SKYLINE LANDFILL
CITY OF FERRIS
DALLAS AND ELLIS COUNTIES, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 42D

PERMIT AMENDMENT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN
ATTACHMENT D6
LEACHATE AND CONTAMINATED WATER MANAGEMENT PLAN

Prepared for

Waste Management of Texas, Inc.

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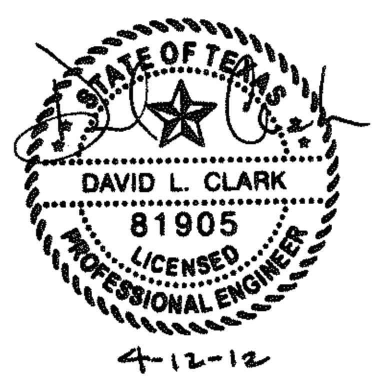
30 TAC §§330.65(c), 330.177, 330.207, 330.227, 330.331(a)(2), 330.333, 330.337(d)



1 INTRODUCTION

30 TAC §§330.65(c), 330.177, 330.207, 330.227, 330.331(a)(2), 330.333, 330.337(d)

1.1 Purpose

This Leachate and Contaminated Water Management Plan has been prepared for the Skyline Landfill consistent with 30 TAC §§330.65(c), 330.177, 330.207, 330.227, 330.331(a)(2), 330.333, and 330.337(d). This plan provides the details of the collection, storage, treatment, and disposal of contaminated water, leachate, and gas condensate from the leachate collection system, gas monitoring and collection systems, and site operations.

1.2 Definitions

Leachate is defined in §330.3(78) as a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.

Contaminated water is defined in §330.3(36) as leachate, gas condensate, or water that has come into contact with waste.

Gas condensate is defined in §330.3(57) as the liquid generated as a result of any gas recovery process at a municipal solid waste facility.

2 LEACHATE MANAGEMENT

30 TAC §§330.227, 330.331(a)(2), 330.333, 330.337(d)

2.1 Leachate Generation

The capacity of solid waste to absorb moisture is known as field capacity. Leachate is generated as water infiltrates and percolates through layers of solid waste and the field capacity is exceeded. The quantity of leachate that is generated depends upon rainfall, site topography, type of cover, operating procedures, and waste characteristics.

The Hydrologic Evaluation of Landfill Performance (HELP) model was used to predict the quantity of leachate that will be generated at the Skyline Landfill. The HELP model is a water balance model that uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage. Leachate generation was evaluated for both active and closed landfill conditions. An explanation and results of the HELP model are included in Appendix D6-B – Leachate Generation Model.

2.2 Leachate Collection

2.2.1 Leachate Collection System Design

The leachate collection system (LCS) will consist of the following:

- A geocomposite leachate collection layer
- The leachate collection trenches and piping
- Leachate collection pipe cleanout risers
- The leachate collection sumps and pumps

Each cell will have the configuration described below:

- Leachate collection pipes will have a maximum spacing of 400 feet.
- Leachate collection trenches will have a minimum slope of 1 percent.
- Cross-slopes into the leachate collection trench will be a minimum of 2 percent.

The LCS plan and details are provided in Attachment D3 – Construction Design Details.

The LCS has been designed in accordance with 30 TAC §§330.331(a)(2) and 330.333(3)(A-G) to:

- Maintain less than 30 cm (12 inches) depth of leachate over the liner (see Appendix D6-B – Leachate Generation Model).
- Be constructed of materials that are chemically resistant to the leachate expected to be generated. The components of the leachate collection system have been designed with materials that are inert to leachates typically produced by municipal solid waste facilities. Drainage nets and pipes will be high density polyethylene (HDPE). Aggregates will be resistant to carbonate loss. Geotextiles have been designed with factors of safety for biological and chemical clogging (see Appendix D6-A – Leachate Collection System Design Calculations).
- Be constructed of materials that have sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill (see Appendix D6-A – Leachate Collection System Design Calculations).
- Function through the scheduled closure and postclosure care period of the landfill considering:
  - Estimated rate of leachate removal (Appendix D6-A, pages D6-A-3 through D6-A-4)
  - Capacity of sumps (Appendix D6-A, page D6-A-6)
  - Pipe material and strength (Appendix D6-A, pages D6-A-12 through D6-A-16)
  - Pipe network spacing and grading (Attachment D3 – Construction Design Details, Drawing D3.4 – Leachate Collection System Plan)
  - Collection sump materials and strength (Appendix D6-A, pages D6-A-17 through D6-A-21)
  - Drainage media specifications and performance (Appendix D6-A, pages D6-A-1 and D6-A-2)
  - Demonstration that pipes and perforations will be resistant to clogging and can be cleaned (Sections 2.2.3 through 2.2.5)

In accordance with 30 TAC §330.337(d), the LCS has been designed to handle both the leachate generated and the groundwater inflow from materials beneath and lateral to the liner system (see Appendix D6-A – Leachate Collection System Design Calculations).

2.2.2 Leachate Collection Layer

The leachate collection layer consists of geocomposite drainage net installed above the geomembrane. 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. Leachate collection layer design calculations are presented in Appendix D6-A – Leachate Collection System Design Calculations. The geocomposite properties are provided in Attachment D7 – Liner Quality Control Plan (LQCP).

2.2.3 Geotextile

The drainage aggregate will be covered by a geotextile to prevent migration of the protective cover soil into the LCS. The geotextile will be inert to commonly encountered chemicals, hydrocarbons, and mildew, and will be rot resistant. Geotextile design calculations are presented in Appendix D6-A – Leachate Collection System Design Calculations. The geotextile properties are provided in Attachment D7 – Liner Quality Control Plan (LQCP).

2.2.4 Leachate Aggregate

Leachate aggregate will be placed in the collection trenches and in the sumps. The aggregate shall consist of manufactured or natural materials having the properties listed in Attachment D7 – Liner Quality Control Plan (LQCP).

In addition, aggregates must meet the following criteria:

For circular pipe perforations, the ratio:

$$\frac{\text{85 Percent Size of Aggregate}}{\text{Perforation Hole Diameter}} > 1.7$$

For slotted pipe perforations, the ratio:

$$\frac{\text{85 Percent of Aggregate Material}}{\text{Perforation Slot Width}} > 2.0$$

Chimney drains will be installed above the leachate collection pipes and will extend through the protective cover. The chimney drains will be constructed from the same drainage aggregate described above. Details illustrating the construction of the chimney drains are included in Attachment D3 – Construction Design Details.

2.2.5 Leachate Collection Trenches and Piping

The leachate collection layer will slope toward the leachate collection trenches. The leachate piping includes perforated collection trench pipes and the solid sidewall riser pipes. Sidewall risers will extend to the top of the perimeter berm to provide access for cleaning the leachate collection pipes and sump risers. The leachate piping shall meet the criteria listed in Attachment D7 – Liner Quality Control Plan (LQCP).

Each collection trench will contain a 6-inch-diameter perforated leachate collection pipe surrounded by drainage aggregate. The leachate collection trench will convey the leachate to sumps located along the toe of the side slopes. The leachate collection pipes have been designed for the critical loading condition expected at the site. Both the overburden load (due to the weight of the waste and soil layers over the pipe) and the construction load (due to the weight of equipment and operations layers) were considered. Leachate collection system details are provided in Attachment D3 – Construction Design Details. Leachate collection pipe design calculations are provided in Appendix D6-A – Leachate Collection System Design Calculations.

2.2.6 Leachate Sumps

The leachate sumps will consist of a 3-foot-deep rectangular area. The sumps have different minimum dimensions for various cells due to the significant difference in the amount of contributing area. Details of the leachate sumps and varying minimum dimensions are provided in Attachment D3 – Construction Design Details. Each sump will be backfilled with leachate drainage aggregate. Sump capacity and strength calculations are presented in Appendix D6-A – Leachate Collection System Design Calculations. Leachate will be transferred from the sumps by submersible pumps, as discussed in Section 2.4. The submersible pumps will be equipped with internal pressure transducers to measure the depth of the leachate in the sumps. A leachate level readout will be provided in the pump control panel. The pumps may be operated manually or by an automatic start switch. In either case, the pumps will be operated to limit the leachate level to the top of the sump. The allowable maximum leachate head is 12 inches on the liner (or 48 inches in the sump). Leachate sump material requirements are provided in Attachment D7 – Liner Quality Control Plan (LQCP).

