction of the liner system, the GP will submit a GCLER/SLER and GLER in triplicate to the TCEQ on behalf of the owner. The GCLER/SLER and GLER may be combined into a single report. These reports will be submitted to the TCEQ prior to the disposal of solid waste over the specified constructed area. If no response, either written or verbal is provided within 14 days, the GCLER/SLER or GLER shall be considered approved and solid waste placement may proceed. Testing, evaluation, and submission of the GCLERs/SLERs and GLERs for liner system construction will be in accordance with the requirements of this SLQCP prepared for the provisions of current TCEQ rules.

At a minimum, the GCLER/SLER and GLER will contain the following:

- A summary of all construction activities in accordance with the SLQCP.
- A detailed description of the liner and leachate collection systems.
- All laboratory and field test results.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- Record drawings.
- The GP will sign and seal a statement of compliance with the SLQCP and construction plans.
- The data and other information must be sufficient to support the conclusions in the reports.
- The seal and signature of the GP in accordance with the Texas Engineering Practice Act.

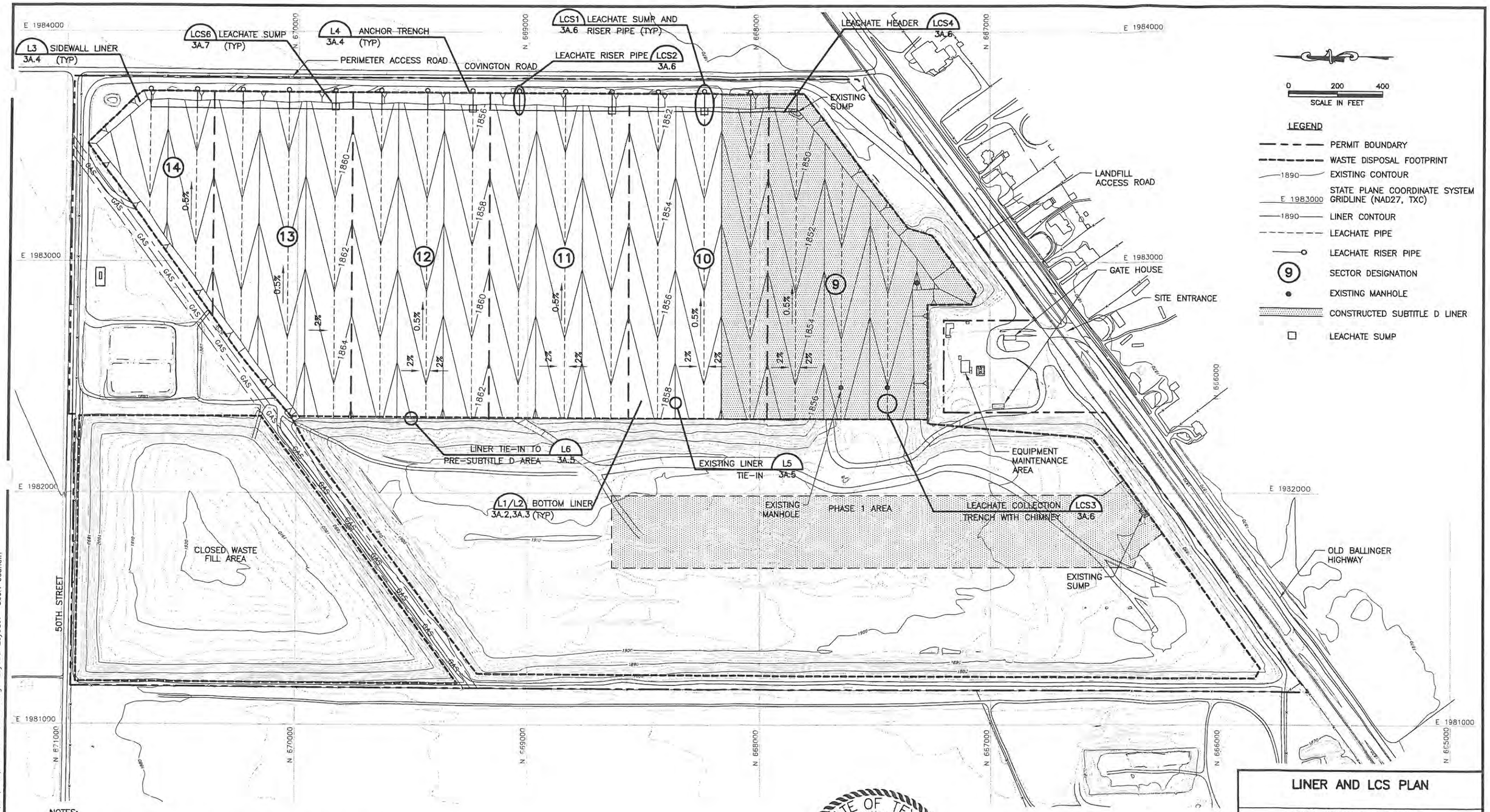
Markers shall be placed on site so that the disposal areas for which the GCLER/SLER and GLER have been submitted and approved are readily determinable. The markers are to provide site workers immediate knowledge at all times of the extent of approved disposal areas. These markers shall be located so that they are not destroyed during operations and shall be in accordance with Part IV, Section 8.7.

The surface of the liner will be covered with a layer of solid waste within a period of six months to mitigate the effects of surface erosion and rutting due to traffic. Liner surfaces not covered with waste within six months shall be checked by the GP, who

shall then submit a letter report on his findings to the TCEQ. Any required repairs shall be performed promptly. An addendum to the GLER shall be submitted on the new construction for all liners that need repair due to damage.

APPENDIX 3A

LINER AND LEACHATE COLLECTION SYSTEM DETAILS



J:\225\02\103\ExvationSitePlan2.dwg Layout: Layout1 User: scundiff

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MAY 11, 2006 BY METROPOLITAN AERIAL SURVEYS.
2. EXCAVATION CONTOURS ARE COMPILED FROM THE CITY OF SAN ANGELO, 1994 PERMIT MODIFICATION.
3. PHASE I AREA AND CELLS 9 AND 10A LINER SYSTEM ARE CONSTRUCTED.
4. DEEPEST EXCAVATION AT BOTTOM OF LEACHATE SUMPS: 1844.19 FT-MSL.
5. LEACHATE COLLECTION TRENCHES AT 0.5% SLOPE.

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100296
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2-2008

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1	02/08	SUMP PERMIT MOD	-	-	-	-	

LINER AND LCS PLAN

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

BIGGS & MATHEWS ENVIRONMENTAL
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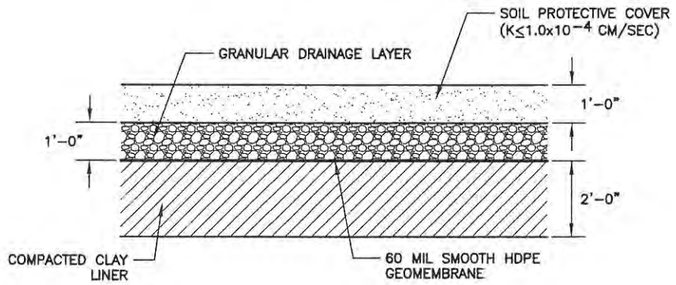
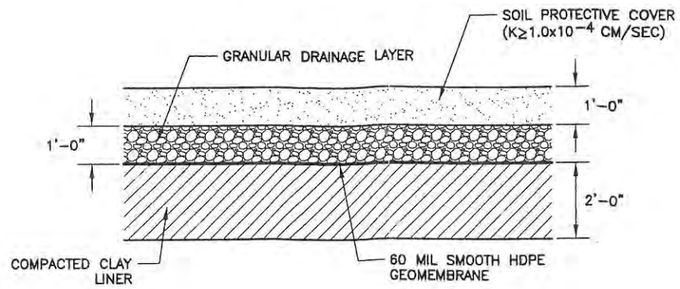
DWN.	RMP	SCALE :	GRAPHIC
CHK.	KJW	DWG :	ExvationSitePlan2.dwg

ATTACHMENT 3A.1



BOTTOM LINER L1A
CHIMNEYS REQUIRED 3A.2

0 2 4
SCALE IN FEET



BOTTOM LINER L1B
CHIMNEYS NOT REQUIRED 3A.2

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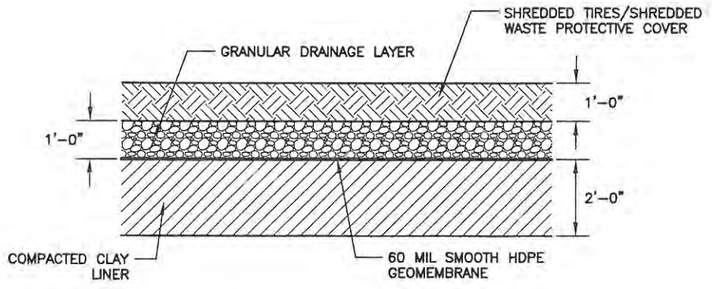
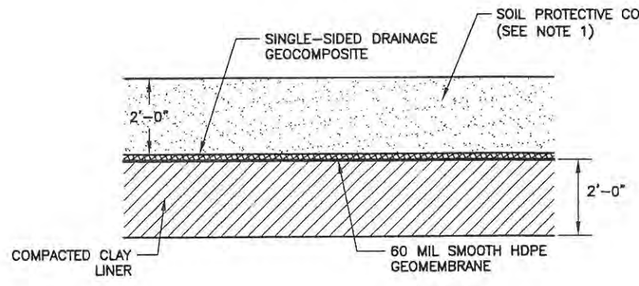
SCALE IN FEET



BOTTOM LINER L1C
CHIMNEYS NOT REQUIRED 3A.2

0 2 4
SCALE IN FEET



BOTTOM LINER L1D
CHIMNEY REQUIREMENTS VARY 3A.2
(SEE NOTE 1)

0 2 4
SCALE IN FEET

NOTES:

1. THE PROTECTIVE COVER HAS A COEFFICIENT OF PERMEABILITY GREATER THAN $1.0x10^{-4}$ CM/SEC, THEN CHIMNEYS ARE NOT REQUIRED. IF THE PROTECTIVE COVER HAS A MAXIMUM COEFFICIENT OF PERMEABILITY LESS THAN $1.0x10^{-4}$ CM/SEC, THEN CHIMNEYS ARE REQUIRED.

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60773
REGISTERED
PROFESSIONAL ENGINEER
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LINER DETAILS

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DSN. KJW	DATE : 07/07	ATTACHMENT
DWN. RMP	SCALE : GRAPHIC	3A.2
CHK. KJW	DWG : LinerDetails.dwg	

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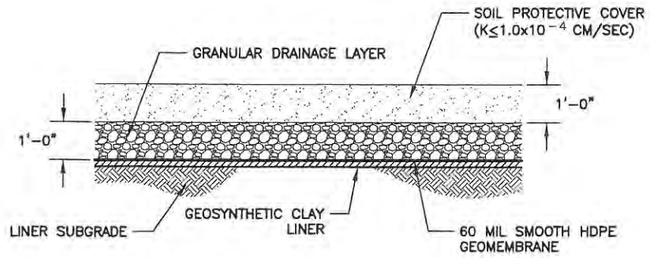
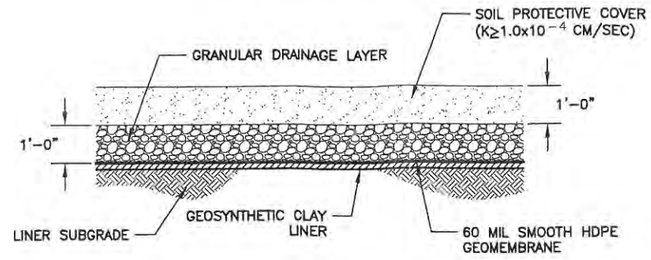


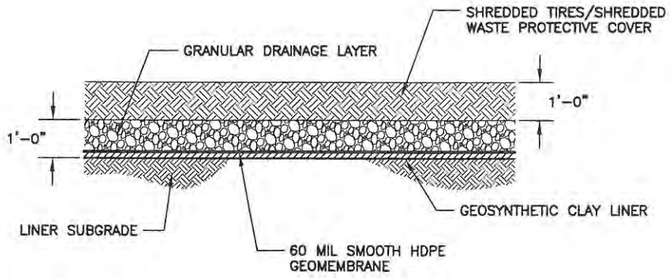
BOTTOM LINER L2A
CHIMNEYS REQUIRED 3A.3

0 2 4
SCALE IN FEET



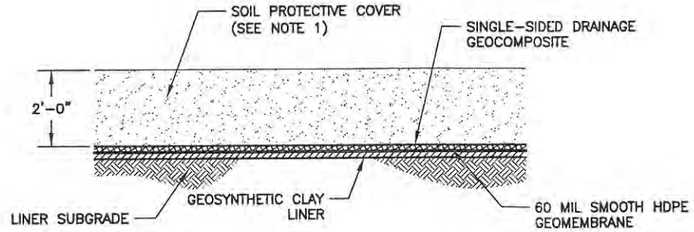
BOTTOM LINER L2B
CHIMNEYS NOT REQUIRED 3A.3

0 2 4
SCALE IN FEET



BOTTOM LINER L2C
CHIMNEYS NOT REQUIRED 3A.3

0 2 4
SCALE IN FEET



BOTTOM LINER L2D
CHIMNEY REQUIREMENTS VARY 3A.3
(SEE NOTE 1)

0 2 4
SCALE IN FEET

NOTES:

1. THE PROTECTIVE COVER HAS A COEFFICIENT OF PERMEABILITY GREATER THAN $1.0x10^{-4}$ CM/SEC, THEN CHIMNEYS ARE NOT REQUIRED. IF THE PROTECTIVE COVER HAS A MAXIMUM COEFFICIENT OF PERMEABILITY LESS THAN $1.0x10^{-4}$ CM/SEC, THEN CHIMNEYS ARE REQUIRED.

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KENNETH J. WELCH
60773
REGISTERED
PROFESSIONAL ENGINEER
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DSN. KJW	DATE : 07/07		ATTACHMENT
DWN. RMP	SCALE : GRAPHIC		3A.3
CHK. KJW	DWG : LinerDetails.dwg		

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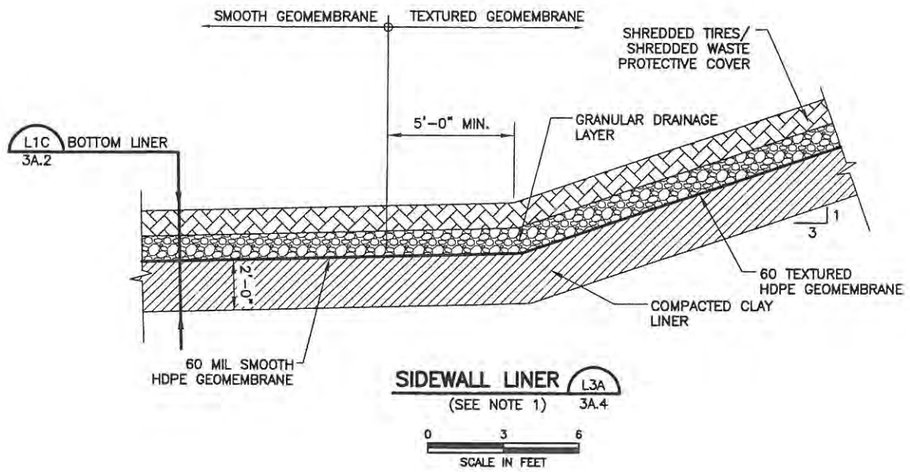
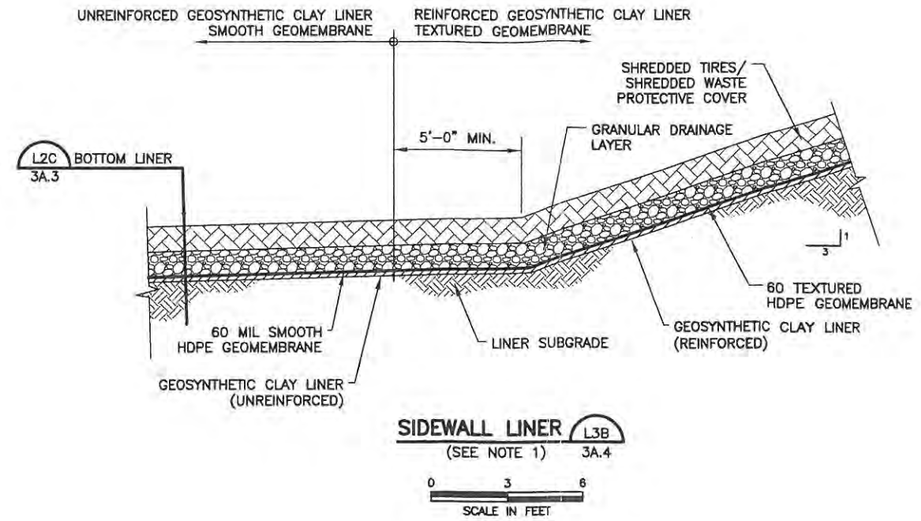
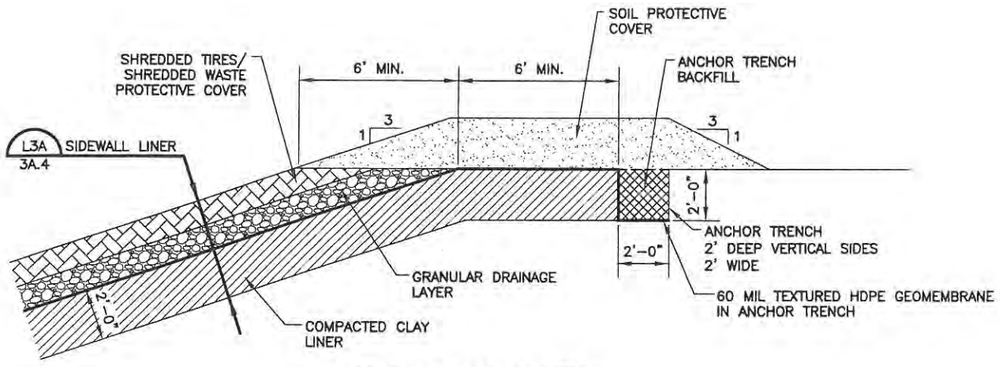


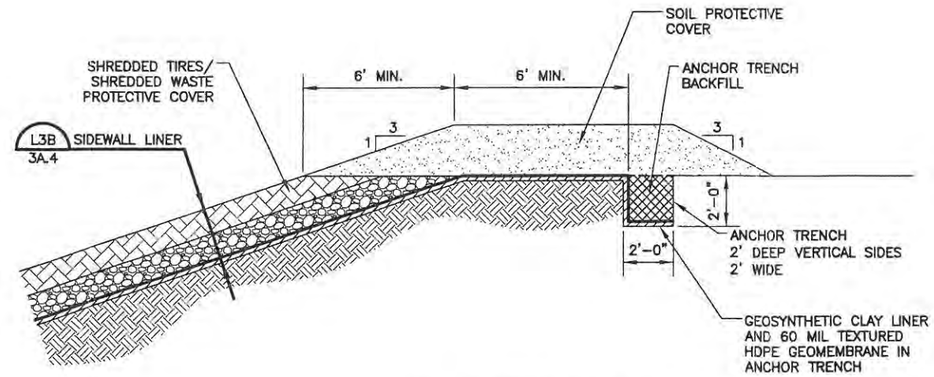
SIDEWALL LINER (L3A) (SEE NOTE 1) 3A.4



SIDEWALL LINER (L3B) (SEE NOTE 1) 3A.4



ANCHOR TRENCH (L4A) (SEE NOTE 1) 3A.4



ANCHOR TRENCH (L4B) (SEE NOTE 1) 3A.4

NOTES:

1. LEACHATE COLLECTION LAYERS L1C AND L2C ARE SHOWN. ALL LEACHATE COLLECTION LAYERS ARE INTERCHANGEABLE WITH BOTH LINER SYSTEMS.