2.3 Leachate Storage

Primary leachate storage will be provided by the leachate sumps, which are located within each landfill cell. Leachate will be pumped from the sumps through a leachate forcemain to a direct connection to publicly owned treatment works (POTW). Existing storage tanks provide a minimum of approximately 38 hours of temporary leachate storage in the event that the direct connection to the POTW is not functional; the storage tanks will be emptied from the tanks into tanker trucks for transport based on leachate production and storage needs in the event that they are used.

The tanks are located in the area as shown in Attachment D1 – Landfill Unit Design – Site Layout Plan, Drawing D1.5 – Entrance Road and Entrance Facilities Plan. The storage facility consists of one 24,500-gallon storage tank and one 17,000-gallon storage tank. The calculations in Appendix D6-D – Secondary Containment Volume Calculations demonstrate that the secondary containment area provides containment, with 6 inches of freeboard, for the leachate storage tanks and precipitation from the 25-year, 24-hour storm event.

2.4 Leachate Disposal

Leachate will be pumped from the sumps through a leachate forcemain to a direct connection to a POTW. Leachate may be recirculated to active areas of the landfill, consistent with §§330.177 and 330.207. Leachate sampling and analysis will be limited to the POTW's requirements. The results of any monitoring required by the disposal facility will be placed in the site operating record.

Leachate may be recirculated into an on-site landfill unit that is designed and constructed with a leachate collection system and a composite liner in accordance with §330.177. Leachate may be discharged into shallow pits or trenches excavated into the waste as described in the site operating plan. Leachate may also be recirculated by transferring into a tanker and spraying on the active face. Leachate will not be recirculated to the active face during rainy or wet periods. The application of leachate will not cause accumulation, ponding, or other operational problems. The Skyline Landfill will ensure that recirculating will not result in vectors, odor, and other nuisance conditions.

3 CONTAMINATED WATER MANAGEMENT

30 TAC §330.207

3.1 Contaminated Water Generation

Surface water that comes into contact with waste, leachate, or gas condensate is considered to be contaminated water. Best management practices will be used to minimize contaminated water generation. Temporary diversion berms will be constructed around areas of exposed waste to minimize the amount of surface water that comes into contact with waste. Design calculations and typical details for temporary diversion berms are presented in Appendix D6-C – Containment/Diversion Berm Design. Daily cover and intermediate cover will be placed over filled areas to minimize the area of exposed waste. Procedures for verifying the adequacy of daily and intermediate cover placement are provided in Part IV – Site Operating Plan. If waste is exposed in areas where daily or intermediate cover has been previously placed, runoff from these areas will be considered to be contaminated water. Leachate will be collected and segregated from surface water by the LCS as described in Section 2. Secondary containment will be provided around the leachate storage facility to contain leachate in case of a spill or leak. Gas condensate will be collected and segregated from surface water as described in Section 4.

3.2 Contaminated Water Collection and Containment

Temporary containment berms will be constructed around the active face to collect and contain surface water that has come into contact with waste. In addition to the planned containment berms around the active face, temporary containment berms will be constructed wherever needed to collect contaminated water. The design calculations and typical details for containment berms for a 25-year, 24-hour storm event are provided in Appendix D6-C – Containment/Diversion Berm Design. The calculations show the dimensions for typical conditions, but additional storage capacity will be provided as site operating conditions dictate.

3.3 Contaminated Water Storage

Primary contaminated water storage will be provided by the containment berms, which will provide storage for the 25-year, 24-hour storm event.