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LINER DETAILS

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DSN. KJW	DATE : 07/07	ATTACHMENT	
DWN. RMP	SCALE : GRAPHIC	3A.4	
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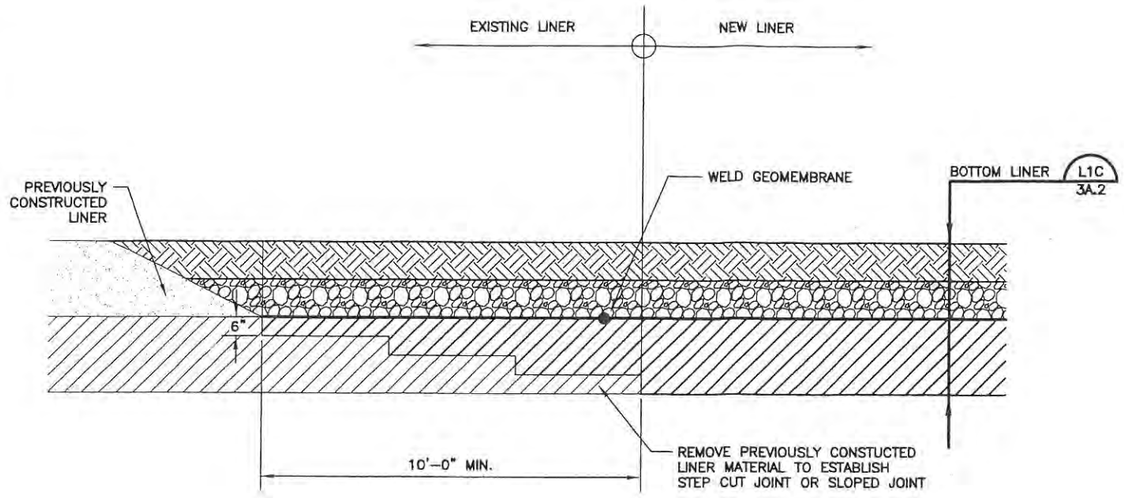
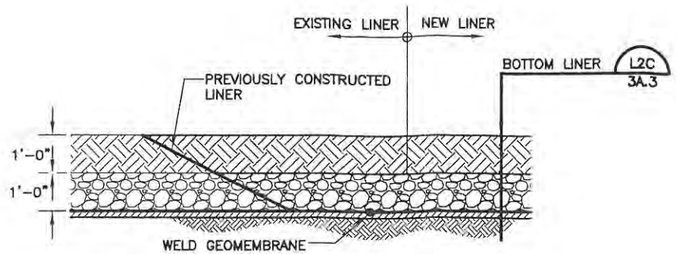


EXISTING LINER TIE–IN L5A 3A.5
(SEE NOTE 2)
0 2 4
SCALE IN FEET



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(SEE NOTE 2)
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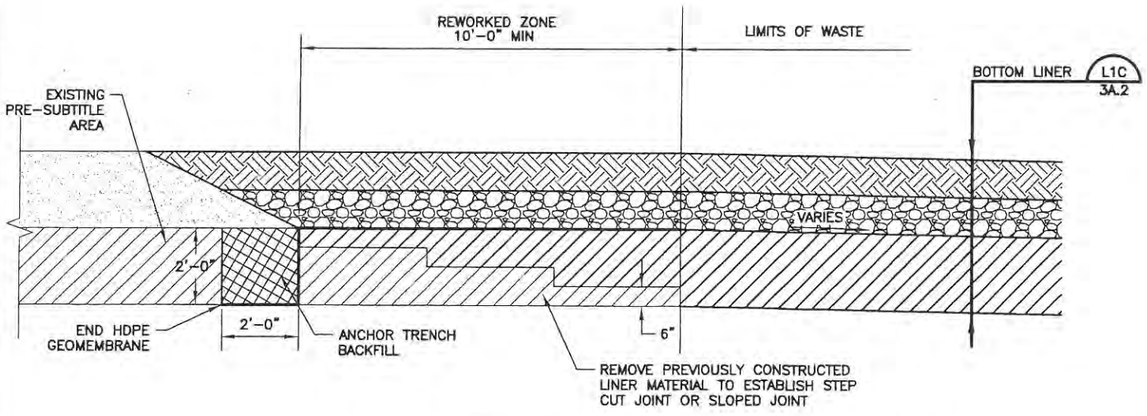

LINER TIE–IN TO PRE–SUBTITLE D AREA L6A 3A.5
(SEE NOTE 2)
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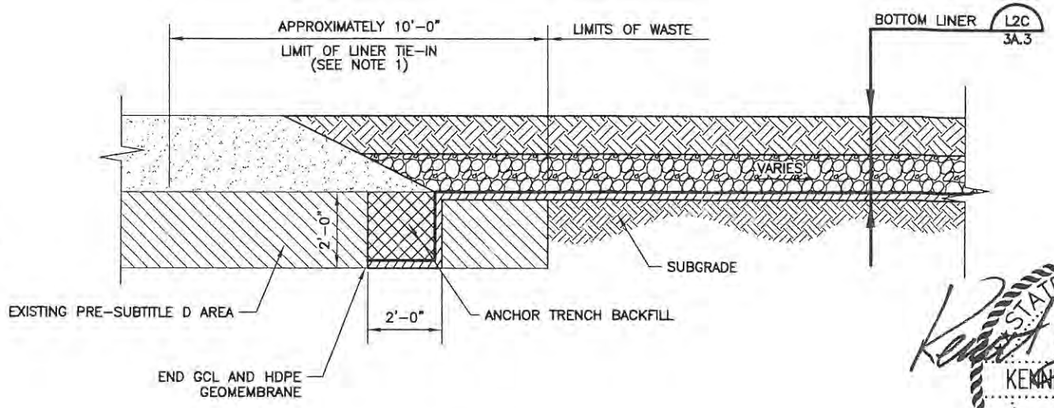
SCALE IN FEET



LINER TIE–IN TO PRE–SUBTITLE D AREA L6B 3A.5
(SEE NOTE 2)
0 2 4
SCALE IN FEET

NOTES:

1. THE GCL LINER WILL EXTEND INTO THE PRE–SUBTITLE D AREAS TO PROVIDE A COMPLETELY LINED CELL.
2. LEACHATE COLLECTION LAYERS L1C AND L2C ARE SHOWN. ALL LEACHATE COLLECTION LAYERS ARE INTERCHANGEABLE WITH BOTH LINER SYSTEMS.

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KENNETH J. WELCH
60773
REGISTERED PROFESSIONAL ENGINEER
11/19/07

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1	11/07	ADDENDUM	WCM	ALN	KJW	KJW	

LINER DETAILS

CITY OF SAN ANGELO
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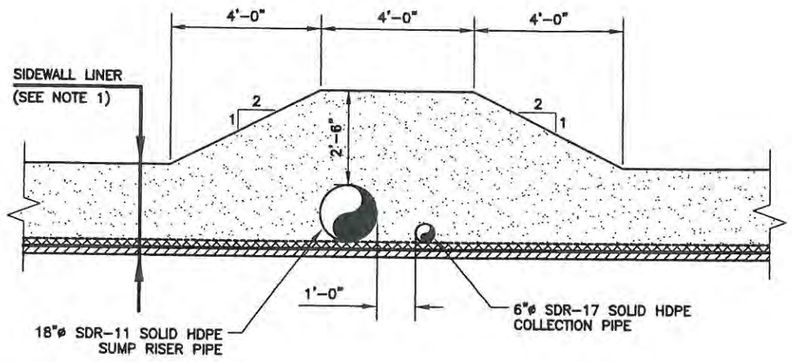
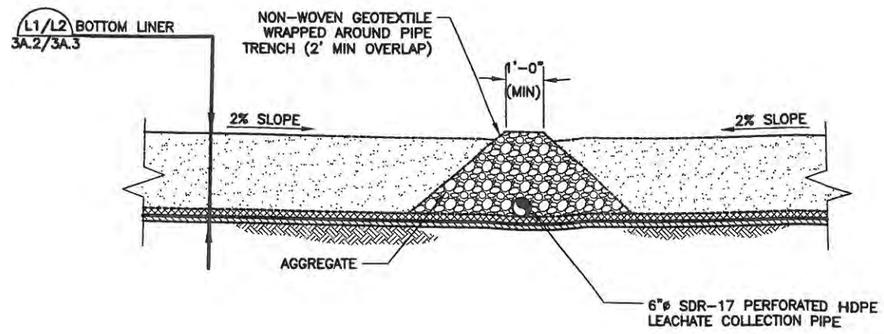
817–563–1144

DSN. KJW	DATE : 07/07	ATTACHMENT	
DWN. RMP	SCALE : GRAPHIC	3A.5	
CHK. KJW	DWG : LinerDetails.dwg		



LEACHATE SUMP AND RISER PIPE (LCS1) 3A.6

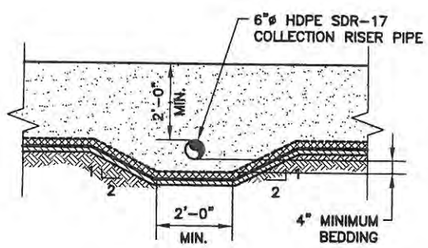
0 2 4
SCALE IN FEET



LEACHATE COLLECTION TRENCH WITH CHIMNEY (LCS3) 3A.6

(SEE NOTE 1)

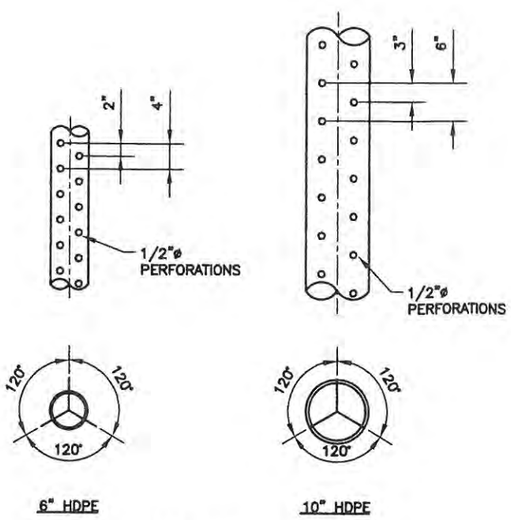
0 2 4
SCALE IN FEET



LEACHATE RISER PIPE (LCS2) 3A.6

(SEE NOTE 1)

0 2 4
SCALE IN FEET

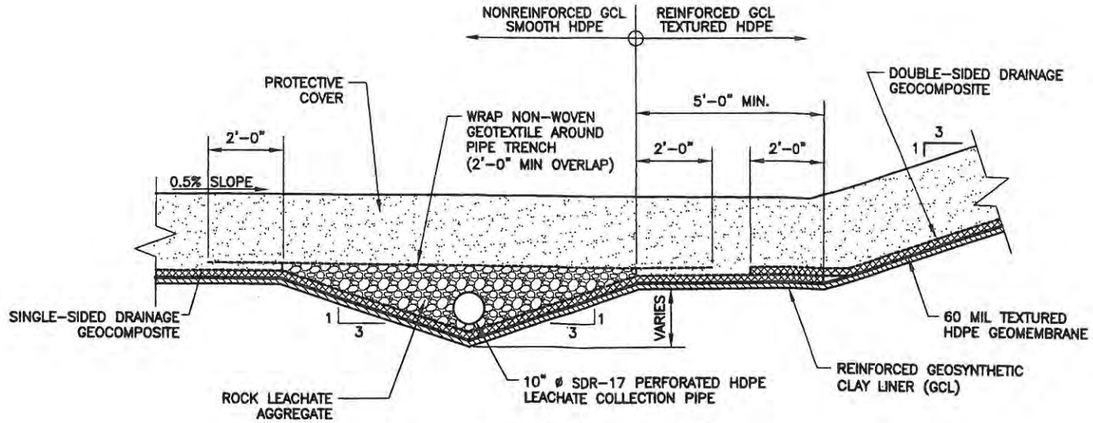


6" HDPE

10" HDPE

PERFORATED PIPE (LCS5) 3A.6

0 2 4
SCALE IN FEET



LEACHATE HEADER (LCS4) 3A.6

(SEE NOTE 1)

0 2 4
SCALE IN FEET

NOTES:

1. LINER SYSTEM L2D SHOWN. LEACHATE COLLECTION SYSTEM CHIMNEYS ARE INTERCHANGEABLE WITH ANY LINER/PROTECTIVE COVER CONFIGFURATION (WHEN REQUIRED).

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1	02/08	SUMP PERMIT MOD	–	–	–	–

LEACHATE COLLECTION SYSTEM DETAILS

SAN ANGELO LANDFILL
CITY OF SAN ANGELO
TCEQ PERMIT NO. MSW 79

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817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. ALN	DATE : 07/07	ATTACHMENT	
DWN. WCM	SCALE : GRAPHIC	3A.6	
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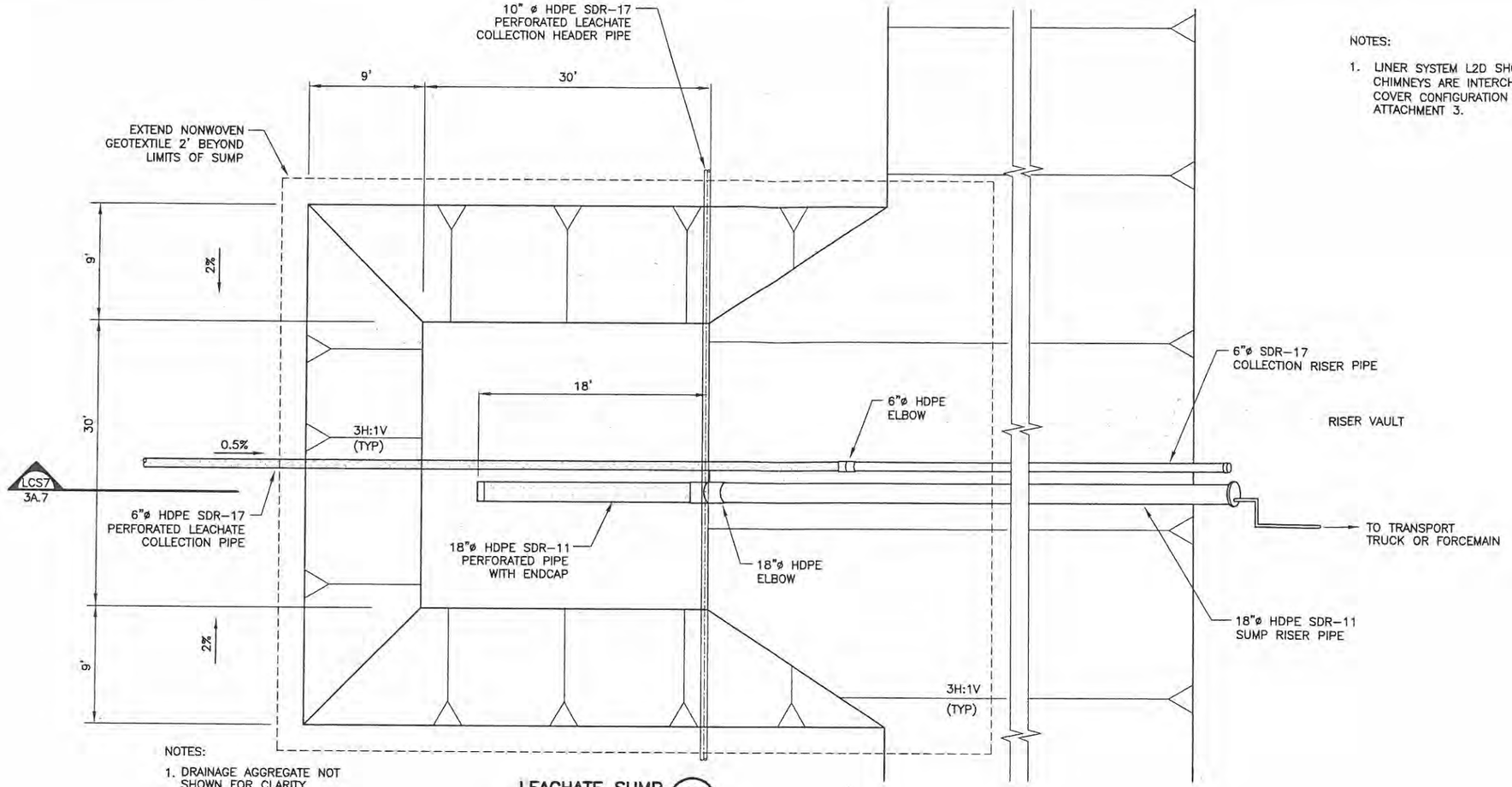
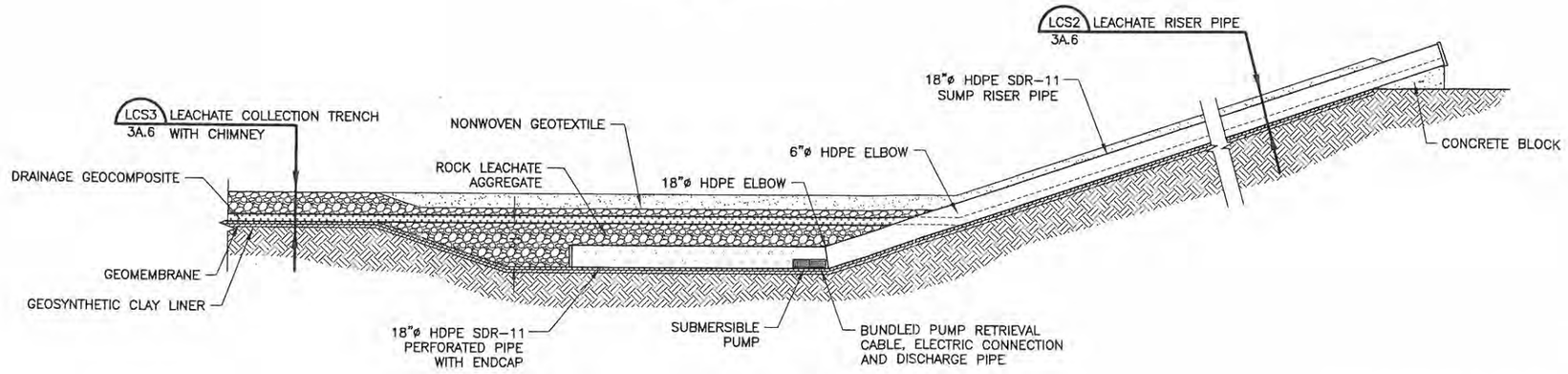


NOTES:

1. DRAINAGE AGGREGATE NOT SHOWN FOR CLARITY

LEACHATE SUMP (LCS6, 3A.7)

NOT TO SCALE



LEACHATE SUMP AND RISER (LCS7, 3A.7)

NOT TO SCALE
(SEE NOTE 1)

NOTES:

1. LINER SYSTEM L2D SHOWN. LEACHATE COLLECTION SYSTEM CHIMNEYS ARE INTERCHANGEABLE WITH ANY LINER/PROTECTIVE COVER CONFIGURATION (WHEN REQUIRED), AS DISCUSSED IN ATTACHMENT 3.

STATE OF TEXAS
AMY L. NUNES
100296
REGISTERED
PROFESSIONAL ENGINEER
2-20-08

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LEACHATE COLLECTION SYSTEM DETAILS

SAN ANGELO LANDFILL
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DSN.	ALN	DATE :	02/08
DWN.	WCM	SCALE :	GRAPHIC
CHK.	ALN	DWG :	LeachateDetails2.dwg

ATTACHMENT 3A.7

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APPENDIX 3B

GEOSYNTHETIC RESEARCH INSTITUTE STANDARD GM13

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

Revision 8: July 10, 2006
Revision schedule on pg. 11

GRI Test Method GM13*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers high density polyethylene (HDPE) geomembranes with a formulated sheet density of 0.940 g/ml, or higher, in the thickness range of 0.75 mm (30 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

1.4 This standard specification is intended to ensure good quality and performance of HDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

values for test indicated, may be necessary under conditions of a particular application.

Note 2: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

2.2 GRI Standards

GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet
GM 11 Accelerated Weathering of Geomembranes using a Fluorescent UVA-Condensation Exposure Device
GM 12 Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

2.3 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HDPE polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

4. Material Classification and Formulation

4.1 This specification covers high density polyethylene geomembranes with a formulated sheet density of 0.940 g/ml, or higher. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.932 g/ml or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth HDPE geomembranes and Table 2 is for single and double sided textured HDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is soft.

Note 3: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of 23°C ± 2°C. Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of 21°C ± 2°C. The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of 23°C ± 2°C should be utilized for testing purposes.

Note 4: There are several tests often included in other HDPE specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693)
- Wide Width Tensile
- Water Vapor Transmission
- Water Absorption
- Ozone Resistance
- Modulus of Elasticity
- Hydrostatic Resistance
- Tensile Impact
- Field Seam Strength
- Multi-Axial Burst
- Various Toxicity Tests

Note 5: There are several tests which are included in this standard (that are not customarily required in other HDPE specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet (see Note 6)

Note 6: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength

associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

Note 7: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Puncture Resistance
- Stress Crack Resistance
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

Note 8: There are several GRI tests currently included in this standard. Since these topics are not covered in ASTM standards, this is necessary. They are the following:

- UV Fluorescent Light Exposure
- Asperity Height Measurement

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The properties of the HDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 9: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively.

6. Workmanship and Appearance

6.1 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.

6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marketing

9.1 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

ENGLISH UNITS

Table 1(a) – High Density Polyethylene (HDPE) Geomembrane -Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.)	D5199	nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Nom.	Per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Density mg/l (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties *(1)* (min. ave.) • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 63 lb/in. 114 lb/in. 12% 700%	 84 lb/in. 152 lb/in. 12% 700%	 105 lb/in. 190 lb/in. 12% 700%	 126 lb/in. 228 lb/in. 12% 700%	 168 lb/in. 304 lb/in. 12% 700%	 210 lb/in. 380 lb/in. 12% 700%	 252 lb/in. 456 lb/in. 12% 700%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	54 lb	72 lb	90 lb	108 lb	144 lb	180 lb	216 lb	45,000 lb
Stress Crack Resistance *(2)*	D5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI-GM10
Carbon Black Content (range)	D 1603 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	GM 11 D 3895 D 5885	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 in.

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (METRIC) UNITS

Table 1(b) – High Density Polyethylene (HPDE) Geomembrane - Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness - mils (min. ave.) • lowest individual of 10 values	D5199	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	per roll
Density (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties *(1)* (min. ave.) • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 11 kN/m 20kN/m 12% 700%	 15 kN/m 27 kN/m 12% 700%	 18 kN/m 33 kN/m 12% 700%	 22 kN/m 40 kN/m 12% 700%	 29 kN/m 53 kN/m 12% 700%	 37 kN/m 67 kN/m 12% 700%	 44 kN/m 80 kN/m 12% 700%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	240 N	320 N	400 N	480 N	640 N	800 N	960 N	20,000 kg
Stress Crack Resistance *(2)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM-10
Carbon Black Content - %	D 1603 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	9,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	D 3895 D 5885	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 3895 D 5885	N. R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	N.R. *(8)* 50%	per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

ENGLISH UNITS

Table 2(a) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	GM 12	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(3)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	63 lb/in. 45 lb/in. 12% 100%	84 lb/in. 60 lb/in. 12% 100%	105 lb/in. 75 lb/in. 12% 100%	126 lb/in. 90 lb/in. 12% 100%	168 lb/in. 120 lb/in. 12% 100%	210 lb/in. 150 lb/in. 12% 100%	252 lb/in. 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(4)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM10
Carbon Black Content (range)	D 1603 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	D 3895 D 5885	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	GM11 D 3895 D 5885	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils; also see Note 6.

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

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

(4) P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(6) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (METRIC UNITS)

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.) *(1)*	GM 12	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) *(3)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	11 kN/m 8 kN/m 12% 100%	15 kN/m 10 kN/m 12% 100%	18 kN/m 13 kN/m 12% 100%	22 kN/m 16 kN/m 12% 100%	29 kN/m 21 kN/m 12% 100%	37 kN/m 26 kN/m 12% 100%	44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance *(4)*	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	per GRI GM10
Carbon Black Content (range)	D 1603 *(5)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	9,000 kg
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	D 3895 D 5885	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	GM11 D 3895 D 5885	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13 mm; also see Note 6.

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

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

(6) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

Adoption and Revision Schedule

for

HDPE Specification per GRI-GM13

"Test Methods, Test Properties, Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

Adopted:	June 17, 1997
Revision 1:	November 20, 1998; changed CB dispersion from allowing 2 views to be in Category 3 to requiring all 10 views to be in Category 1 or 2. Also reduced UV percent retained from 60% to 50%.
Revision 2:	April 29, 1999: added to Note 5 after the listing of Carbon Black Dispersion the following: "(In the viewing and subsequent quantitative interpretation of ASTM D5596 only near spherical agglomerates shall be included in the assessment)" and to Note (4) in the property tables.
Revision 3:	June 28, 2000: added a new Section 5.2 that the numeric table values are neither MARV or MaxARV. They are to be interpreted per the the designated test method.
Revision 4:	December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".
Revision 5:	May 15, 2003: Increased minimum acceptable stress crack resistance time from 200 hrs to 300 hrs.
Revision 6:	June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 2.
Revision 7:	February 20, 2006: Added Note 6 on Asperity Height clarification with respect to shear strength.
Revision 8:	Removed recommended warranty from specification.

APPENDIX 3C

GEOSYNTHETIC RESEARCH INSTITUTE STANDARD GCL3

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

Original - May 16, 2005

GRI-GCL3*

Standard Specification for

"Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers the manufacturing quality control (MQC) of geosynthetic clay liners (GCLs), describing types of tests, the proper test methods, minimum and sometimes maximum values, and the minimum testing frequencies.

Note 1: Geosynthetic Clay Liners (GCLs) are also called Clay Geosynthetics Barriers (GBR-Cs).

1.2 There are two general categories of GCLs covered in this specification: reinforced and nonreinforced. Within each category there are geotextile, polymer coated geotextiles, and geomembrane/geofilm related types.

1.3 This specification is intended to aid manufacturers, suppliers, purchasers and users of GCLs in establishing an acceptable level of effort for manufacturing quality control.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version and is kept current on the Institute's Website <<geosynthetic-institute.org>>.

1.4 This specification does not address manufacturing quality assurance (MQA), product acceptance testing, or conformance testing. These are independent activities taken by organizations other than the GCL manufacturer.

1.5 The values stated in SI (metric) units are to be regarded as the standard. The U.S. (English) units are calculated values using a "soft" conversion accuracy.

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

2. Referenced Documents

2.1 ASTM Standards

D 638 Test Method for Tensile Properties of Plastics
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 882 Test Method for Tensile Properties of Thin Plastic Sheeting
D 1141 Practice for Preparation of Substitute Ocean Water
D 1505 Test Method for Density of Plastics by the Density-Gradient Method
D 4354 Practice for Sampling of Geosynthetics for Testing
D 4439 Terminology for Geosynthetics
D 4632 Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4759 Practice for Determining the Specification Conformance of Geosynthetics
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5887 Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using Flexible Wall Permeameter
D 5888 Practice for Storage and Handling of Geosynthetic Clay Liners
D 5889 Practice for Quality Control of Geosynthetic Clay Liners
D 5890 Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
D 5891 Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
D 5993 Test Method for Measuring the Mass Per Unit Area of Geosynthetic Clay Liners
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembrane
D 6102 Guide for Installation of Geosynthetic Clay Liners
D 6141 Guide for Screening the Clay Portion of a GCL for Chemical Compatibility to Liquids

D 6243 Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

D 6495 Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners

D 6496 Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners

D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

D 6766 Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids

D 6768 Test Method for Tensile Strength of Geosynthetic Clay Liners

2.2 GRI Standards

GM13 Test Properties, Testing Frequency and Recommended Warrant for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

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

GM18 Test Properties, Testing Frequency and Recommended Warrant for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes (Presently suspended as of May 3, 2004)

2.3 Government Document:

U.S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Terminology

3.1 Definition

3.1.1 Geosynthetic Definitions:

3.1.1.1 geotextile, n—a permeability geosynthetic comprised solely of textiles. (ASTM D 4439)

3.1.1.2 geomembrane, n—an essentially impermeable geosynthetic barrier composed of one or more synthetic sheets. (ASTM D 4439)

3.1.1.3 geofilm, n—a thin polymeric film which is essentially impermeable having a thickness no greater than 0.25 mm (10 mils).

3.1.1.4 geotextile-polymer, n—a geotextile which has been coated with, or impregnated by, a polymer such as polypropylene

3.1.1.5 geosynthetic clay liner, n—a manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetic materials. (ASTM D 4439)

Note 1: Geotextile Related GCL is one in which two geotextiles are used respectively as cap and carrier to the bentonite. Cap and carrier designations in this standard refer to respective orientations during manufacturing. This may or may not be the as-placed orientation in the field. It can be internally reinforced by needle punching or stitching, or be nonreinforced.
Geotextile Polymer Coated GCL is one in which two geotextiles are used respectively as cap and carrier to the encased bentonite, however, one of the geotextiles has been polymer coated in a manner that the permeability and flux are decreased. Cap and carrier designations refer to the as manufactured product and not necessarily to the as-placed orientation. It can be internally reinforced by needle punching or stitching, or be nonreinforced.
Geomembrane/Geofilm Related GCL is one in which a geomembrane or geofilm is included in the cross section either above or below the cap geotextile. It can be internally reinforced needle punching or be nonreinforced. Also in the nonreinforced category is bentonite adhesively bonded to a geomembrane.

3.1.2 Material Definitions

3.1.2.1 bentonite—a distinct type of fine-grained clay soil typically containing not less than 80% montmorillionite clay, usually characterized by high swelling upon wetting.

3.1.2.2 Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For geosynthetic materials, a formulation refers to the exact percentages of resin, additives, carbon black and/or other additives. It does not necessarily refer to individual suppliers of each ingredient. The individual suppliers must meet the manufacturer's internal quality control specification.

3.1.3 Organizational Definitions:

3.1.3.1 installer, n—the party who installs, or facilitates installation of, any materials purchased from manufacturers or suppliers.

3.1.3.2 manufacturer, n—the group, corporation, partnership, or individual that manufactures a product.

3.1.3.3 purchaser, n—the person, company, or organization that purchases any materials or work to be performed.

3.1.3.4 supplier, n—the party who supplies material or services.

3.1.4 Quality Definitions:

3.1.4.1 Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications, ref. EPA/600/R-93/182

3.1.4.2 Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project, ref. EPA/600/R-93/182

3.1.4.3 Construction Quality Control (CQC) - A planned system of inspections that are used to directly monitor and control the quality of a construction project. Construction quality control is normally performed by the geosynthetics manufacturer or installer, or for natural soil materials by the earthwork contractor, and is necessary to achieve quality in the constructed or installed system. Construction quality control (CQC) refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project, ref. EPA/600/R-93/182

3.1.4.4 Construction Quality Assurance (CQA) - A planned system of activities that provide assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verification, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project, ref. EPA.600/R-93/182

4. Significance and Use

4.1 GCLs must be properly manufactured in a manner consistent with a minimum level of quality control as determined by in-house testing of the final product. This specification presents the types of tests, standard methods of the testing, required (usually minimum) test values, and minimum testing frequencies which should be embodied in the manufacturer's quality control documents. The quoted tests, test methods and test values in Table 1 must appear in the MQC plan and the MQC report.

4.2 It should be clearly recognized that manufacturers may perform additional tests or at greater frequency than required in this specification, or both. In this case, the manufacturer's quality control plan will then take precedence over this specification.

4.3 It should also be recognized that purchasers and installers of GCLs may require additional tests or at a great frequency than called for in this specification, or both. The organization(s) producing such project specific specification or quality assurance plan should recognize that such requirements are beyond the current state-of-the-practice. If such a request is made by purchasers or installers, they should clearly communicate the requirements to the manufacturer or supplier during the contract decisions in order that disputes do not arise at a subsequent time.

5. Procedure

5.1 The procedures embodied in this specification are contained in the respective test methods given in Table 1.

5.1.1 The minimum recommended quality control tests for the manufacture of GCLs are given in Table 1. Specific tests are performed on the bentonite, the geosynthetic component materials, and the finished GCL. Table 1(a) is in S.I. (Metric) units and Table 1(b) is in U.S. (English) units.

Note 2: The conversion from S.I. units into U.S. units is soft.

5.1.2 The individual properties in Table 1 are minimum values; except fluid loss, moisture content, and permeability (or flux). They are maximum values. The manner of taking specimens is described in the appropriate test method. When an average value is indicated, it is listed in the table as "min. ave.", or "max. ave.".

5.2 Bentonite (as received)
Two tests are required; swell index and fluid loss. The latter is a maximum value. These tests should be performed on the bentonite prior to fabrication into a GCL

or on bentonite taken from the manufactured product if the bentonite is modified in any way during manufacturing, e.g., if an adhesive is added.

5.3 Geotextile (as received)
Mass per unit area is required on the as-manufactured cap and carrier fabrics, with different values depending on the fabric being nonwoven or woven.

Note 3: These tests are to be performed on the geotextiles before manufacturing into the final GCL. Removal of the geotextiles from the manufactured product and subsequent testing will give erroneous values and is not an acceptable practice. The exception is polymer coated GCLs where the geotextile must be removed to determine its mass per unit area.

5.4 Geomembrane/Geofilm (as received)
The following tests are required; thickness, density, and tensile strength at break. All are minimum required values. Tensile strength at break is the lowest of machine direction and cross machine direction.

Note 4: These tests are to be performed on the geomembrane or geofilm before manufacturing into the final GCL. Removal of the geomembrane or geofilm from the manufactured product and subsequent testing will give erroneous values and is not an accepted practice.

5.5 GCL (as manufactured)
Six tests are required on the as-manufactured GCL with one having an alternative, i.e., hydraulic conductivity or flux. All are minimum values, with the exception of moisture content and hydraulic conductivity or flux.

5.6 GCL (long-term)
The purpose of these long-term or endurance tests is to provide confidence in the continuing acceptable performance of the bentonite and geosynthetic components of the installed GCL.

5.6.1 The durability of the bentonite is evaluated using a permeant consisting of 0.1 M calcium chloride solution. See ASTM D 6141 which is a guide for this particular aspect of the specification. The GCL is to be hydrated with distilled dionized water prior to conducting the tests with the calcium chloride solution. In this regard, ASTM D6766 Scenario 1 and Method C is the procedure to be used. Furthermore, this test is conducted twice at two different normal pressures, i.e., 35 and 500 kPa. The maximum allowable values are listed in Table 1.

5.6.2 The geotextiles in their as-received condition are evaluated by incubation in a forced air oven per ASTM D5721 set at 60°C for 50 days. The

minimum percent in tensile strength retained at break, as measured by ASTM D6768, is 65%. If individual yarns are used in reinforcing GCLs, they must also meet this same endurance criterion.

5.6.3 The geomembrane in its as-received condition is evaluated for durability via the appropriate GRI Specification. For high density polyethylene (HDPE), the specification is GRI GM13. For linear low density polyethylene (LLDPE), the specification is GRI GM17. For flexible polypropylene (fPP), the specification is GRI GM18.

5.6.4 The geofilm in its as-received condition is evaluated by incubation in a forced air oven per ASTM D5721 set at 60°C for 50 days. The minimum percent tensile strength retained at break for either MD or XMD, as measured by ASTM D882, is reported accordingly and must meet or exceed the specification value.

Note 5: It should be recognized that the above durability criterion for geofilms is not as stringent as the criteria for geomembranes stated in Section 5.6.3.

6. Workmanship and Appearance

6.1 Waterproof ink overlap lines should be printed on both edges of one of the surfaces (geotextile or geomembrane) of the manufactured GCL.

Note 6: The overlap lines are minimally 150 mm (6.0 in.) from the edges of the GCL. Other design-related situations may require greater overlap distances to be printed on the GCLs, e.g., when not backfilled in a timely manner.

6.2 Needle punched and stitch bonded GCLs shall be essentially free of broken needles and fragments of needles that would negatively effect the performance of the final product. There must be continuous needle detection and removal devices, e.g., metal detectors and magnets, used during manufacture of GCL products.

6.3 The manufactured GCL shall have good appearance qualities. It shall be free from such defects that would affect the specified properties and integrity of the product.

6.4 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents. ASTM D5888 and D5889 should be followed in this regard.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Table 1. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width, see ASTM D 4354.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Table 1.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave.". When the property is a maximum value, the designation is "max. ave.".

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marking

9.1 The GCL shall be rolled, clearly labeled, and onto a substantial core, encased in a waterproof wrapper. Packaging must be adequate for safe transportation to the point of delivery.

9.2 The label should include manufacturer, style, lot and/or roll number, weight, length and width.

10. Conformance and Certification

10.1 Conformance of the manufactured GCL to this specification, or agreed-upon variation thereof, shall be performed by the MQA organization or designated by the purchaser/owner. ASTM D 4759 can be used as a general guide, but individual test methods must be clearly stipulated and communicated to the parties involved.

10.2 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

Table 1(a) – Specification for Geosynthetic Clay Liners (GCLs)

Property	ASTM Test Method	Reinforced GCL			Non-Reinforced GCL			Testing Frequency
		GT-Related	GT Polymer Coated	GM-GF Related	GT-Related	GT Polymer Coated	GM-GF Related	
Clay (as received)								
swell index (ml/2g)	D5890	24	24	24	24	24	24	50 tonnes
fluid loss (ml)[1]	D5891	18	18	18	18	18	18	50 tonnes
Geotextiles (as received)								
cap fabric (nonwoven) - mass/unit area (g/m^2)[2]	D5261	200	200	200	70	100	n/a/70	20,000 m^2
cap fabric -(woven) - mass/unit area (g/m^2)	D5261	100	100	100	-	-	-	20,000 m^2
carrier fabric (nonwoven composite) - mass/(g/m^2)[2]	D5261	240	240	240	90	100	n/a/90	20,000 m^2
carrier fabric (woven) - mass/unit area (g/m^2)	D5261	100	100	100	-	-	-	20,000 m^2
coating - mass/unit area (g/m^2)[3]	D5261	n/a	100	n/a	n/a	100	n/a	4,000 m^2
Geomembrane/Geofilm (as received)								
thickness[5] (mm)	D5199/D5994	n/a	n/a	0.40/0.50/0.10	n/a	n/a	0.40/0.75/0.10	20,000 m^2
density (g/cc)	D1505/D792	n/a	n/a	0.92	n/a	n/a	0.92	20,000 m^2
break tensile strength, MD&XMD (kN/m)	D6693	n/a	n/a	n/a	n/a	n/a	6.0	20,000 m^2
break tensile strength, MD (kN/m)	D882	n/a	n/a	2.5	n/a	n/a	2.5	20,000 m^2
GCL (as manufactured)								
mass of GCL (g/m^2)[6]	D5993	4000	4050	4100	4000	4050	4100	4,000 m^2
mass of bentonite (g/m^2)[6]	D5993	3700	3700	3700	3700	3700	3700	4,000 m^2
moisture content[1] (%)	D5993	(4)	(4)	(4)	(4)	(4)	(4)	4,000 m^2
tensile str., MD (kN/m)	D6768	4.0	4.0	4.0	4.0	4.0	4.0	20,000 m^2
peel strength (N/m)	D6496	360	360	360	n/a	n/a	n/a	4,000 m^2
permeability[1] (m/sec), "or"	D5887	5×10^{-11}	5×10^{-12}	5×10^{-12}	5×10^{-11}	5×10^{-12}	5×10^{-12}	25,000 m^2
flux[1] ($m^3/sec\text{-}m^2$),	D5887	1×10^{-8}	1×10^{-9}	1×10^{-9}	1×10^{-8}	1×10^{-9}	1×10^{-9}	25,000 m^2
GCL permeability[1],[7] (m/sec) (max. at 35 kPa)	D6766	1×10^{-8}	1×10^{-9}	1×10^{-9}	1×10^{-8}	1×10^{-9}	1×10^{-9}	yearly
GCL permeability[1],[7] (m/sec) (max. at 500 kPa)	D6766 mod.	5×10^{-10}	5×10^{-11}	5×10^{-11}	5×10^{-10}	5×10^{-11}	5×10^{-11}	yearly
Component Durability								
geotextile and reinforcing yarns [8] (% strength retained)	See § 5.6.2	65	65	n/a	65	65	n/a	yearly
geomembrane	See § 5.6.3	n/a	n/a	GM Spec[9]	n/a	n/a	GM Spec[9]	yearly
geofilm/polymer treated[8] (% strength retained)	See § 5.6.4	n/a	85	80	n/a	85	80	yearly

n/a = not applicable with respect to this property

(1) These values are maximum (all others are minimum)
(2) For both cap and carrier fabrics for nonwoven reinforced GCLs; one, or the other, must contain a scrim component of mass ≥ 100 g/m^2 for dimensional stability
(3) Calculated value obtained from difference of coated fabric to as-received fabric
(4) Value is both site-specific and product-specific and is currently being evaluated
(5) First value is for smooth geomembrane; second for textured geomembrane; third for geofilm
(6) Mass of the GCL and bentonite is measured after oven drying per the stated test method
(7) Value represents GCL permeability after permeation with a 0.1 M calcium chloride solution (11.1 g CaCl2 in 1-liter water)
(8) Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days
(9) Durability criteria should follow the appropriate specification for the geomembrane type used; i.e., GRI GM-13 for HDPE, GRI GM-17 for LLDPE or GRI GM-18 for fPP

Table 1(b) – Specification for Geosynthetic Clay Liners (GCLs)