3.4 Contaminated Water Disposal

Contaminated water will not be allowed to discharge into waters of the United States. Contaminated water may be transported to a POTW for treatment and disposal in accordance with §330.207(f). Sampling and analysis will be limited to the POTW's requirements. The results of any monitoring required by the disposal facility will be placed in the site operating record.

4 GAS CONDENSATE MANAGEMENT

30 TAC §330.207

4.1 Gas Condensate Generation

Gas condensate is the liquid generated during the gas recovery process at a municipal solid waste facility.

4.2 Gas Condensate Collection, Storage, and Disposal

Gas condensate will be collected in the gas recovery system as described in Attachment G – Landfill Gas Management Plan. The gas condensate will be hauled from the gas recovery system to the on-site leachate storage facility. Gas condensate will be recirculated with leachate or disposed of per Section 2.4.

SKYLINE LANDFILL

APPENDIX D6-A
LEACHATE COLLECTION SYSTEM
DESIGN CALCULATIONS

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Includes pages D6-A-1 through D6-A-21

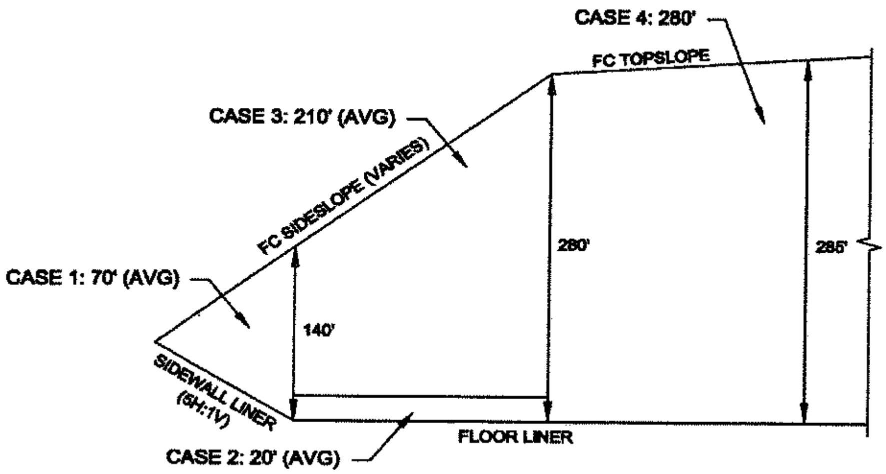
Geocomposite Design

Required: Determine the minimum transmissivities for the sidewall and floor liner geocomposite.

References: 1) *Designing with Geosynthetics*, Fourth Edition; Robert M. Koerner.

Solution: <u>**Bottom Liner Geocomposite**</u>

1) Summarize the HELP model cases based on the waste depths included in the typical landfill expansion cross section.



Case	Waste Depth ft	Cover Type
Sidewall LCS		
1	70	daily cover
Floor LCS		
2	20	active face - no cover
3	210	intermediate cover
4	280	intermediate cover
5	280	final Cover

2) Adjust the thickness of the geocomposite for various stages of landfill development. Typical compressibility of geonet is 50% @ 20,000 psf. Assume linear compression between 0 and 20,000 psf.

Unloaded geonet thickness : 0.20 inch

Case	Layer	Depth ft	Unit Wt pcf	Load psf	t inch
1	protective cover	2.0	105.0	210.0	
	waste/daily cover	70.0	44.0	3,080.0	
		72.0		3,290.0	0.18
2	protective cover	2.0	105.0	210.0	
	waste/daily cover	20.0	44.0	880.0	
		22.0		1,090.0	0.19
3	protective cover	2.0	105.0	210.0	
	waste/daily cover	210.0	44.0	9,240.0	
		212.0		9,450.0	0.15
4	protective cover	2.0	105.0	210.0	
	waste/daily cover	280.0	44.0	12,320.0	
		282.0		12,530.0	0.14
5	protective cover	2.0	105.0	210.0	
	waste/daily cover	280.0	44.0	12,320.0	
	final cover	4.5	115.0	517.5	
		286.5		13,047.5	0.13

3) The ultimate transmissivity value for the geocomposite is shown below.