Property	ASTM Test Method	Reinforced GCL			Non-Reinforced GCL			Testing Frequency
		GT-Related	GT Polymer Coated	GM-GF Related	GT-Related	GT Polymer Coated	GM-GF Related	
Clay (as received)								
swell index (ml/2g)	D5890	24	24	24	24	24	24	50 tonnes
fluid loss (ml)[1]	D5891	18	18	18	18	18	18	50 tonnes
Geotextiles (as received)								
cap fabric (nonwoven) - mass/unit area (oz/yd^2)[2]	D5261	5.8	5.8	5.8	2.1	2.9	n/a/2.1	25,000 yd^2
cap fabric (woven) - mass/unit area (oz/yd^2)	D5261	3.0	3.0	3.0	-	-	-	25,000 yd^2
carrier fabric (nonwoven composite) - mass/(oz/yd^2)[2]	D5261	5.9	5.9	5.9	2.7	2.9	n/a/2.7	25,000 yd^2
carrier fabric (woven) - mass/unit area (oz/yd^2)	D5261	3.0	3.0	3.0	-	-	-	25,000 yd^2
coating - mass/unit area (oz/yd^2)[3]	D5261	n/a	2.9	n/a	n/a	2.9	n/a	5,000 yd^2
Geomembrane/Geofilm (as received)								
thickness[5] (mils)	D5199/D5994	n/a	n/a	15/20/4	n/a	n/a	15/30/4	25,000 yd^2
density (g/cc)	D1505/D792	n/a	n/a	0.92	n/a	n/a	0.92	25,000 yd^2
break tensile strength, MD&XMD (lb/in.)	D6693	n/a	n/a	n/a	n/a	n/a	34	25,000 yd^2
break tensile strength, MD & XMD (lb/in.)	D882	n/a	n/a	14	n/a	n/a	14	25,000 yd^2
GCL (as manufactured)								
mass of GCL (lb/ft^2)[6]	D5993	0.82	0.83	0.84	0.82	0.83	0.84	5,000 yd^2
mass of bentonite (lb/ft^2)[6]	D5993	0.75	0.75	0.75	0.75	0.75	0.75	5,000 yd^2
moisture content[1] (%)	D5993	(4)	(4)	(4)	(4)	(4)	(4)	5,000 yd^2
tensile str., MD (lb/in.)	D6768	23	23	23	23	23	23	25,000 yd^2
peel strength (lb/in.)	D6496	2.1	2.1	2.1	n/a	n/a	n/a	5,000 yd^2
permeability[1] (cm/sec), "or"	D5887	5×10^{-9}	5×10^{-10}	n/a	5×10^{-9}	5×10^{-10}	n/a	30,000 yd^2
flux[1] (cm^3/sec-cm^2),	D5887	1×10^{-6}	1×10^{-7}	n/a	1×10^{-6}	1×10^{-7}	n/a	30,000 yd^2
GCL permeability[1],[7] (cm/sec) (max. at 5 lb/in.^{2})	D6766	1×10^{-6}	1×10^{-7}	1×10^{-7}	1×10^{-6}	1×10^{-7}	1×10^{-7}	yearly
GCL permeability[1],[7] (cm/sec) (max. at 70 lb/in.^{2})	D6766 mod.	5×10^{-8}	5×10^{-9}	5×10^{-9}	5×10^{-8}	5×10^{-9}	5×10^{-9}	yearly
Component Durability								
geotextile and reinforcing yarns[8] (% strength retained)	See § 5.6.2	65	65	n/a	65	65	n/a	yearly
geomembrane	See § 5.6.3	n/a	n/a	GM Spec[9]	n/a	n/a	GM Spec[9]	yearly
geofilm/polymer treated[8] (% strength retained)	See § 5.6.4	n/a	85	80	n/a	85	80	yearly

n/a = not applicable with respect to this property :

(1) These values are maximum (all others are minimum)
(2) For both cap and carrier fabrics for nonwoven reinforced GCLs; one, or the other, must contain a scrim component of mass > 2.9 oz/yd^2 for dimensional stability
(3) Calculated value obtained from difference of coated fabric to as-received fabric
(4) Value is both site-specific and product-specific and is currently being evaluated
(5) First value is for smooth geomembrane; second for textured geomembrane; third for geofilm
(6) Mass of the GCL and bentonite is measured after oven drying per the stated test method
(7) Value represents GCL permeability after permeation with a 0.1 M calcium chloride solution (11.1 g CaCl2 in 1-liter water)
(8) Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days
(9) Durability criteria should follow the appropriate specification for the geomembrane used; i.e., GRI GM-13 for HDPE, GRI GM-17 for LLDPE or GRI GM-18 for fPP

orig. 5/16/05

APPENDIX 3D

ALTERNATE LINER DESIGN PERMIT MODIFICATION

(APPROVED BY TCEQ AS PERMIT MODIFICATION JANUARY 1999)

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

January 22, 1999

Will H. Wilde, P.E.
Director of Public Works
City of San Angelo
P.O. Box 1751
San Angelo, Texas 76902-1751

RE: CITY OF SAN ANGELO LANDFILL
Amendment to Permit No. MSW-79

Enclosed is a copy of the referenced permit for a municipal solid waste facility issued pursuant to Chapter 361, Texas Health and Safety Code. The Site Development Plan, the Site Operating Plan, and all other documents and plans prepared and submitted to support the permit application shall be considered as a part of this permit and shall be considered as operational requirements of this permit.

Should you have any questions, please contact Jessica Leyendecker of the Texas Natural Resource Conservation Commission's Office of the Chief Clerk (MC 105) at (512) 239-4517.

Sincerely,

LaDonna Castañuela
Chief Clerk

LC/jl

cc: TNRCC Region 8
Nevzat Turan, P.E., TNRCC Municipal Solid Waste Division, Permit Section (MC 124)

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

MINOR AMENDMENT TO MUNICIPAL SOLID WASTE PERMIT NO. MSW 79

City of San Angelo Landfill
Tom Green County

In accordance with 30 Texas Administrative Code (TAC) Section 305.62, the Site Development Plan for Municipal Solid Waste Permit No. 79 is hereby amended as follows:

Change the City of San Angelo Landfill's bottom liner system from a 2 feet thick clay and 0.06 inches thick geomembrane composite liner to a 0.25 inches thick geosynthetic lay liner and 0.06 inches thick geomembrane composite liner.

The exact details of this request are explained in the letters from Mr. Kyle B. Combest, Consultant, dated October 15, 1998 and November 16, 1998.

The Type I municipal solid waste facility is located on the notheast side of the City of San Angelo, Texas, on Old Ballinger Highway, San Angelo Texas, Tom Green County.

This minor amendment is part of Permit No. MSW 79 and should be attached thereto.

Issued Date: JAN 15 1999

ATTEST: _____

_____
For the Commission

WILL
WILDE

TEXAS NATURAL RESOURCE CONSERVA

November 12, 1998 *Protecting Texas by Reducing and Preventin*

Kyle B. Combest, Environmental Geologist
Combest Geoscience
706 Austin
San Angelo, Texas 76903

Subject: Minor Permit Amendment: City of San Angelo MSW Landfill
City of San Angelo
Municipal Solid Waste-Tom Green County: Permit App. No. MSW 79

The TNRCC Municipal Solid Waste Division received a minor permit amendment application for the landfill completion plan on October 19, 1998 for the subject municipal solid waste facility. I have completed the review of the permit amendment application for the performance based liner design. The following are review comments and the technical issues that are needed to be addressed before the application is considered technically complete.

1. Correct the typographic error in Table 1.0.1 for proposed "scenario 5: Notes" as "chimneys not required."

2. Please sign and seal the cover page(s) of the section(s) of the document.

3. (§ 305.69)
Please demonstrate the equivalency of the proposed liner system to the existing liner system.

4. Please provide information about the distance between the groundwater and the deepest elevation of the proposed excavation(s).

If you have any questions regarding this letter, please contact Mr. Nevzat Turan, P.E. of Permits Division at MC-124, P.O. Box 13087, Austin, Texas 78711-3087, or (512)239-6681.

Sincerely,

Susan H. Janek

Susan H. Janek, P.E. Section Manager
Municipal Solid Waste Permits Section
Permits Division

SHJ/NT:nt

cc: Permit Application File MSW-79
TNRCC Region 8, San Angelo

Fax Transmittal Memo

# of Pages -1-	
To: Kyle Combest	From: Nevzat Turan
Co.: Combest Geoscience	Co.: TNRCC/PERMITS
Dept.:	Phone #(512)239-6681
Fax #(915)655-4304	Fax # (512)239-6000

DMFX14

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

December 1, 1998

Mr. Will H. Wilde, Director
Public Works Department
City of San Angelo
P.O. Box 1751
San Angelo, Texas 76902-1751

Re: Municipal Solid Waste, Tom Green County
City of San Angelo Type I Municipal Solid Waste Disposal Facility, MSW Permit No. 79
Change in Landfill Bottom Liner Design

Dear Mr. Wilde:

We have received a letter dated October 26, 1998, from Mr. Kyle Combest, regarding the above-referenced facility. Mr. Combest requests a change in the City of San Angelo Landfill's bottom liner system from a 2 feet thick clay and 0.06 inches thick geomembrane composite liner to a 0.25 inches thick geosynthetic lay liner and 0.06 inches thick geomembrane composite liner. The staff of the Municipal Solid Waste Permits Section have determined that the request requires a minor permit amendment, and you furnished us with an adjacent landowners list on November 15, 1998. Upon review, it has been determined that the requirements of our regulations have been met; therefore, we are forwarding your request to the TNRCC Office of the Chief Clerk for processing as a minor permit amendment. The Chief Clerk will be contacting you regarding final action on this matter.

If you have any questions regarding this matter, you may contact Mr. Nevzat Turan, P.E. of my staff at 512-239-6681. The Chief Clerk, LaDonna Castañuela, may be contacted at (512) 239-3300.

Sincerely,

for

Susan H. Janek, P.E., Manager
Municipal Solid Waste Permits Section
Permits Division

SHJ/NT:nt

c: Waste Program, TNRCC Region 8
Jean Doyle, MSW

Combest Geosciences

Geological / Hydrological Consulting & Testing

915/655-4302 off
915/655-4304 fax
915/656-2537 mob

3 S. Washington Street • San Angelo, Texas 76901

16 November 1998

TNRCC Municipal Solid Waste Division - Permits
P.O. Box 13087
Austin, Texas 78711-3087
Attn: Mr. Nezvat Turan MC-124

Subject: Subject: City of San Angelo MSWLF (Permit #79)
Tom Green County, Texas
Alternate liner request

Dear Mr. Turan:

As requested in the 12 November 1998 TNRCC letter, revisions have been made to the 15 October 1998 alternate liner demonstration for The City of San Angelo. The revisions can be summarized as follows:

- As shown in Table 1.0.1 for Scenario 5, "chimneys required" has been changed to "chimneys not required";
- Appropriate pages have been signed and sealed by a Registered Professional Engineer;
- Additional information demonstrating equivalency of the proposed liner system to the existing liner system has been added to Section 4.0 of the report;
- Information regarding the distance between the ground water and the deepest excavation has been added to Section 2.4.

Please replace pages in the original document (dated 15 October 1998) with the revised pages which are attached to this letter.

If you need additional information for reviewing this request, please let us know as soon as possible and we will promptly forward the information to you. Thank you.

Sincerely,

Kyle B. Combest
Geologist/Project Manager

attachments

xc: Will Wilde, P.E., City of San Angelo Public Works Director
Adam Hernandez, TNRCC Region 8
Lawrence Kennedy, Sr., Trashaway Service, Inc.
Ed Rhodes, Charter Waste

Combest Geoscience

Geological / Hydrological Consulting & Testing

915/655-4302 off
915/655-4304 fax
915/656-2537 mob

123 S. Washington Street • San Angelo, Texas 76901

October 15, 1998

TNRCC Municipal Solid Waste Division - Permits
P.O. Box 13087
Austin, Texas 78711-3087
Attn: Ms. Susan Janek MC-124

Subject: Subject: City of San Angelo MSWLF (Permit #79)
Tom Green County, Texas
Alternate liner request

Dear Ms. Janek:

The City of San Angelo is requesting approval for an alternate liner design at the MSWLF. Attached documents describe the proposed design and demonstrate that the design meets requirements in 30 TAC 330.202.

Attached documents include the following:

- An alternate liner demonstration which includes: (1) revised engineering drawings, (2) HELP model data and results, and (3) Multimed model data and results; and
- QA/QC requirements for the installation of geosynthetic clay liners (GCLs). After the QA/QC document is approved, it will become Attachment C to the SLQCP. The SLQCP can be found in Section 3 of the permit.

Plans are being made for construction of the next cell. If you need additional information for reviewing this request, please let us know as soon as possible and we will promptly forward the information to you. Thank you.

Sincerely,

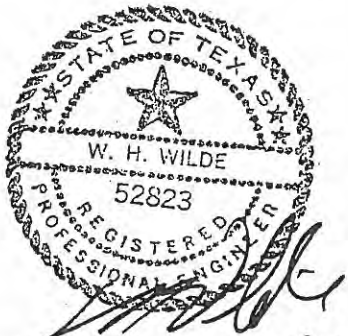
Kyle B. Combest

Kyle B. Combest
Geologist/Project Manager

attachments

xc: Will Wilde, P.E., City of San Angelo Public Works Director
Adam Hernandez, TNRCC Region 8
Lawrence Kennedy, Sr., Trashaway Service, Inc.
Ed Rhodes, Charter Waste

ALTERNATE LINER DESIGN FOR THE CITY OF SAN ANGELO MSWLF (Permit 79) TOM GREEN COUNTY, TEXAS



November 18, 1998

ALTERNATE LINER DESIGN DEMONSTRATION FOR CITY OF SAN ANGELO MSWLF (Permit 79) TOM GREEN COUNTY, TEXAS

1.0 INTRODUCTION

The City of San Angelo is requesting approval for an alternate liner design at the MSWLF. The difference between the alternate design and the currently approved design is the use of a geosynthetic clay liner (gcl) rather than 2-ft of compacted clay. Both of these require the use of a flexible membrane to complete the liner. The overlying leachate collection system has various optional components, thus requiring the evaluation of 5 different scenarios (Table 1.0.1; Appendix A).

Table 1.0.1 Various design scenarios and components for liner and LCS.

Status	Scenario	Components	Notes
Approved	NA	1-ft protective cover (k<1.0E-04 cm/sec) 1-ft granular drainage layer 2-ft compacted clay / fml	chimneys required clay: k<1.0E-07 cm/sec
Approved	NA	1-ft protective cover (k>1.0E-04 cm/sec) 1-ft granular drainage layer 2-ft compacted clay / fml	chimneys not required clay: k<1.0E-07 cm/sec
Approved	NA	1-ft protective cover (shred. tires or shred. waste) 1-ft granular drainage layer 2-ft compacted clay / fml	chimneys not required clay: k<1.0E-07 cm/sec
Proposed	1	2-ft protective cover (k>1.0E-04 cm/sec) drainage net gcl/fml	chimneys not required k<5.0E-09 cm/sec
Proposed	2	2-ft protective cover (k<1.0E-04 cm/sec) drainage net gcl/fml	chimneys required k<5.0E-09 cm/sec
Proposed	3	1-ft protective cover (shred. tires or shred. waste) 1-ft granular drainage layer gcl/fml	chimneys not required k<5.0E-09 cm/sec
Proposed	4	2-ft protective cover (k<1.0E-04 cm/sec) granular drainage gcl/fml	chimneys required k<5.0E-09 cm/sec
Proposed	5	2-ft protective cover (k>1.0E-04 cm/sec) granular drainage gcl/fml	chimneys not required k<5.0E-09 cm/sec

The purpose of this document is to demonstrate that, by the use of these various designs, the concentrations listed in Table 1 of 30 TAC 330.200 will not be exceeded in the uppermost aquifer at the relevant point of compliance (POC). The POC is Monitoring Well 6R (Figure 1). To make these demonstrations, the following computer models were used: (1) the Hydrologic Evaluation of Landfill Performance model, and (2) the Multimedia Exposure Assessment model.

2.0 SITE DESCRIPTION

2.1 Location

The MSWLF is located near the northeastern edge of the City of San Angelo along Old Ballinger Highway. San Angelo is in the central part of Tom Green County in west-central Texas.

2.2 Physiography

The City of San Angelo is within the Concho River Valley which is bounded to the north, south, and west by the erosional edge of the Edwards Plateau. Three major streams have created the valley. These are the North Concho, Middle Concho, and South Concho. The three streams merge at San Angelo to form the Concho River.

The natural surface at the landfill slopes from the northwest to southeast at a very gradual dip of 10-ft to 12-ft per mile. Surface elevations range between 1870-ft and 1880-ft MSL in comparison to surface elevations throughout Tom Green County which range from 2,550-ft (SW corner of Tom Green County) to 1,650-ft (bed of Concho River at Tom Green-Concho County line).

2.3 Climate

The climate at San Angelo is classified as semi-arid even though the area does have some humid temperate characteristics (NFIC, 1987). Warm, dry weather predominates but rapid changes can occur with the passage of cold fronts. The summer is characterized by high temperatures, fair skies, south to southwest winds, and dry air (Table 2.3.1). Much of the rainfall occurs during thunderstorms with the heaviest rainfalls during April, May, June, September, and October. During the late summer months, particularly heavy precipitation may occur when tropical disturbances move inland from the Gulf of Mexico. The prevailing wind direction is from the south and winds can be persistent for several days. March and April are the windiest months.

Table 2.3.1. Summary of Climatic data.

MONTH	MEAN PRECIP. (in)	PEAK PRECIP. (in)	MEAN TEMP (deg F)	MAX TEMP (deg F)	MIN TEMP (deg F)	%HUMIDITY (hour 12)
January	0.87	3.65	45.40	58.50	32.20	53.00
February	0.88	2.86	49.50	63.20	35.80	49.00
March	0.92	5.00	57.10	71.60	42.60	44.00
April	1.88	5.10	65.80	79.90	51.80	43.00
May	2.92	7.10	73.30	86.40	60.30	46.00
June	2.01	5.82	80.80	93.20	68.40	49.00
July	1.68	7.21	83.60	96.10	71.00	43.00
August	1.99	8.13	83.10	95.70	70.50	45.00
September	2.86	11.00	76.10	88.30	63.90	54.00
October	2.28	6.59	66.30	79.10	53.40	53.00
November	1.14	3.55	54.30	67.40	41.20	52.00
December	1.01	2.70	47.40	60.40	34.30	51.00
Annual	20.45	NA	65.20	78.30	52.10	49.00

Notes: Precipitation records began in 1867. Monthly Precipitation peak between 1952-80. Temperature records began in 1907. Humidity records began in 1960.

2.4 Hydrogeology

The surface is formed on Quaternary-aged alluvium referred to as the Leona Formation. Commonly occurring at the base of the Leona is a gravel and clay zone that can yield ground water if a sufficient amount of gravel is present. This is the shallowest potential ground-water zone and is roughly 45-ft deep at the landfill. The Leona yields ground water in monitoring wells MW2, MW4, MW5, MW8, MW9, MW10, and MW11 (Figure 1). At MW6R and MW7R, the basal Leona does not yield ground water because the section is predominantly clay with only minor amounts of gravel (Figure 1).

Finally, underlying the Leona, is the Permian-aged Choza Formation. Fractured dolomite zones in the Choza can produce limited amounts of ground water as found in monitoring wells MW6R, MW7R, and in some of the local wells south of the landfill.

Ground-water levels typically range from 37-ft to 67-ft below natural grade. The landfill permit allows for disposal to 20-ft below natural grade, therefore any liner will be separated from the shallowest ground-water by 17-ft. Monitoring well MW2 is the most up-gradient well and is located at the northeast corner of the permitted area (Figure 1). Beginning at MW2 in the northeast corner, ground-water elevations indicate that the gradient is in a south-southwesterly direction (Figure 1). The gradient appears to flatten across the center of the site, then becomes more south-southeasterly.

To estimate hydraulic conductivity, slug tests were conducted at MW5 and MW6R on 05 December 1995. These wells were selected because they are the slowest recharging wells located along the southern border of the landfill. Water levels were measured at 1 minute intervals for a period of 30 minutes. Hydraulic conductivities were then calculated by using the Bouwer and Rice method (Bouwer and Rice, 1976). Hydraulic conductivity for MW5 was estimated at 0.48 ft/day with a transmissivity of 2.4 ft^2/day. MW6R was 0.40 ft/day with a transmissivity of 2.8 ft^2/day.

For additional information, the following documents further describe the landfill's soil, hydrogeologic, and hydraulic conditions: Combest (1991), Combest (1992), Combest (1995), and Combest (1996).

3.0 COMPUTER MODELS

The HELP model, developed by the US Army Corps of Engineers Waterways Experiment Station, was used to predict the amount of leachate that would be generated under various design scenarios (Table 1.0.1). The various scenarios included an active landfill with 10-ft of waste, and, a closed landfill with 40-ft of waste.

The MULTIMED model, developed by the EPA Athens Research Laboratory, was used to predict contaminant concentrations at the point of compliance. The point of compliance is MW6R (Figure 1). Important to the MULTIMED model are effects of attenuation and dilution along with fate and transport characteristics for each chemical. The critical factor that is calculated by the MULTIMED model is the dilution attenuation factor (DAF). According to the TNRCC alternate liner handbook, the DAF must be 260 or greater to ensure that constituent concentrations at the POC will not exceed the concentrations listed in Table 1 of 30 TAC 330.200.

Predictions from both models were obtained by using conservative input data. Please refer to Appendix B for input data descriptions for the HELP model and Appendix C for the MULTIMED model.

4.0 RESULTS

The DAF calculated for scenarios 3-5 was 1053 (Table 4.0.1; Appendix C). Calculations were not needed for scenarios 1 and 2 because the annual percolation was less for these scenarios than for scenarios 3-5 (Table 4.0.1). It should be mentioned again that conservative values were used for input data. As indicated by the HELP and MULTIMED models, the proposed scenarios will provide a sufficient barrier to leachate migration.

Table 4.0.1. Various design scenarios and model results.

Scenario	Description	Notes	Avg. Ann. Percolation	Max Head In & (cm)	Calc. DAF[1]	Critical DAF	Pass (Y/N)
1 (10ft waste) active	10–ft waste - Uncovered 2-ft protective cover (k>1.0E-04 cm/sec) drainage net gcl/fml	chimneys not required k<1.0E-08 cm/sec[2]	0.0001 in	0.1 (0.254)	>1053	260	Y
1 (40ft waste) closed	fair grass and 6-in erosion layer fml and 18-in compacted clay 40–ft waste 2-ft protective cover (k>1.0E-04 cm/sec) drainage net gcl/fml	chimneys not required k<1.0E-08 cm/sec	0.0001 in	0	>1053	260	Y
2 (10ft waste) active	10-ft waste - Uncovered 2-ft protective cover (k<1.0E-04 cm/sec) drainage net gcl/fml	chimneys required k<1.0E-08 cm/sec	0.0001 in	0.1 (0.254)	>1053	260	Y
2 (40ft waste) closed	fair grass and 6-in erosion layer fml and 18-in compacted clay 40–ft waste 2-ft protective cover (k<1.0E-04 cm/sec) drainage net gcl/fml	chimneys required k<1.0E-08 cm/sec	0.0001 in	0	>1053	260	Y
3 (10ft waste) active	10-ft waste - Uncovered 1-ft protective cover (shred. tires or shred. waste) 1-ft granular drainage layer gcl/fml	chimneys not required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0.0002 in	4.1 (10.4)	1053	260	Y
3 (40ft waste) closed	fair grass and 6-in erosion layer fml and 18-in compacted clay 40–ft waste 1-ft protective cover (shred. tires or shred waste) 1-ft granular drainage layer gcl/fml	chimneys not required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0	0	>1053	260	Y
4 (10ft waste) active	10-ft waste - Uncovered 1-ft protective cover (k<1.0E-04 cm/sec) 1-ft granular drainage gcl/fml	chimneys required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0.0002 in	4.1 (10.4)	1053	260	Y
4 (40ft waste) closed	fair grass and 6-in erosion layer fml and 18-in compacted clay 40–ft waste 1-ft protective cover (k<1.0E-04 cm/sed) 1-ft granular drainage layer gcl/fml	chimneys required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0	0	>1053	260	Y
5 (10ft waste) active	10-ft waste - Uncovered 1-ft protective cover (k>1.0E-04 cm/sec) 1-ft granular drainage gcl/fml	chimneys not required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0.0002 in	4.1 (10.4)	1053	260	Y
5 (40ft waste) closed	fair grass and 6-in erosion layer fml and 18-in compacted clay 40–ft waste 1-ft protective cover (k>1.0E-04 cm/sed) 1-ft granular drainage layer gcl/fml	chimneys not required k>1.0E-02 cm/sec k<1.0E-08 cm/sec	0	0	>1053	260	Y

[1] Critical DAF from Table 2 in TRCCC Alternate Design Handbook

[2] Used 1.0E-08 for HELP Model even though the GCL is tested at 5.0-E-09. This is a more conservative assumption for the model.

To further demonstrate the adequacy of the proposed liner, the Darcy formula was used to calculate flow through time for the existing liner compared to the proposed liner. The FML was not included in this comparison because the FML is identical for both the existing liner and the proposed liner. Therefore, only the 0.25-in GCL and 24-in compacted clay were compared as shown below. The Darcy formula is:

$$Q = K*A*dh/dl$$

where:
Q is quantity of water per unit of time;
K is the hydraulic conductivity;
A is the cross-sectional area at a right angle to the flow direction; and
dh/dl is the hydraulic gradient

Assumptions were as follows:

<u>24-in Clay liner</u>
K = 1E-07 cm/sec
A = 1-cm^2
dh = 10-cm
dl = 60.96-cm (or 24-in)

Therefore:

Q = 1E-07cm/sec * 1cm^2 * 10cm/60.96cm
Q = 1.6404 E-08 cm^3/sec

<u>0.25-in GCL</u>
K = 1E-09 cm/sec
A = 1-cm^2
dh = 10-cm
dl = 0.635-cm (or 0.25-in)

Therefore:

Q = 1E-09cm/sec * 1cm^2 * 10cm/60.96cm
Q = 1.5748 E-08 cm^3/sec

A comparison of the flow rates (Q) shows that flow through the GCL is less than the compacted clay.

5.0 REFERENCES

Bouwer, H. and R.C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, v. 12, no. 3, pp 423-428.

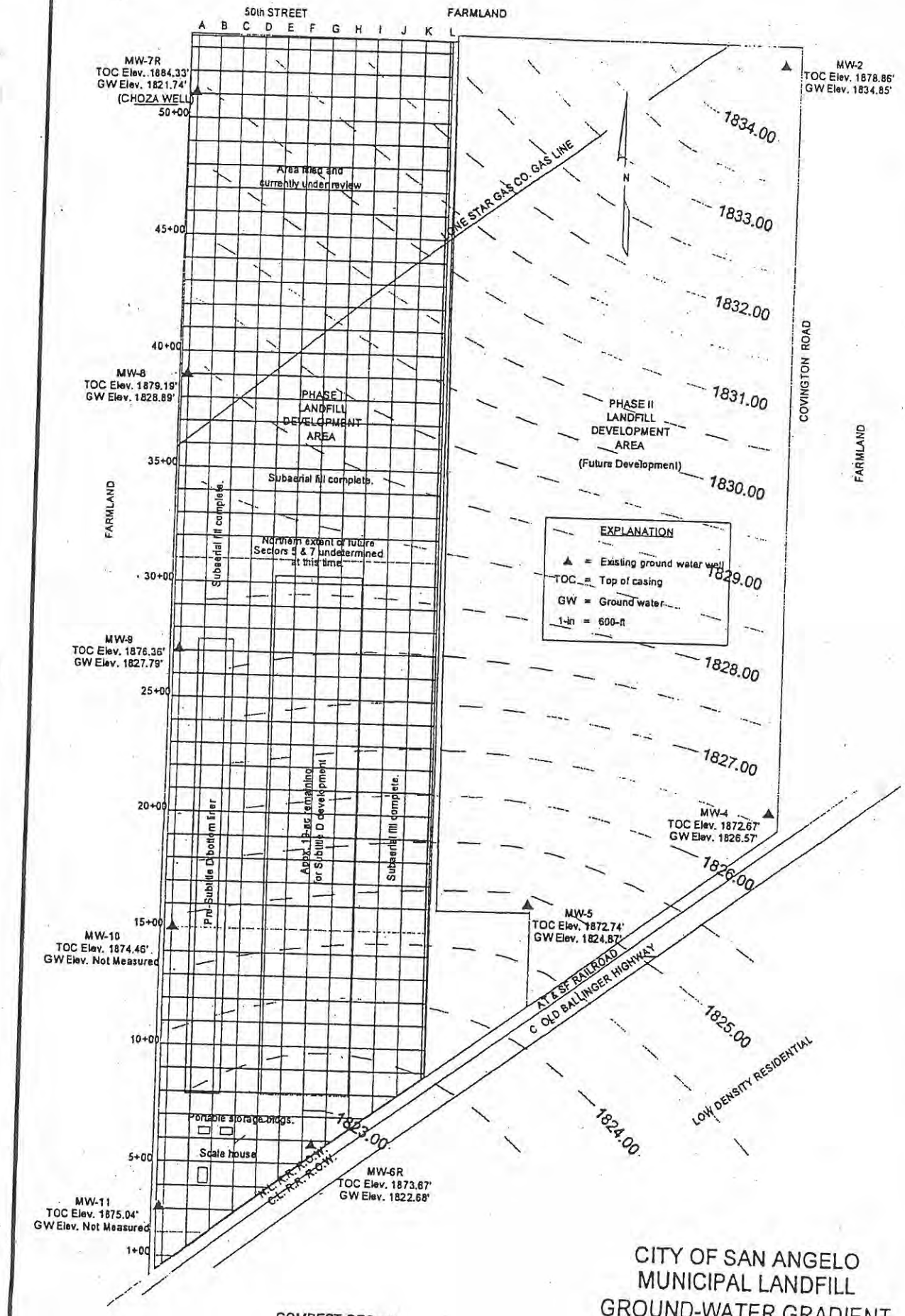
Combest, K.B., 1991, Review of hydrogeologic conditions and previous geotechnical activities at the San Angelo Municipal Landfill: Combest Geoscience, Austin, Texas, 15 pp, maps.

Combest, K.B., 1992, Improvement of the ground-water monitoring system and further review of hydrogeology at the San Angelo Municipal Landfill (Permit 79-A): Combest Geoscience, Austin, Texas, 41 pp., maps.

Combest, K.B., 1995, Phase I of ground-water remedial investigation and 1st quarter 1995 sampling results at the San Angelo MSWLF in Tom Green County (#79). Combest Geoscience, San Angelo, Texas.

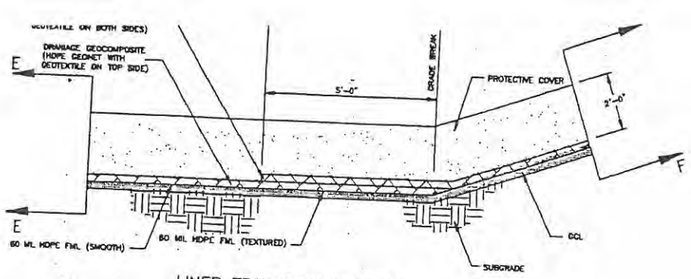
Natural Fibers Information Center (NFIC), 1987, The Climates of Texas Counties. University of Texas, Bureau of Business Research, Austin, Texas.

FIGURES

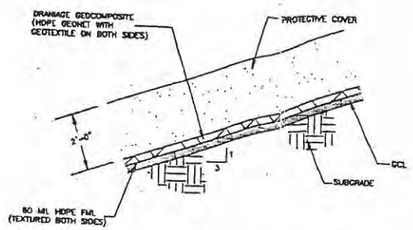


CITY OF SAN ANGELO
MUNICIPAL LANDFILL
GROUND-WATER GRADIENT
2nd QUARTER 1998

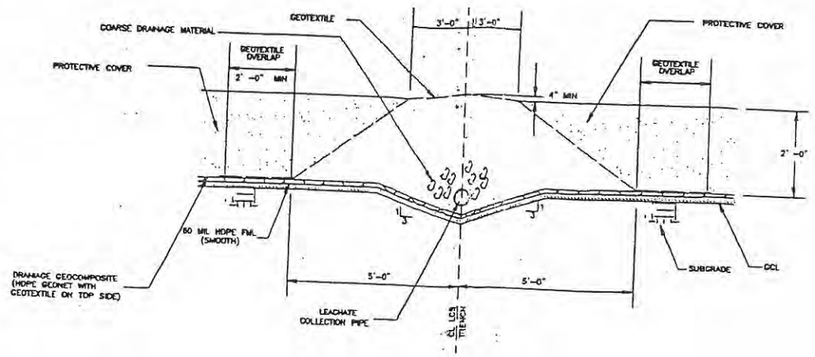
COMBEST GEOscience
San Angelo, Texas
30 April 1998



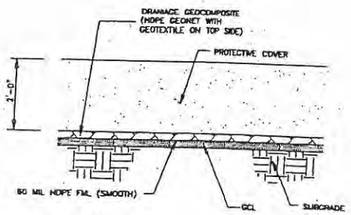
LINER TRANSITION AT SLOPE



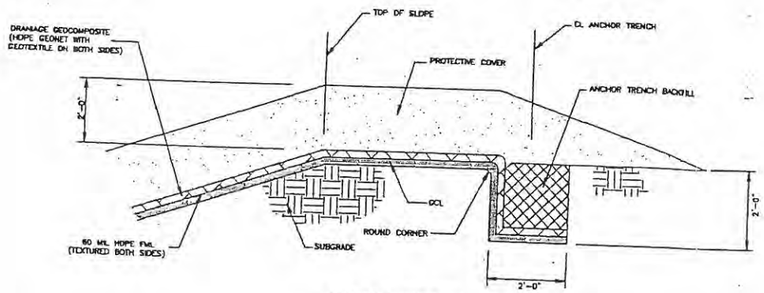
SECTION F-F
SIDEWALL LINER



LEACHATE TRENCH AND CHIMNEY



SECTION E-E
BOTTOM LINER



ANCHOR TRENCH

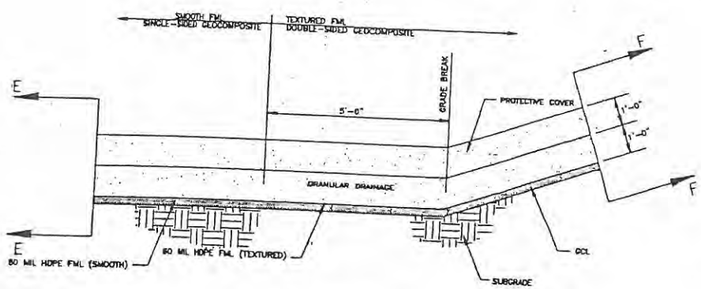
⚠1

ALTERNATE DESIGN SCENARIO 2

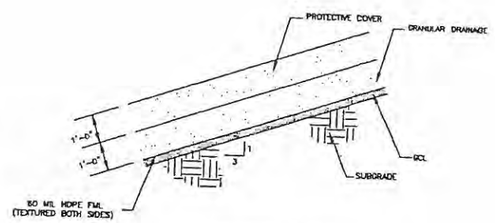
2-ft cover soil (k < 1.0E-04)
drainage net
GCL/FML

Note: chimneys required

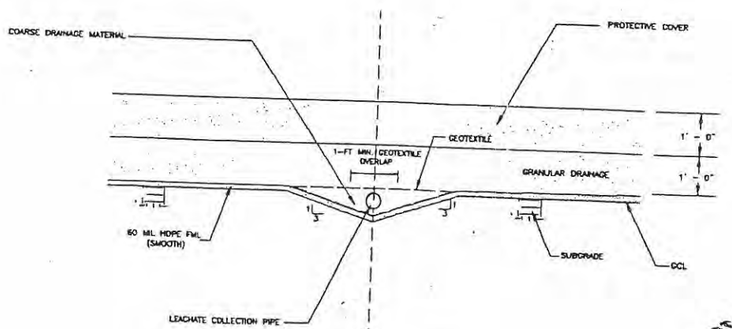
ITS



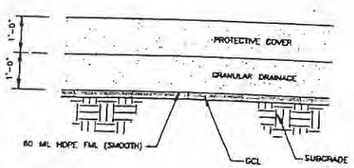
LINER TRANSITION AT SLOPE



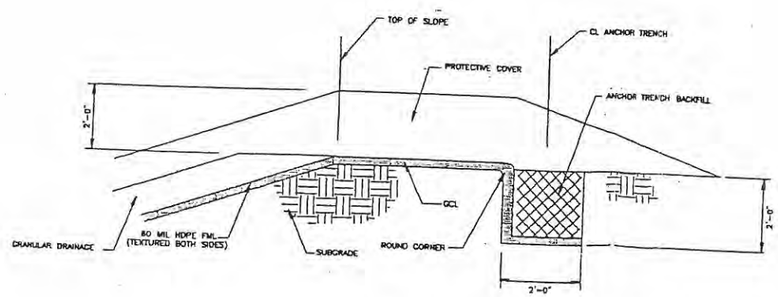
SECTION F-F
SIDEWALL LINER



LEACHATE COLLECTION TRENCH



SECTION E-E
BOTTOM LINER



ANCHOR TRENCH

⚠1

ALTERNATE DESIGN SCENARIO 3

1-ft protective cover (shred.tires or shred.waste)
1-ft granular drainage (k > 1.0E-02 cm/sec)
GCL/FML

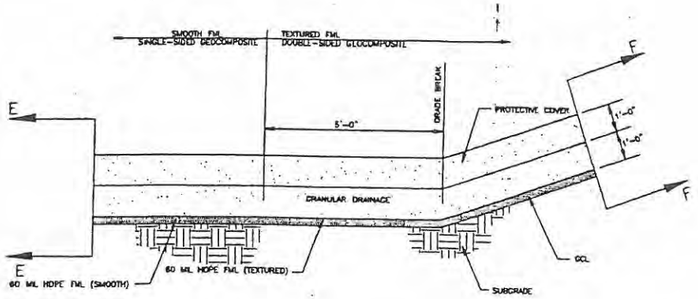
Note: chimneys not required

STATE OF TEXAS
W. H. WILDE
52623
REGISTERED PROFESSIONAL ENGINEER

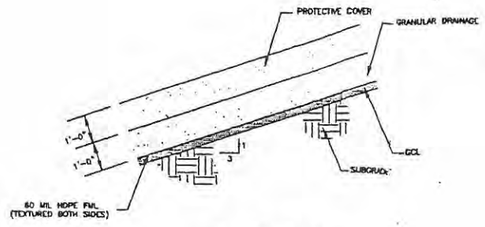
October 15, 1998

REVISION TABLE			
ITEM	DATE REVISED	DESCRIPTION	BY:
⚠1	10/12/98	Added alternate design	
△			
△			

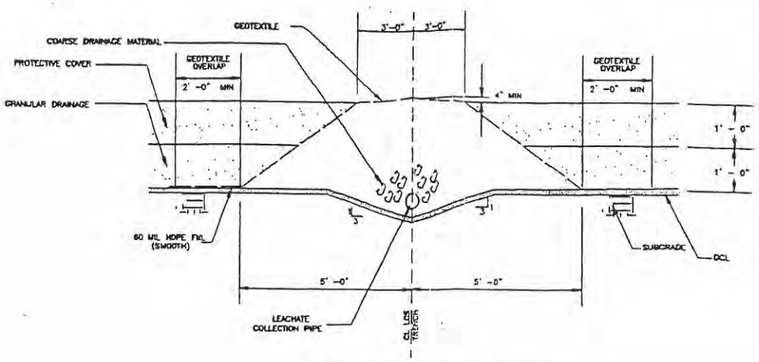
CITY OF SAN ANGELO
DEPARTMENT OF PUBLIC WORKS
1994 LANDFILL PERMIT MODIFICATION
LEACHATE COLLECTION PLAN



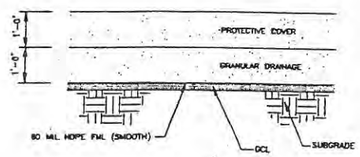
LINER TRANSITION AT SLOPE



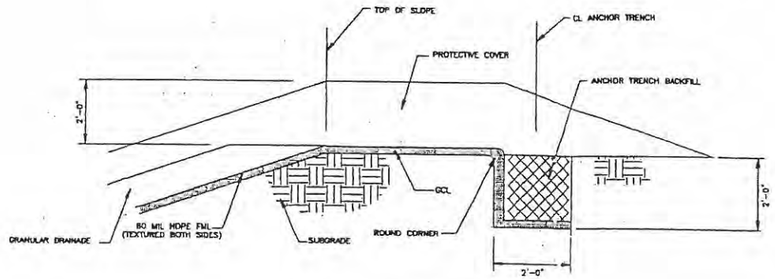
SECTION F-F
SIDEWALL LINER



LEACHATE TRENCH AND CHIMNEY



SECTION E-E
BOTTOM LINER



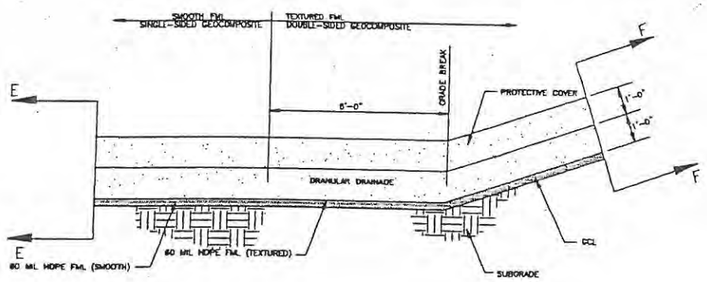
ANCHOR TRENCH

1

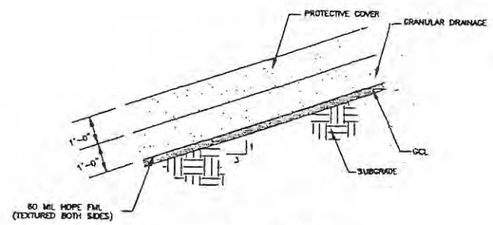
ALTERNATE DESIGN SCENARIO 4

1-ft protective cover (k < 1.0E-04 cm/sec)
1- ft granular drainage (k > 1.0E-02 cm/sec)
GCL/FML

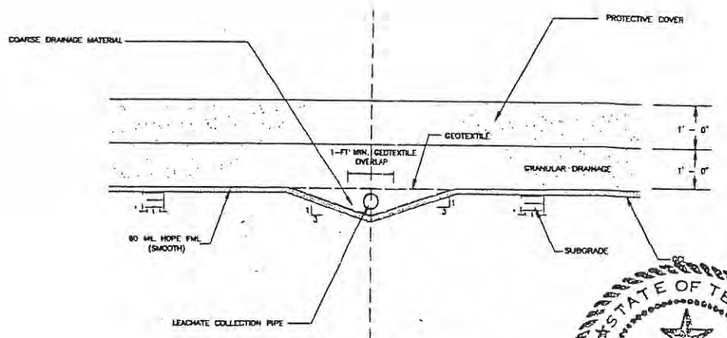
Note: chimneys required



LINER TRANSITION AT SLOPE



SECTION F-F
SIDEWALL LINER



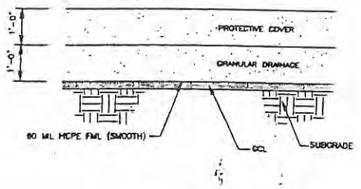
LEACHATE COLLECTION TRENCH

1

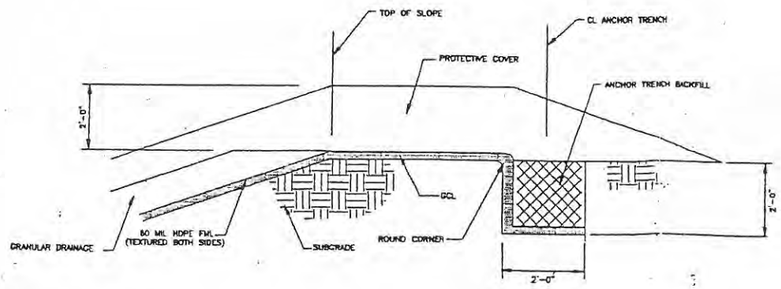
ALTERNATE DESIGN SCENARIO 5

1-ft protective cover (k > 1.0E-04 cm/sec)
1- ft granular drainage (k > 1.0E-02 cm/sec)
GCL/FML