Transmissivity, m^2/sec	
Sidewall LCS	Floor LCS
3.00E-05	***4.00E-04***

4) Calculate the allowable transmissivity from Reference 1, Equation 4.5.

$$T_{all} = T_{ult}\ (1 / RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC})$$

where: RF_{CR} = creep reduction factor
RF_{IN} = intrusion reduction factor
RF_{CC} = chemical clogging reduction factor
RF_{BC} = biological clogging reduction factor

Case	RF_{CR}	RF_{IN}	RF_{CC}	RF_{BC}	T_{all} m^2/sec
Sidewall LCS					
1	1.3	1.3	1.3	1.3	1.05E-05
Floor LCS					
2	1.0	1.0	1.0	1.0	4.00E-04
3	1.5	1.5	1.5	1.5	7.90E-05
4	1.7	1.7	1.7	1.7	4.79E-05
5	2.0	2.0	2.0	2.0	2.50E-05

5) Calculate the allowable hydraulic conductivity from Reference 1, Equation 4.2.

$$k_{all} = T_{all} / t$$

Case	t inch	T_{all} m^2/sec	k_{all} cm/sec
Sidewall LCS			
1	0.18	1.05E-05	0.23
Floor LCS			
2	0.19	4.00E-04	8.09
3	0.15	7.90E-05	2.04
4	0.14	4.79E-05	1.37
5	0.13	2.50E-05	0.73

Skyline Landfill
Leachate Collection System Flow Rates

Required: Determine the design flowrates for the following components of the leachate system.
1) Collection Pipe and Sump
2) Geotextile

References: 1) Appendix D6-B HELP Model Analyses.

Approach: 1) The total contributing area to each of the sumps is shown below.

SUMP	CONTRIBUTING AREA acres
Cell 11[1]	24.1
Cell 12	17.8
Cell 13[2]	145.4
Cell 14	12.7
Cell 15	14.9
Cell 16	17.2
Cell 17	19.4
Cell 18	34.0

[1]Includes Cell 9 (9.8 acres), Cell 10 (8.4 acres), and Cell 11 (5.9 acres).

[2]Includes entire Phase IA (74.4 acres), entire Phase IB (54.3 acres), Cell 7 (11.1 acres), and Cell 13 (14.6 acres).

2) Separate design calculations are included within this appendix for Cells 13 and 18 (cells with the highest contributing areas). The design used for these cells will be used to size the LCS components for the remaining cells with lesser contributing area.

	DESIGN CALCULATION				
Cell	Leachate Chimney	Leachate Pipe	Leachate Sump	Leachate Trench GT	Geocomposite Geotextile (GT)
Cell 13 Cell 18	SEE NOTE 1	SEE NOTE 1	SEE NOTE 2 SEE NOTE 3	SEE NOTE 1	SEE NOTE 1

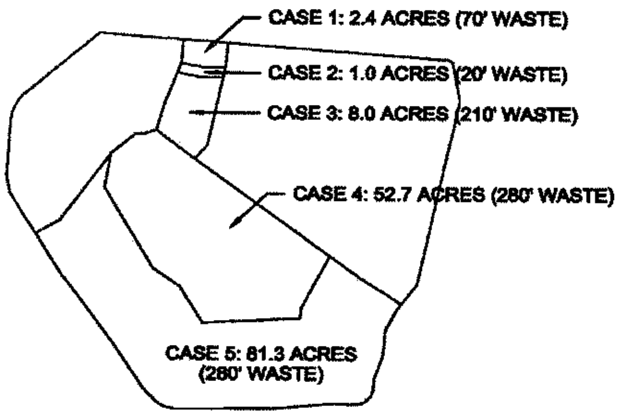
[1]Calculated design used for Cells 10-18

[2]Calculated design used for Cell 13 only

[3]Calculated design used for Cells 10-12 and 14-18

Solution:

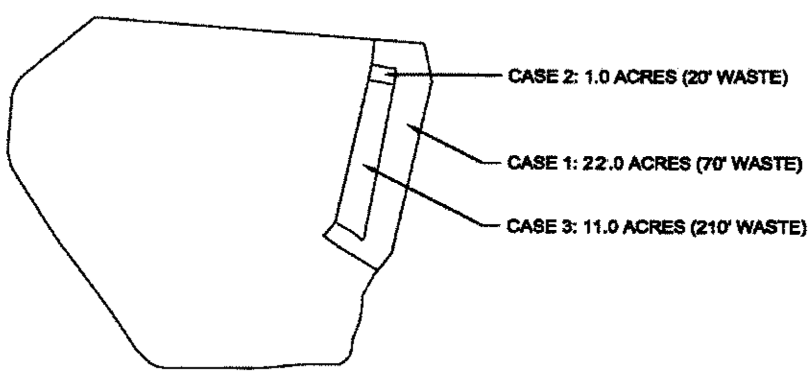
CELL 13 FLOW RATES



CONDITION	AREA acres	AVERAGE RATE cf/yr/ac	AVERAGE cfs	PEAK RATE cf/day/ac	PEAK cfs
Case 1	2.4	17,119.0	0.001	221.0	0.006
Case 2	1.0	27,567.0	0.001	206.0	0.002
Case 3	8.0	19,498.0	0.005	209.0	0.019
Case 4	52.7	20,100.0	0.034	209.0	0.127
Case 5	81.3	20.0	0.000	6.0	0.006
TOTAL	145.4		0.041		0.161

CELL 18 FLOW RATES

Cell 18 flow rates are the critical flow rates for geotextile design.



CONDITION	AREA acres	AVERAGE RATE cf/yr/ac	AVERAGE cfs	PEAK RATE cf/day/ac	PEAK cfs
Case 1	22.0	17,119.0	0.012	221.0	0.056
Case 2	1.0	27,567.0	0.001	206.0	0.002
Case 3	11.0	19,498.0	0.007	209.0	0.027
TOTAL	34.0		0.020		0.085

Skyline Landfill
Leachate Collection System Design

Required: Size the following elements of the leachate collection system:
1) Leachate Chimney
2) Leachate Collection Pipe
3) Leachate Sump

Assumptions:
1) The leachate chimney will extend the length of the collection trench.
2) Minimum leachate aggregate permeability shall be 0.01 cm/sec.
3) The leachate chimney should be sized to convey the peak flow rate to the sumps.
4) The collection pipe should be sized to convey the peak flow rate.
5) The leachate sump should be sized to store the average flow rate for 12 hours.

Solution:

1) Leachate Chimney

Use Darcy's Equation to determine the width of the leachate chimney.

CELL 13 FLOW RATE

$Q = KiA$

where:	Q = design flowrate =		0.161	cfs
	K = hydraulic conductivity of aggregate =		0.01	cm/sec
		=	3.28E-04	fps
	i = hydraulic gradient = Dh/l			
	for vertical flow $Dh = l$		1	ft/ft
	L = length of trench =		550	ft
	A = cross section area = L x W			
Substitute and solve for W =			0.9	ft
Width provided (Attachment D3.6) =			**5.0**	**ft**

2) Leachate Collection Pipe

Use Manning's Equation to size the leachate collection pipe.

CELL 13 FLOW RATE

$Q = (1.486/n)AR^{2/3}S^{1/2}$

where:	Q = design flowrate =		0.161	cfs
	n = Manning's number =		0.009	
	A = cross section area of pipe =		$\pi dia^2/4$	sf
	R = hydraulic radius of pipe =		dia/4	ft
	S = slope of pipe =		0.01	ft/ft
Substitute and solve for diameter =			0.27	ft
		=	3.3	in
Diameter provided (Attachment D3.6) =			**6.0**	**in**

Determine the inflow capacity of the perforated leachate collection pipe using the following equation:

$$Q = Ca(2g\Delta h)^2$$

where:

C = coefficient of discharge =	0.61	
g = acceleration of gravity =	32.2	ft/sec^2
Δh = maximum head on leachate pipe (ft) =	1.0	ft
p = perforations per linear foot of pipe =	5	/ft
d = diameter of perforations =	3/8	in
a = orifice area (p x π $(d/12)^2/4$) =	0.004	sf/ft
q = inflow capacity per linear foot of pipe =	0.019	cfs/ft
L = linear feet of collection pipe =	550	ft

Q = design flowrate =	0.16	cfs
Inflow capacity provided by perforated leachate pipe (Attachment D3.6) = q x L =	**10.3**	**cfs**

3) Leachate Collection Sump

Size a square 3-foot deep sump with 3:1 side slopes from the following equation.

$$V = 1/3(L_t^2 h_t) - 1/3(L_b^2 h_b)$$

where:

V = required sump volume (cf)
L_t = length of top side (ft)
L_b = length of bottom side (ft)
h_t = height of 3:1 pyramid with length L_t (ft)
h_b = height of 3:1 pyramid with length L_b (ft)

CELL 13 FLOW RATE

Q = average flowrate to the sump =	0.041	cfs
P = porosity of aggregate =	0.350	
$V = Q \times 12\ hr\ /\ P$ =	5,031	cf

Substitute and solve for L_t = 49.6 ft
Length provided (Attachment D3.5) = 58.0 ft

CELL 18 FLOW RATE

Q = average flowrate to the sump =	0.020	cfs
P = porosity of aggregate =	0.350	
$V = Q \times 12\ hr\ /\ P$ =	2,421	cf

Substitute and solve for L_t = 36.9 ft
Length provided (Attachment D3.5) = 38.0 ft

4) Summarize the results of the design calculations.

DESIGN SUMMARY		
LCS Component	**Cell 13**	**Cells 10-12, 14-18**
Leachate Chimney (ft)	5.0	5.0
Leachate Pipe (in)	6.0	6.0
Leachate Sump, L_t (ft)	58.0	38.0

Required: Determine the minimum properties for:
1) Geotextile around leachate trench aggregate.
2) Geotextile component of geocomposite.

References: 1) *Designing with Geosynthetics,* Fourth Edition; Robert M. Koerner.

Assumptions: 1) The protective cover will have at least 50% finer than the No. 200 sieve.
2) The leachate aggregate will be subangular, open graded stone.

Solution: 1) ***Leachate trench geotextile***

Calculate the allowable permittivity from the equation:

$$\Psi_{all} = q / \Delta hA$$

where: Ψ_{all} = *allowable* permittivity

q = peak inflow rate for leachate trench geotextile =	0.085	cfs
Δh = maximum allowable head =	1.0	ft
L = trench length =	1,830.0	ft
W = trench width =	5.0	ft
A = inflow area =	9150.0	sf

Substitute and solve for allowable permittivity = 9.3E-06 sec^{-1}

1a) Calculate the ultimate permittivity from Reference 1, Equation 2.25a.

$$\Psi_{all} = \Psi_{ult} \; (1 / RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	3.0	(Ref. 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5	(Ref. 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2	(Ref. 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.5	(Ref. 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	3.0	(Ref. 1, Table 2.12)

Substitute and solve for ultimate permittivity = 2.3E-04 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1, Figure 2.4.

The AOS must be less than 0.22 mm for fine-grained, non-dispersive soils.

Leachate trench geotextile:	**calculated minimum permittivity =**	**2.3E-04 sec^{-1}**
	required permittivity =	**0.10 sec^{-1}**
	maximum AOS =	**0.22 mm**

2) ***Geocomposite geotextile***

Calculate the allowable permittivity from the equation:

$$\Psi_{all} = q / \Delta hA$$

where: Ψ_{all} = *allowable* permittivity

q = peak inflow rate for critical condition =	0.085 cfs
Δh = maximum allowable head =	1.0 ft
A = area =	1,481,040 sf

Substitute and solve for allowable permittivity = 5.757E-08 sec^{-1}

Calculate the ultimate permittivity from Reference 1, Equation 2.25a.

$$\Psi_{all} = \Psi_{ult} (1 / RF_{SCB} \times RF_{CR} \times RF_{IN} \times RF_{CC} \times RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	3.0 (Ref. 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5 (Ref. 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2 (Ref. 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.5 (Ref. 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	3.0 (Ref. 1, Table 2.12)

Substitute and solve for ultimate permittivity = 1.4E-06 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1, Figure 2.4.