Note: chimneys not required



SECTION E-E
BOTTOM LINER



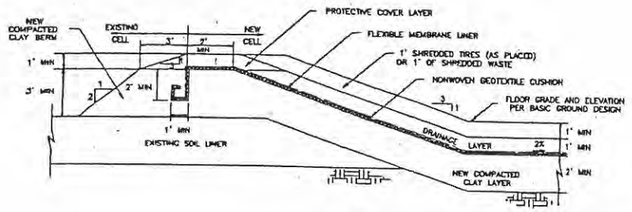
ANCHOR TRENCH

STATE OF TEXAS
W. H. WILDE
52823
REGISTERED PROFESSIONAL ENGINEER

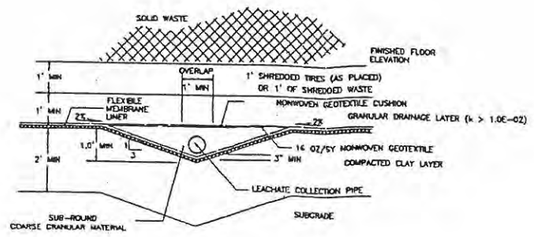
October 15, 1998

REVISION TABLE			
ITEM	DATE REVISED	DESCRIPTION	BY:
1	10/12/98	Added alternate design	

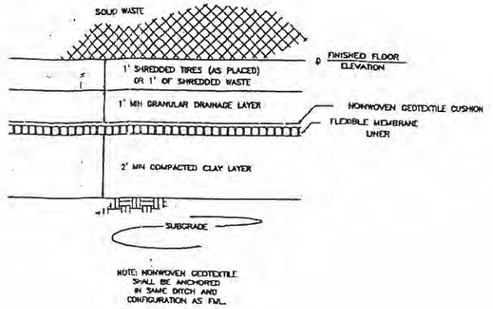
CITY OF SAN ANGELO
DEPARTMENT OF PUBLIC WORKS
1994 LANDFILL PERMIT MODIFICATION
LEACHATE COLLECTION PLAN



SECTION A–A
TYPICAL TIE–IN BERM



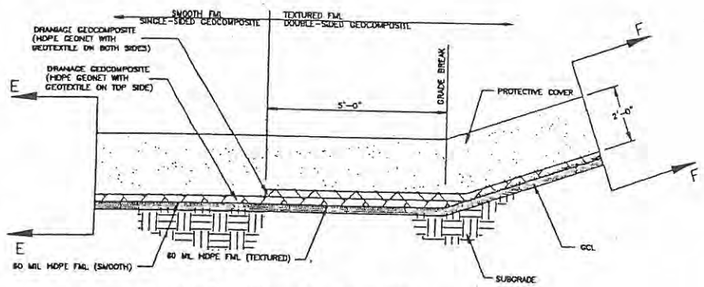
SECTION B–B
LEACHATE COLLECTION TRENCH



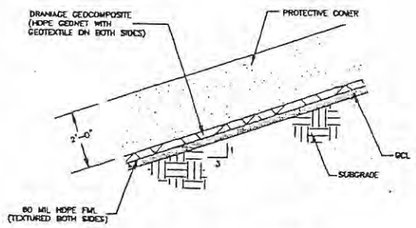
NOTE: NONWOVEN GEOTEXTILE SHALL BE ANCHORED IN SAME DITCH AND CONFIGURATION AS FML.

SECTION C–C
COMPOSITE LINER DETAIL

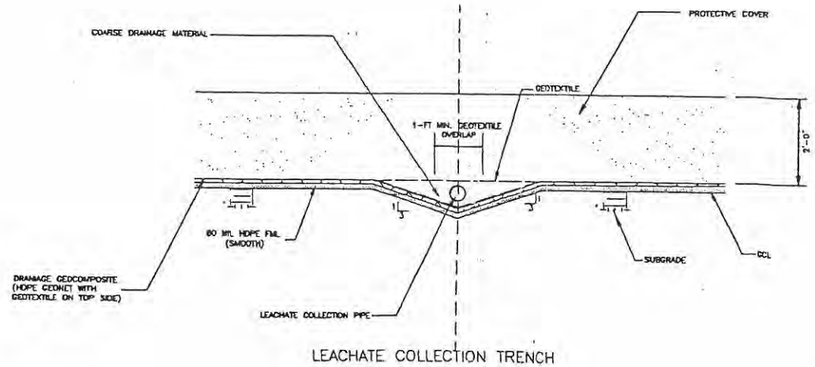
NTS



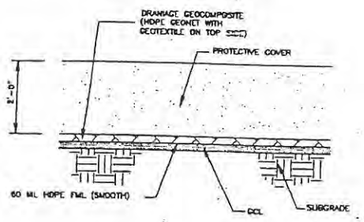
LINER TRANSITION AT SLOPE



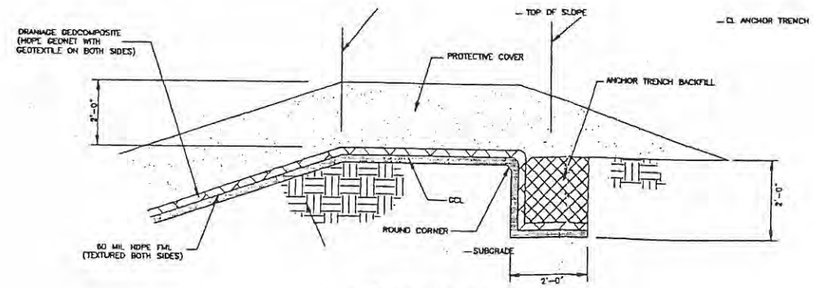
SECTION F–F
SIDEWALL LINER



LEACHATE COLLECTION TRENCH



SECTION E–E
BOTTOM LINER



ANCHOR TRENCH

⚠1 ⚠2

ALTERNATE DESIGN – APPROVED

1–ft shredded tires or shredded waste
1–ft granular drainage layer
FML
2–ft clay (k<1.0e–07 cm/sec)

⚠3

ALTERNATE DESIGN SCENARIO 1

2–ft protective cover (k > 1.0E–04)
drainage net
GCL/FML

Note: chimneys not required

STATE OF TEXAS
W. H. WILDE
52323
REGISTERED PROFESSIONAL ENGINEER

October 15, 1998

REVISION TABLE			
ITEM	DATE REVISED	DESCRIPTION	BY:
⚠1	4/11/98	Added alternate design	
⚠2	10/12/98	Deleted leachate collection trench with chimney detail	
⚠3	10/12/98	Added alternate design	

CITY OF SAN ANGELO
DEPARTMENT OF PUBLIC WORKS
1994 LANDFILL PERMIT MODIFICATION
LEACHATE COLLECTION PLAN
DWG. NO. 94–09 M–500

SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

DRAWINGS

CITY OF SAN ANGELO LANDFILL

TOM GREEN COUNTY, TEXAS

TCEQ PERMIT NO. MSW 79

CELL 11A CONSTRUCTION PLANS

FEBRUARY 2014

PREPARED FOR

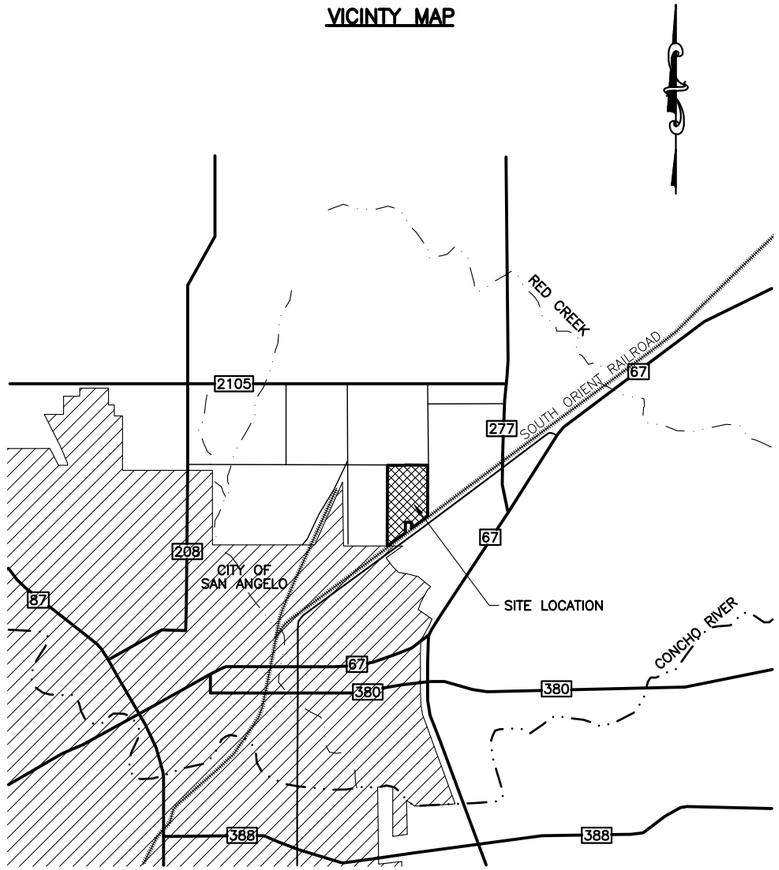
CITY OF SAN ANGELO

PREPARED BY

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
1700 ROBERT ROAD
MANSFIELD, TEXAS 76063
(817) 563-1144
TBPE FIRM NO. F-256

FOR BIDDING PURPOSES ONLY

VICINITY MAP



DRAWING INDEX

DRAWING	TITLE	REV.	DATE
G1	COVER SHEET	0	02/14
G2	VICINITY/DRAWING INDEX/GENERAL NOTES	0	02/14
C1	GENERAL SITE PLAN	0	02/14
C2	SUBGRADE AND LINER PLAN	0	02/14
C3	PROTECTIVE COVER AND LEACHATE COLLECTION PLAN	0	02/14
C4	LINER DETAILS	0	02/14
C5	LINER DETAILS	0	02/14
C6	LEACHATE COLLECTION SYSTEM DETAILS	0	02/14
C7	SUMP AND RISER DETAILS	0	02/14
C8	LCS VAULT, ELECTRICAL, AND FORCEMAIN DETAILS	0	02/14

GENERAL NOTES

1. ALL THE WORK UNDER THIS CONTRACT SHALL BE PERFORMED IN ACCORDANCE WITH THE PLANS AND PROJECT SPECIFICATIONS.
2. FINISHED GROUND ELEVATIONS SHALL MATCH EXISTING GROUND ELEVATIONS EXCEPT AS SHOWN ON THE PLANS. ALL EXCESS SOIL FROM EXCAVATION AND GRADING SHALL BE PLACED IN STOCKPILE AREAS DESIGNATED BY THE OWNER. TRANSPORT OF SOIL TO STOCKPILE AREAS SHALL BE CONDUCTED BY THE CONTRACTOR AT NO ADDITIONAL EXPENSE TO THE OWNER.
3. COORDINATE SYSTEM IS BASED ON STATE PLANE COORDINATES. THE BENCHMARKS TO BE USED FOR CONSTRUCTION ARE LOCATED AS SHOWN ON DRAWING C1. EXISTING CONTOURS WERE BASED ON AERIAL FLOWN MARCH 6, 2013 BY COOPER AERIAL SURVEYS COMPANY. CURRENT GROUND ELEVATIONS MAY VARY FROM THOSE SHOWN.
4. THE CONTRACTOR SHALL VERIFY EXISTING CONTOURS PRIOR TO THE START OF EARTHWORK. THE EXISTING TOPOGRAPHY MAY HAVE CHANGED SINCE THE DATE OF THE TOPOGRAPHIC MAP.
5. THE CONTRACTOR SHALL REMOVE ALL VEGETATION WITHIN THE CONSTRUCTION LIMITS AS REQUIRED TO CONSTRUCT THIS PROJECT. ALL VEGETATION MAY BE DISPOSED OF ONSITE AS DIRECTED BY THE OWNER OR ENGINEER.
6. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES HAVE NOT BEEN LOCATED BY THE OWNER OR HIS REPRESENTATIVES. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND IS FULLY RESPONSIBLE FOR ANY AND ALL DAMAGE WHICH MIGHT BE CAUSED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UTILITIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING PROPER SAFE WORKING DISTANCE FROM ALL UTILITY EASEMENTS.
7. TEMPORARY CONSTRUCTION SLOPES SHALL NOT BE STEEPER THAN 1H:1V. STEEPER SLOPES WILL ONLY BE ALLOWED IF THE CONTRACTOR HAS A GEOTECHNICAL ENGINEERING REPORT SPECIFYING MAXIMUM SLOPES AND THE DURATION WHICH SUCH SLOPES SHALL REMAIN IN PLACE.
8. EXCAVATION BY "BLASTING," UNDER ANY CIRCUMSTANCES, IS NOT ALLOWED ON THIS PROJECT.
9. GEOTECHNICAL INVESTIGATION REPORTS FOR THE SITE ARE AVAILABLE FOR REVIEW. THE CONTRACTOR MAY PERFORM ADDITIONAL GEOTECHNICAL INVESTIGATIONS AS HE DEEMS NECESSARY FOR HIS CONSTRUCTION ACTIVITIES. THERE SHALL NOT BE ANY ADDITIONAL PAYMENT TO THE CONTRACTOR FOR ANY ADDITIONAL GEOTECHNICAL INVESTIGATIONS THAT HE MAY REQUIRE.
10. GROUNDWATER AT THE SITE WILL VARY DEPENDING UPON STREAM FLOW, RAINFALL, AND SUBSURFACE CONDITIONS. GROUNDWATER LEVELS SHOWN ON THE LOGS OF BORINGS ARE ONLY AN INDICATION OF GROUNDWATER LEVELS AT THE TIME OF DRILLING THE BORINGS. THERE SHALL NOT BE ANY ADDITIONAL PAYMENT OR EXTENSION OF CONTRACT TIME FOR WORKING WITH SATURATED SOILS OR HANDLING GROUNDWATER SEEPAGE.
11. THE CONTRACTOR SHALL CONSTRUCT DIVERSION DITCHES OR DIKES AS NECESSARY TO PROTECT THE NEW EXCAVATED CELL FROM SURFACE WATER INTRUSION.
12. CONTRACTOR SHALL INSTALL, MAINTAIN, AND, UPON COMPLETION OF PROJECT, REMOVE TEMPORARY EROSION AND SEDIMENT CONTROLS. SUCH CONTROLS SHALL BE PLACED AT LIMITS OF DISTURBED AREAS, AT TOP OF DITCH BANKS, AND AT INTERMEDIATE LOCATIONS WHERE CONCENTRATED FLOW IS LIKELY.
13. CONTRACTOR SHALL CONSTRUCT AND, UPON COMPLETION OF PROJECT, REMOVE TEMPORARY CONSTRUCTION ACCESS ROADS. SUCH ROADS SHALL BE LOCATED AS APPROVED BY THE OWNER. DRAINAGE PATTERNS SHALL NOT BE BLOCKED BY ROAD CONSTRUCTION. CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION AND MAINTENANCE OF TEMPORARY DRAINAGE STRUCTURES, INCLUDING CULVERTS, AS NEEDED TO FACILITATE NATURAL DRAINAGE AT NO ADDITIONAL COST TO THE OWNER.
14. CONSTRUCTION WATER FOR THE PROJECT MAY BE OBTAINED FROM THE EXISTING CITY FIRE HYDRANT CONNECTION PROVIDED BY OWNER AT NO ADDITIONAL COST TO THE OWNER.
15. THE CONTRACTOR SHALL REPORT TO THE ENGINEER ANY ERROR OR DISCREPANCY FOUND ONCE THE CONTRACT DOCUMENT IS CAREFULLY REVIEWED AND ALL ASPECTS OF FIELD WORK HAVE BEEN VERIFIED. IN THE EVENT THE CONTRACTOR CONTINUES TO WORK ON AN ITEM WHERE AN ERROR EXISTS, IT SHALL BE DEEMED THAT THE CONTRACTOR BID AND INTENDED TO EXECUTE THE MORE STRINGENT OR HIGHER QUALITY REQUIREMENT. WITHOUT ANY INCREASE TO THE CONTRACT SUM OR CONTRACT TIME.
16. THE DRAWINGS AND SPECIFICATIONS SHOULD AGREE WITH EACH OTHER, AND WORK CALLED FOR BY DRAWINGS AND NOT MENTIONED IN SPECIFICATIONS, OR VICE VERSA, SHALL BE FURNISHED. WHEN DISCREPANCIES BETWEEN SCALE AND DIMENSIONS OCCUR, THE DIMENSIONED FIGURE SHALL BE USED. IF DISCREPANCIES BETWEEN THE DRAWINGS AND SPECIFICATIONS OCCUR, THE CONTRACTOR SHALL NOT WORK WITHOUT CLARIFICATION FROM ENGINEER AND RESOLUTION BY OWNER.
17. CONTRACTOR SHALL PROTECT EXISTING GROUNDWATER MONITORING WELLS, EXTRACTION WELLS, AND LANDFILL GAS MONITORING PROBES. REFER TO DRAWING C1 FOR APPROXIMATE LOCATION.
18. CONTRACTOR SHALL CONDUCT WORK IN ACCORDANCE WITH EXISTING SAN ANGELO LANDFILL SWPPP AND TPDES STORMWATER PERMIT.
19. CELL 11A CONSTRUCTION SHALL NOT INTERFERE WITH ONGOING LANDFILL OPERATIONS. CONSTRUCTION ACTIVITIES MUST BE COORDINATED WITH LANDFILL PERSONNEL TO ALLOW ACCESS TO THE LANDFILL WORKING FACE DURING NORMAL OPERATING HOURS.
20. GEOSYNTHETICS MATERIAL AND INSTALLATION WILL BE PROVIDED UNDER SEPARATE CONTRACT FROM GENERAL CONTRACTOR. GENERAL CONTRACTOR SHALL COORDINATE AND WORK WITH GEOSYNTHETICS CONTRACTOR SELECTED BY OWNER.

FOR BIDDING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

VICINITY/DRAWING INDEX/ GENERAL NOTES

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	
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CHK. DLC	DWG : G2-GenVicinity.dwg		

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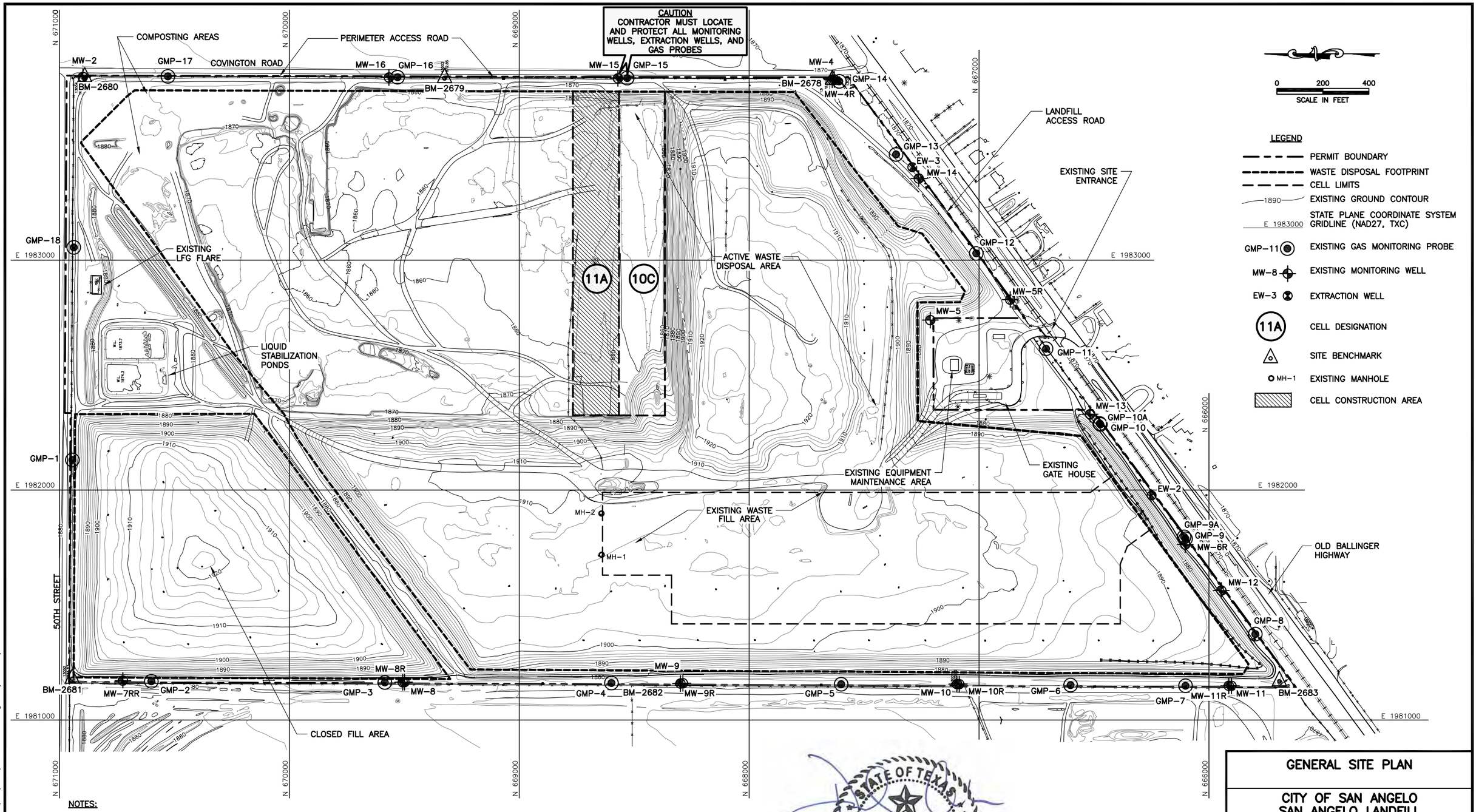

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- WASTE DISPOSAL FOOTPRINT
- CELL LIMITS
- 1890 EXISTING GROUND CONTOUR
- E 1983000 STATE PLANE COORDINATE SYSTEM GRIDLINE (NAD27, TXC)
- GMP-11 EXISTING GAS MONITORING PROBE
- MW-8 EXISTING MONITORING WELL
- EW-3 EXTRACTION WELL
- 11A CELL DESIGNATION
- SITE BENCHMARK
- MH-1 EXISTING MANHOLE
- CELL CONSTRUCTION AREA

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MARCH 6, 2013 BY COOPER AERIAL SURVEYS COMPANY.
2. CONTRACTOR SHALL COORDINATE EQUIPMENT/MATERIAL STORAGE AREA WITH LANDFILL OPERATIONS.
3. THE LIQUID STABILIZATION POND AND COMPOSTING AREA HAVE ONGOING WASTE PROCESSING ACTIVITIES. CONTRACTOR SHALL NOT DISRUPT WASTE DISPOSAL OPERATIONS OR THESE ONGOING WASTE ACTIVITIES.

SITE BENCHMARKS

BENCHMARK	NORTHING	EASTING	ELEVATION
BM-2678	667637.41	1983782.52	1869.65
BM-2679	669324.19	1983790.56	1872.59
BM-2680	670890.00	1983794.33	1876.32
BM-2681	670944.01	1981179.76	1881.87
BM-2682	668481.77	1981167.64	1875.74
BM-2683	665694.25	1981168.62	1871.95

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-25-14

FOR BIDDING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

GENERAL SITE PLAN

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	C1
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CHK. DLC	DWG : C1-SitePlan.dwg		

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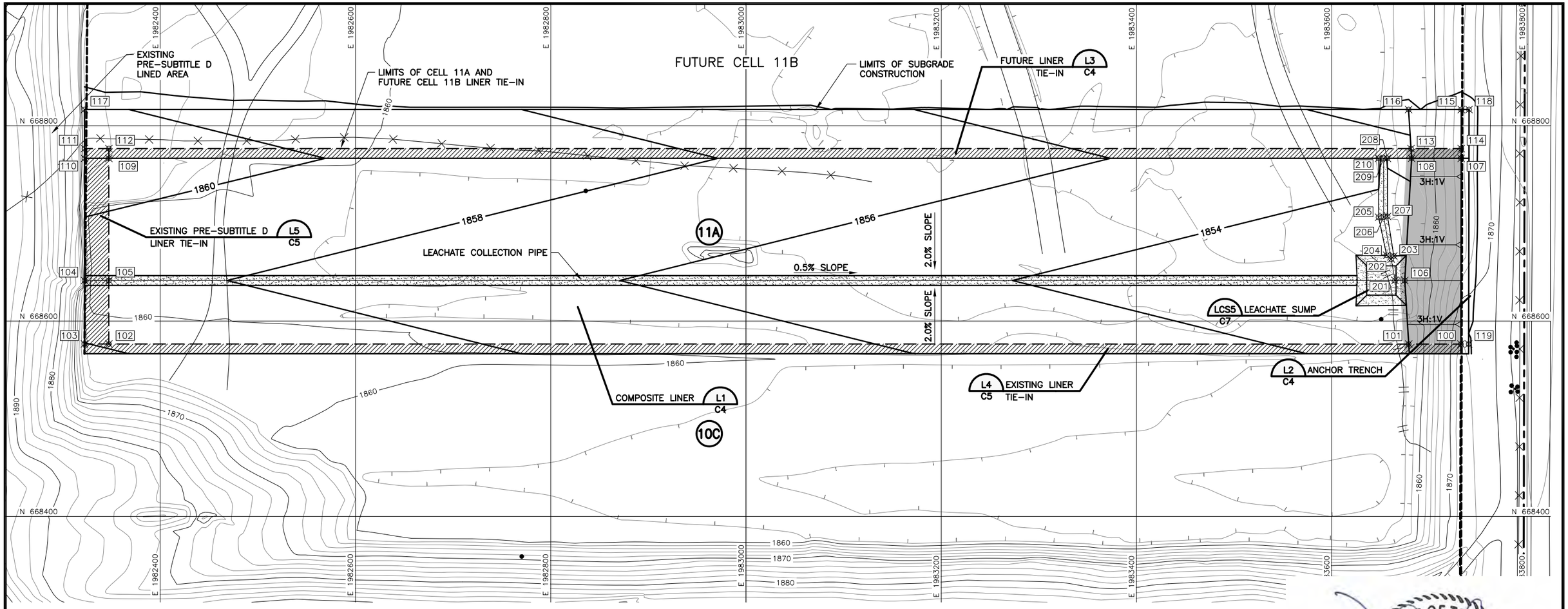

LEGEND

- PERMIT BOUNDARY
- EXISTING WASTE DISPOSAL FOOTPRINT
- 1880 EXISTING GROUND CONTOUR
- E 1983000 STATE PLANE COORDINATE SYSTEM GRIDLINE (NAD27, TXC)
- TEXTURED LINER
- 11A CELL DESIGNATION
- 100 POINT

0 50 100
SCALE IN FEET

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MARCH 6, 2013 BY COOPER AERIAL SURVEYS COMPANY.
2. CELL 10C LIMITS INCORPORATED FROM CELL 10C GM/GLER PREPARED BY LANDTEC ENGINEERS, SEPTEMBER 2012.
3. LEACHATE TRENCHES ARE SHOWN AS EXCAVATION GRADES. THE LEACHATE TRENCHES WILL BE GRADED AS SHOWN ON DRAWING C6.
4. THE LIMITS OF EXISTING PRE-SUBTITLE D LINER ARE APPROXIMATE AND WILL BE VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION. CQA ENGINEER SHALL DETERMINE AND APPROVE LINER TIE-IN TO EXISTING PRE-SUBTITLE D LINER.

SUBGRADE COORDINATE TABLE

POINT NUMBER	NORTHING	EASTING	ELEVATION	DESCRIPTION
100	668576.46	1983732.33	1871.09	TOP OF SLOPE
101	668576.46	1983678.92	1853.28	TOE OF SLOPE
102	668576.54	1982347.42	1859.90	SUBGRADE FLOOR
103	668576.54	1982322.42	1860.03	SUBGRADE FLOOR
104	668641.54	1982322.42	1858.73	SUBGRADE FLOOR
105	668641.54	1982347.42	1858.60	SUBGRADE FLOOR
106	668641.54	1983674.86	1852.00	TOE OF SLOPE
107	668766.54	1983732.62	1871.39	TOP OF SLOPE
108	668766.54	1983681.84	1854.47	TOE OF SLOPE
109	668766.54	1982347.42	1861.10	SUBGRADE FLOOR
110	668766.54	1982322.42	1861.23	SUBGRADE FLOOR
111	668776.54	1982322.42	1861.03	SUBRADE FLOOR
112	668766.54	1982347.42	1861.16	SIBGRADE FLOOR
113	668776.54	1983681.22	1854.27	TOE OF SLOPE
114	668776.54	1983732.64	1871.41	TOP OF SLOPE
115	668816.54	1983732.70	1871.48	TOP OF SLOPE
116	668816.54	1983678.72	1853.48	TOE OF SLOPE
117	668816.54	1982322.42	1860.23	SUBGRADE FLOOR
118	668816.53	1983740.70	1871.48	ANCHOR TRENCH
119	668576.44	1983740.33	1871.09	ANCHOR TRENCH

LEACHATE TRENCH COORDINATE TABLE

POINT NUMBER	NORTHING	EASTING	ELEVATION	DESCRIPTION
201	668641.54	1983664.87	1851.05	END OF PIPE
202	668663.35	1983660.96	1851.27	INVERT OF LEACHATE TRENCH
203	668666.60	1983663.59	1852.36	TOP OF LEACHATE TRENCH
204	668667.36	1983656.31	1852.61	TOP OF LEACHATE TRENCH
205	668706.28	1983648.05	1853.43	TOP OF LEACHATE TRENCH
206	668706.54	1983653.22	1851.71	INVERT OF LEACHATE TRENCH
207	668707.11	1983657.23	1853.06	TOP OF LEACHATE TRENCH
208	668766.54	1983657.07	1854.19	TOP OF LEACHATE TRENCH
209	668766.54	1983653.23	1852.91	INVERT OF LEACHATE TRENCH
210	668766.54	1983648.06	1854.63	TOP OF LEACHATE TRENCH

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-25-14

FOR BIDDING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

SUBGRADE AND LINER PLAN

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	C2
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CHK. DLC	DWG : C2-Subgrade-Liner.dwg		

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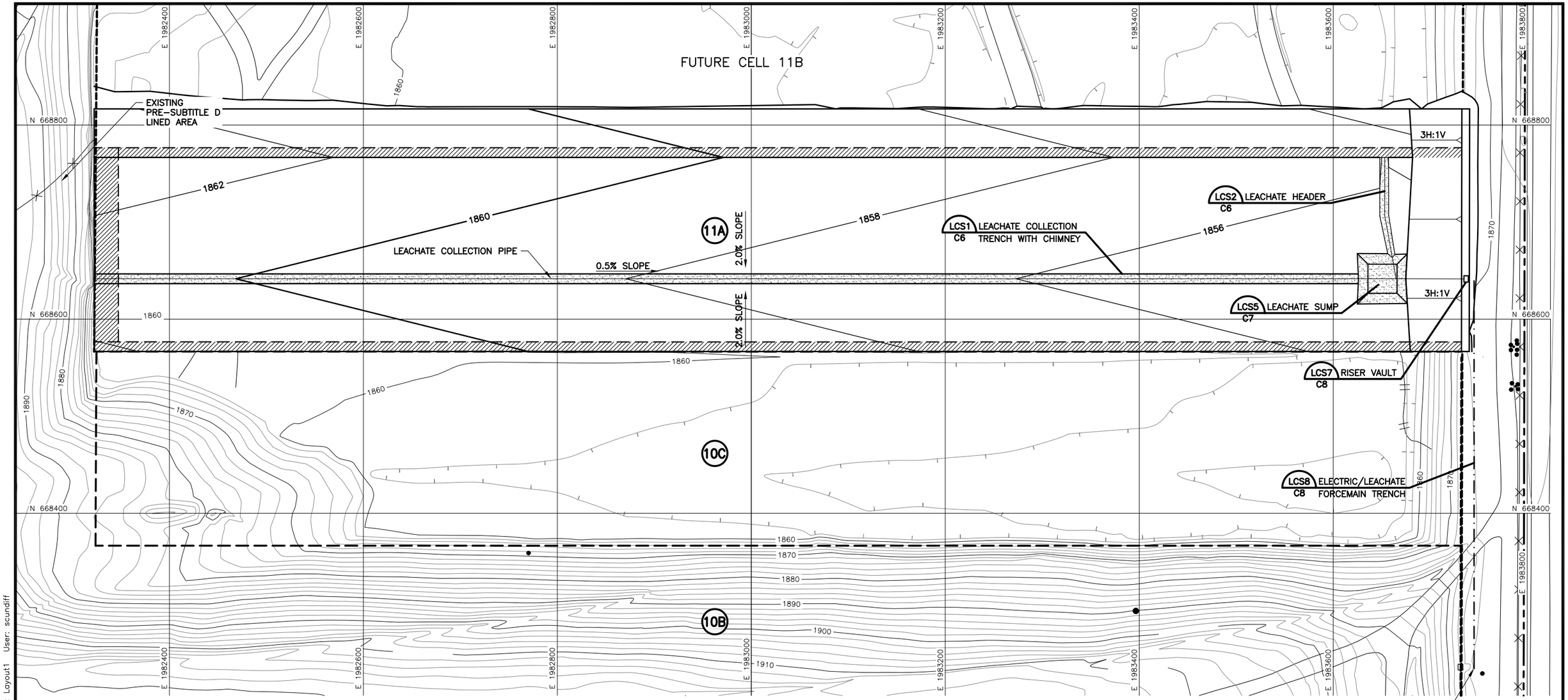

0 50 100
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- EXISTING WASTE DISPOSAL FOOTPRINT
- 1880 EXISTING GROUND CONTOUR
- E 1983000 STATE PLANE COORDINATE SYSTEM GRIDLINE (NAD27, TXC)
- 11A CELL DESIGNATION
- PROPOSED LEACHATE FORCEMAIN/ ELECTRICAL CONDUIT

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL SURVEY FLOWN ON MARCH 6, 2013 BY COOPER AERIAL SURVEYS COMPANY.

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-25-14

FOR BIDDING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

PROTECTIVE COVER AND LEACHATE COLLECTION PLAN

CITY OF SAN ANGELO SAN ANGELO LANDFILL CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING
DWN. SRC	SCALE : GRAPHIC	C3
CHK. DLC	DWG : C3-TOPCPlan.dwg	

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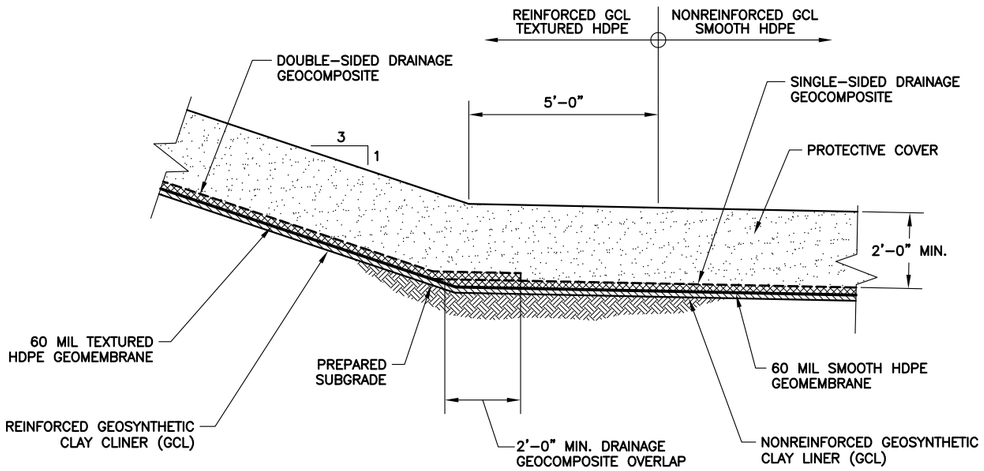
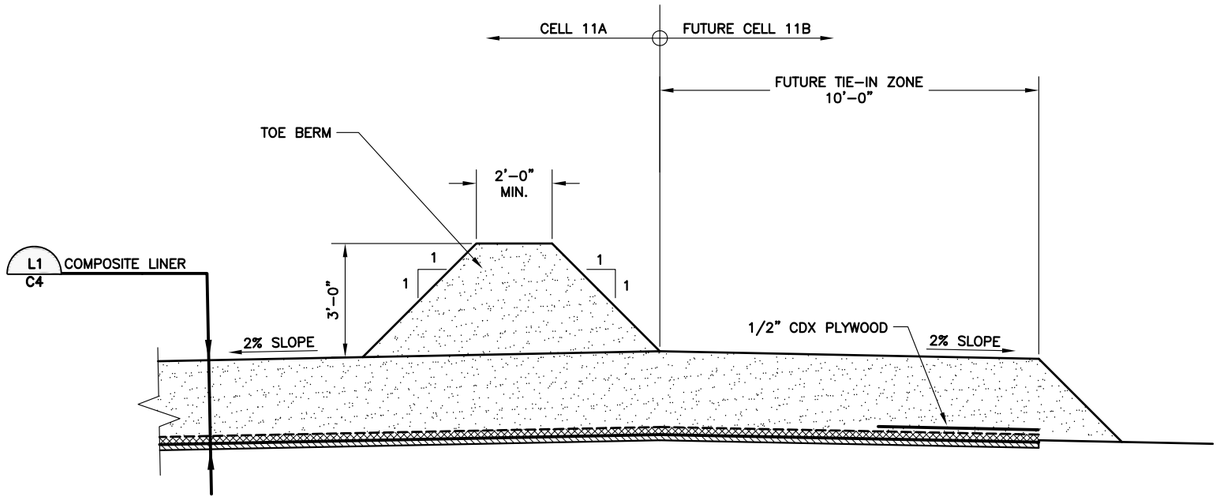


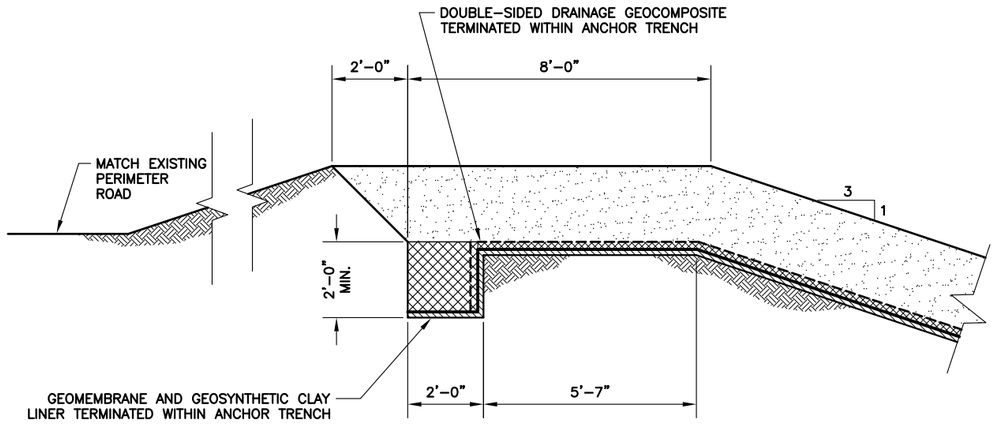
COMPOSITE LINER L1 C4

0 2 4
SCALE IN FEET



FUTURE LINER TIE–IN L3 C4

0 2 4
SCALE IN FEET



ANCHOR TRENCH L2 C4

0 2 4
SCALE IN FEET

NOTE:

1. GEOSYNTHETIC CLAY LINER, GEOMEMBRANE, AND GEOCOMPOSITE WILL BE PROVIDED AND INSTALLED BY OTHERS.

FOR BIDDING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

LINER DETAILS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817–563–1144

TBPE FIRM NO. F–256 | TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	C4
DWN. SRC	SCALE : GRAPHIC		
CHK. DLC	DWG : C4–C6–LinerDetails.dwg		

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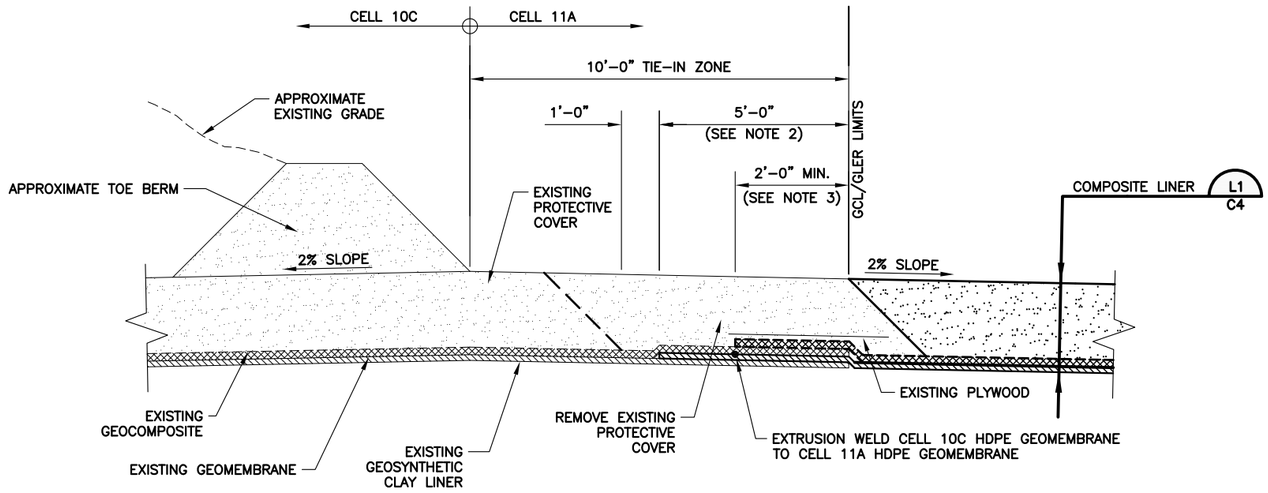
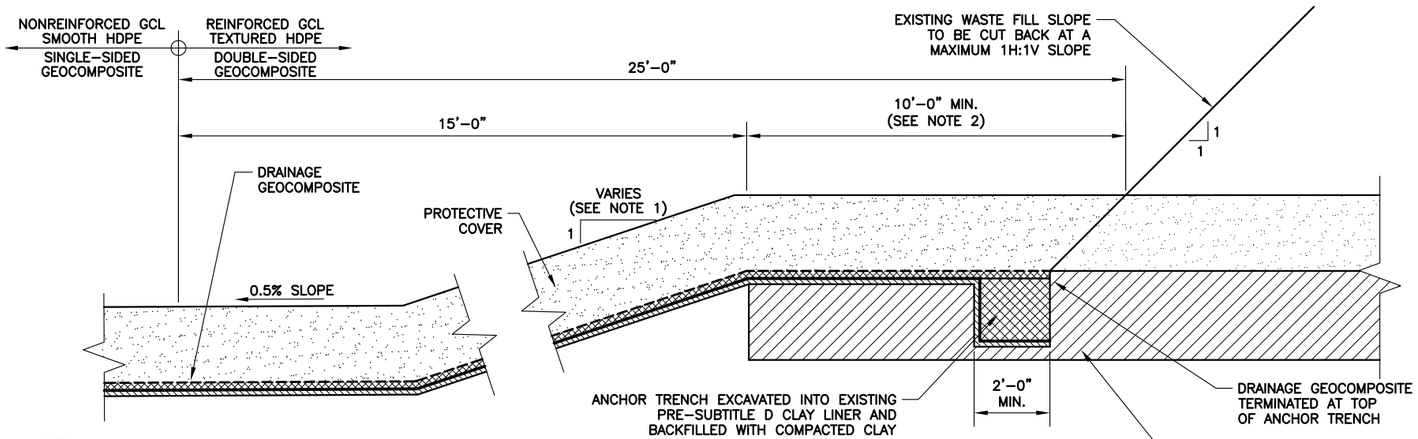


NOTE:

1. HDPE GEOMEMBRANE AND DRAINAGE GEOCOMPOSITE TO BE PULLED BACK TO EXPOSE GEOSYNTHETIC CLAY LINER.
2. OVERLAP CELL 10C GEOSYNTHETIC CLAY LINER WITH CELL 11A GEOSYNTHETIC CLAY LINER 5'–0".
3. OVERLAP CELL 10C DRAINAGE GEOCOMPOSITE WITH CELL 11A DRAINAGE GEOCOMPOSITE 2'–0".
4. GEOSYNTHETIC LINER WILL BE PROVIDED AND INSTALLED BY OTHERS.

EXISTING LINER TIE–IN L4 C5

0 2 4
SCALE IN FEET



NOTE:

1. SLOPE VARIES BUT WILL NOT EXCEED 3H:1V UNLESS APPROVED BY CQA ENGINEER.
2. LINER TIE–IN TO EXISTING PRE–SUBTITLE D LINER MAY VARY. TO BE DETERMINED DURING CONSTRUCTION BY CQA ENGINEER.

EXISTING PRE–SUBTITLE D LINER TIE–IN L5 C5

0 2 4
SCALE IN FEET

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-25-14

FOR BIDDING PURPOSES ONLY

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

LINER DETAILS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817–563–1144
TBPE FIRM NO. F–256
TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	C5
DWN. SRC	SCALE : GRAPHIC		
CHK. DLC	DWG : C4–C6–LinerDetails.dwg		

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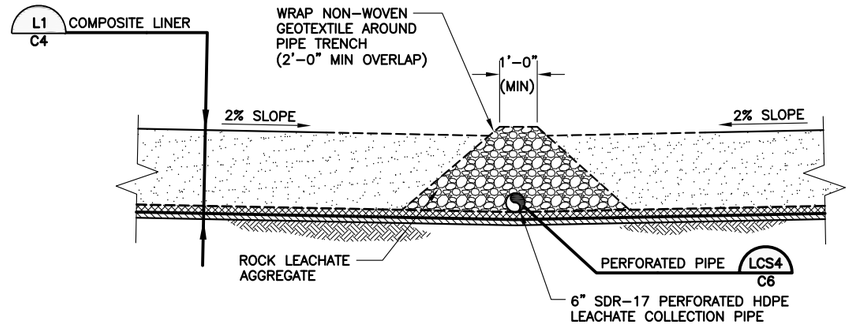
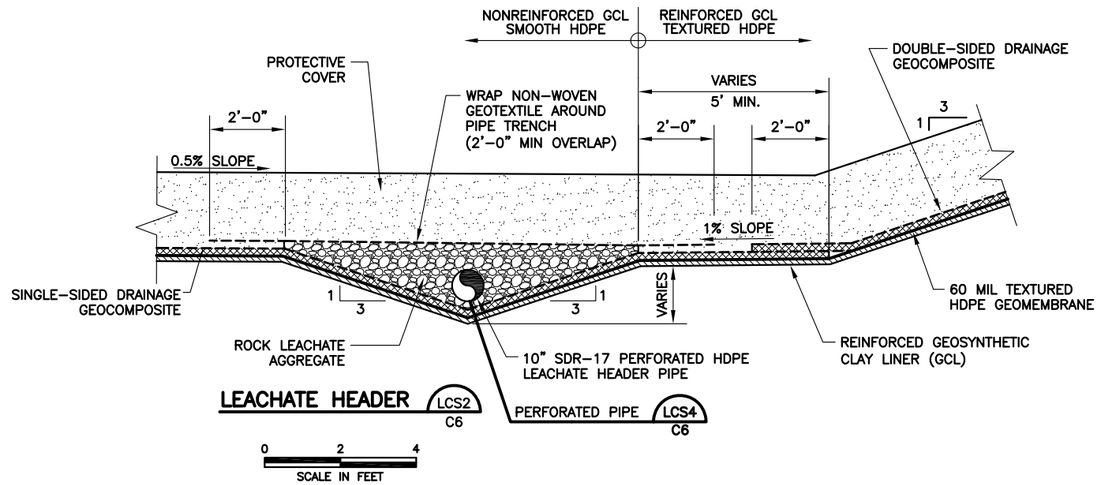


LEACHATE COLLECTION TRENCH WITH CHIMNEY LCS1 C6

0 2 4
SCALE IN FEET

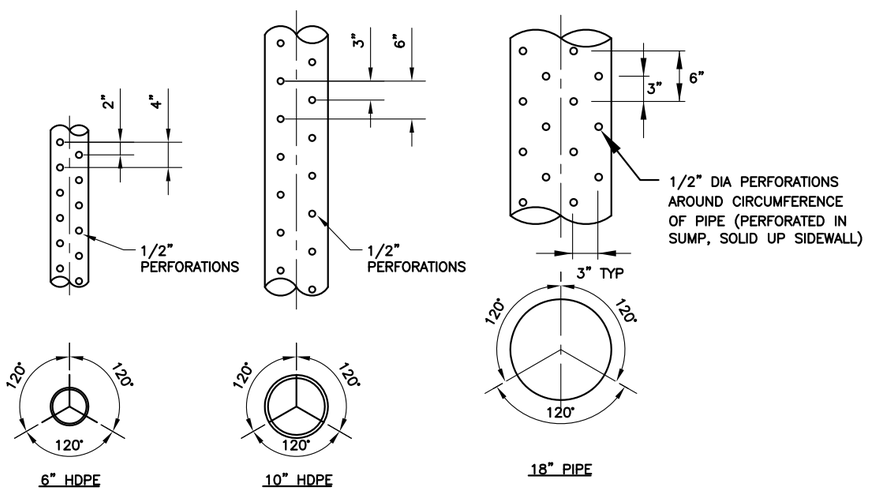


LEACHATE HEADER LCS2 C6

0 2 4
SCALE IN FEET

LEACHATE SUMP AND RISER PIPE LCS3 C6

0 2 4
SCALE IN FEET



PERFORATED PIPE LCS4 C6

0 1 2
SCALE IN FEET

NOTE:

1. GEOSYNTHETIC LINER WILL BE PROVIDED AND INSTALLED BY OTHERS. GEOTEXTILE IN LEACHATE COLLECTION TRENCH, HEADER, AND SUMP WILL BE PROVIDED BY OWNER AND INSTALLED UNDER THIS CONTRACT.

FOR BIDDING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

LEACHATE COLLECTION SYSTEM DETAILS

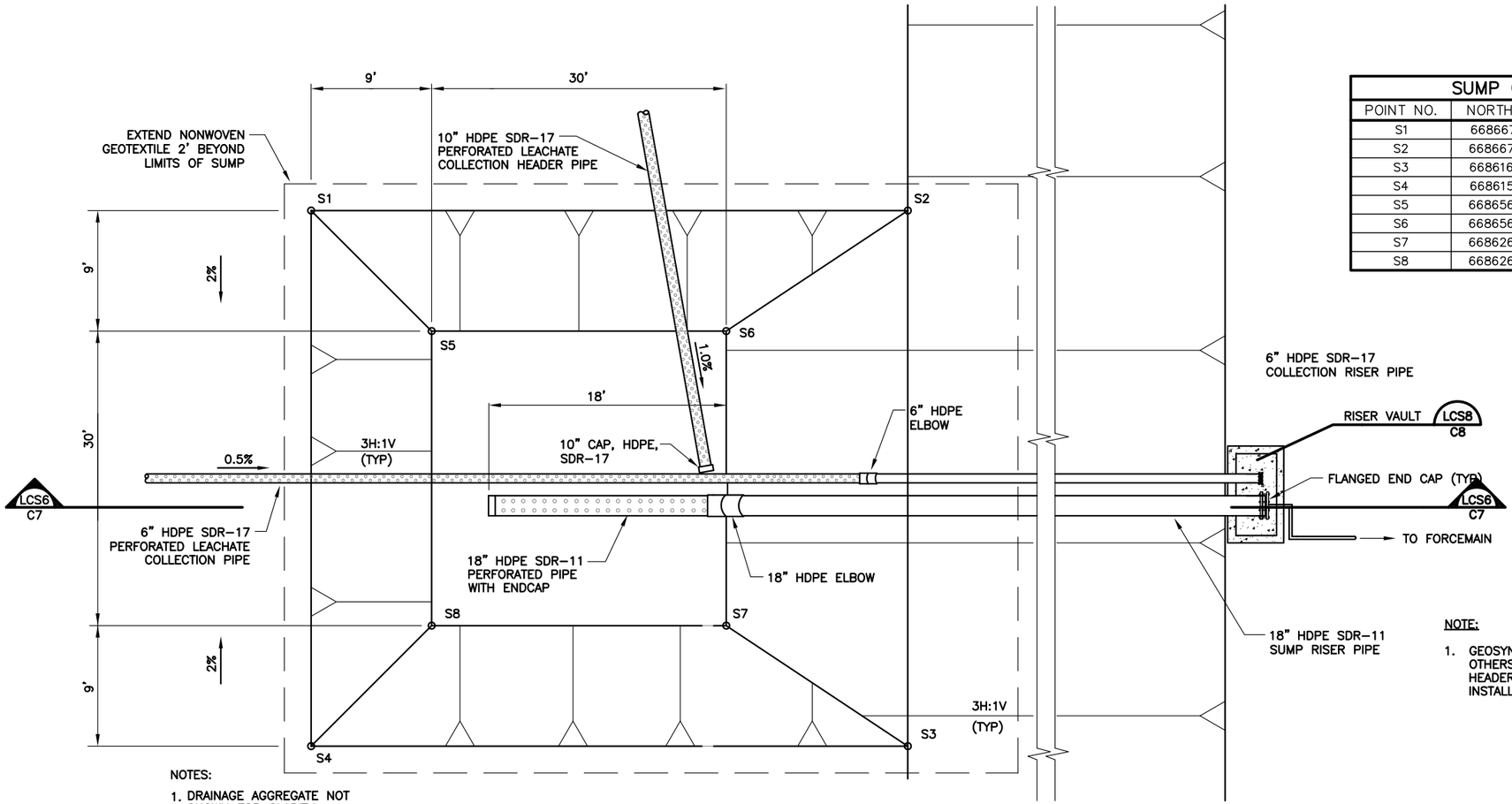
CITY OF SAN ANGELO SAN ANGELO LANDFILL CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING	C6
DWN. SRC	SCALE : GRAPHIC		
CHK. DLC	DWG : C4-C6-LinerDetails.dwg		

SUMP GRADING TABLE			
POINT NO.	NORTHING	EASTING	ELEVATION
S1	668667.51	1983624.88	1852.72
S2	668667.03	1983676.28	1852.50
S3	668616.04	1983676.45	1852.50
S4	668615.56	1983624.88	1852.72
S5	668656.54	1983635.86	1849.00
S6	668656.54	1983665.86	1849.00
S7	668626.54	1983665.86	1849.00
S8	668626.54	1983635.86	1849.00



NOTES:

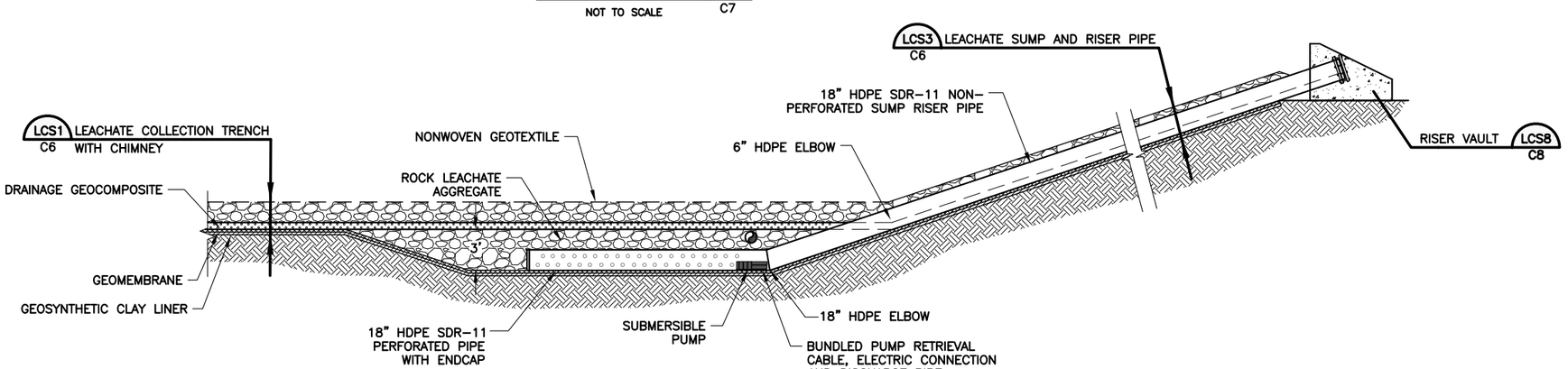
1. DRAINAGE AGGREGATE NOT SHOWN FOR CLARITY

NOTE:

1. GEOSYNTHETIC LINER WILL BE PROVIDED AND INSTALLED BY OTHERS. GEOTEXTILE IN LEACHATE COLLECTION TRENCH, HEADER, AND SUMP WILL BE PROVIDED BY OWNER AND INSTALLED UNDER THIS CONTRACT.

LEACHATE SUMP LCS5 C7

NOT TO SCALE



LEACHATE SUMP AND RISER LCS6 C7

NOT TO SCALE

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-25-14

SUMP AND RISER DETAILS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144

FOR BIDDING PURPOSES ONLY

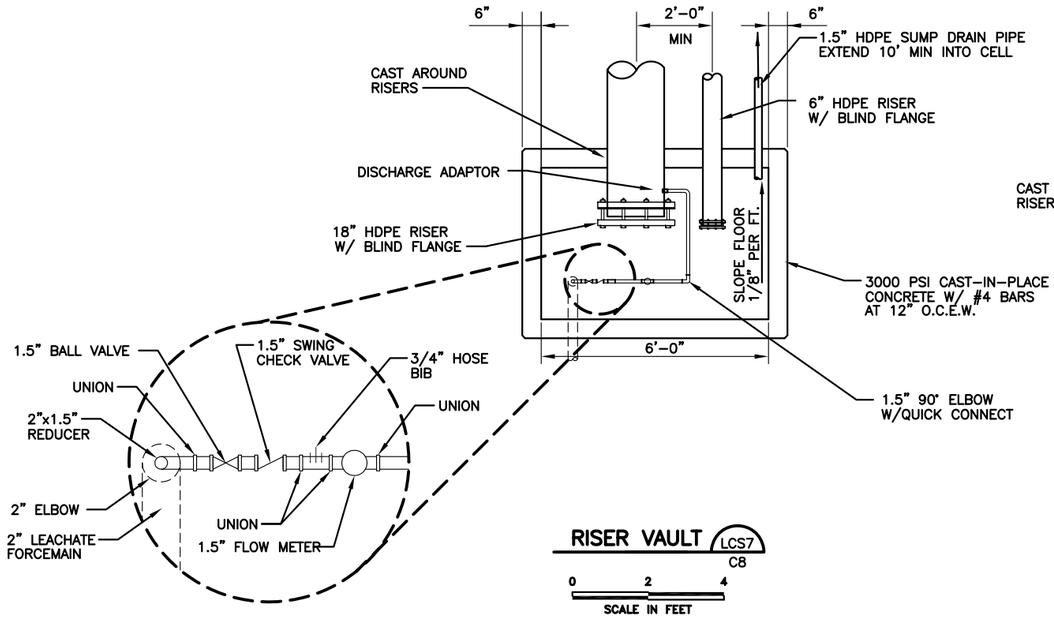
REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JHP | DATE : 02/14
DWN. SRC | SCALE : GRAPHIC
CHK. DLC | DWG : C7-SumpRiserDtls.dwg

DRAWING C7

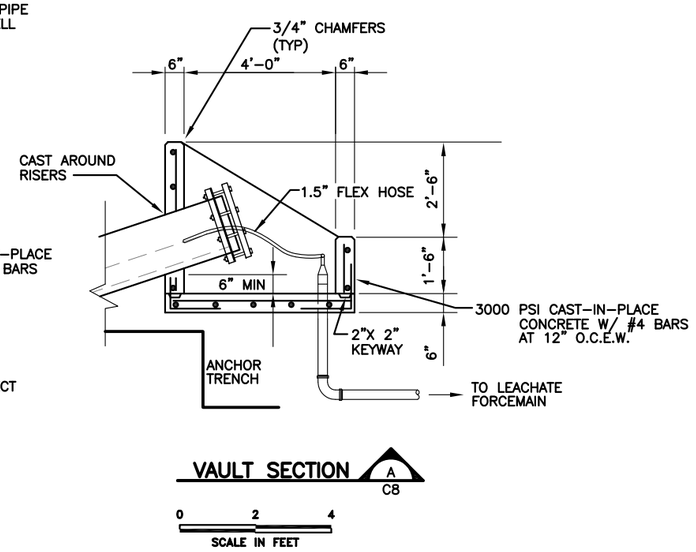
J:\225\02\208\C7-SumpRiserDtls.dwg Layout: C7 User: scundiff



RISER VAULT LCS7 C8

0 2 4

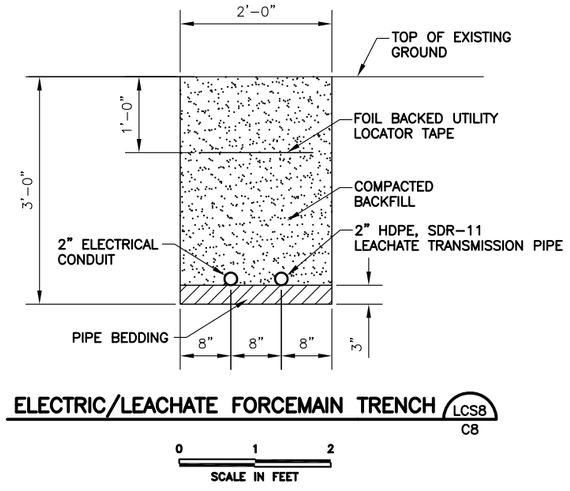
SCALE IN FEET



VAULT SECTION A C8

0 2 4

SCALE IN FEET



ELECTRIC/LEACHATE FORCEMAIN TRENCH LCS8 C8

0 1 2

SCALE IN FEET

FOR BIDDING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

LCS VAULT, ELECTRICAL, AND FORCEMAIN DETAILS

CITY OF SAN ANGELO
SAN ANGELO LANDFILL
CELL 11A CONSTRUCTION

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD ◆ WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. JHP	DATE : 02/14	DRAWING
DWN. SRC	SCALE : GRAPHIC	C8
CHK. DLC	DWG : C8-LCS_Dtls.dwg	

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