The AOS must be less than 0.22 mm for fine-grained, non-dispersive soils.

Geocomposite geotextile:	**minimum permittivity =**	**1.4E-06 sec^{-1}**
	required permittivity =	**0.10 sec^{-1}**
	maximum AOS =	**0.22 mm**

Skyline Landfill
Groundwater Infiltration

Required: Demonstrate the adequacy of the LCS to handle additional flow from groundwater infiltration.

References: 1) *Hydrologic Evaluation of Landfill Performance (HELP),* Engineering Documentation.

Solution: For good liner contact, soil leakage will occur from pinholes and installation defects.

Radius of leakage

<u>Pinholes</u> $R = 0.174h^{0.45}K^{-0.13}$ — Ref. 1, Equation 163

where: R = radius of wetted area around pinhole (in)
h = hydraulic head beneath liner = 80 ft
K = hydraulic conductivity of clay liner = 1.00E-07 cm/sec
0.0034 in/day

R = 8.01 in

<u>Defects</u> $R = 0.222h^{0.45}K^{-0.13}$ — Ref. 1, Equation 164

where: R = radius of wetted area around defect (in)
h = hydraulic head beneath liner = 80 ft
K = hydraulic conductivity of clay liner = 1E-07 cm/sec
0.0034 in/day

R = 10.22 in

Average hydraulic gradient

$i = 1 + [h / (2T ln (R / r))]$ — Ref. 1, Equation 152

where: i = average hydraulic gradient (in)
h = hydraulic head beneath liner = 80 ft
T = thickness of controlling layer = 24 in
R = radius of wetted area (in)
r = radius of flaw (in)

<u>Pinholes</u>

R = 8.01 in
r = 0.02 in
i = 4.34 in/in

<u>Defects</u>

R = 10.22 in
r = 0.22 in
i = 6.21 in/in

Leakage rate

$q = 0.877[(Kin p R^2) / 6,276,640]$ — Ref. 1, Equation 151

where: q = leakage rate (in/day)
i = average hydraulic gradient (in)
n = density of flaws (no./ac)
T = thickness of controlling layer = 24 in
R = radius of wetted area (in)
K = hydraulic conductivity of clay liner = 0.0034 in/day

Skyline Landfill
Groundwater Infiltration

Pinholes	n =	0.5 holes/ac
	i =	4.34 in/in
	R =	8.01 in
	q_p =	2.076E-07 in/day/ac
Defects	n =	1 holes/ac
	i =	6.21 in/in
	R =	10.22 in
	q_d =	9.678E-07 in/day/ac

Vapor diffusion

$q = K_m \, [(h + T) / T]$ — Ref. 1, Equation 141

where: q = leakage rate (in/day)

T = thickness of geomembrane =	0.06 in
h = hydraulic head beneath liner =	80 ft
K_m = hydraulic conductivity of geomembrane =	6.8E-09 in/day

q = 0.0001088 in/day/ac

Inflow rate $Q = q + q_p + q_d$ =

1.1E-04 in/day/ac
4.0E-01 cf/day/ac
4.6E-06 cfs/ac

Inflow will occur after the ballast is in place and the temporary dewatering system is turned off.

Cell 13 contributing area	145.4 ac
Cell 13 peak leachate rate =	0.1610 cfs
Groundwater inflow rate =	4.6E-06 cfs/ac
Total required inflow capacity =	**0.16 cfs**
Provided inflow capacity =	**10.30 cfs**

Since the leachate collection pipe for Cell 13 provides for an inflow capacity of 10.3 cfs, the pipe has sufficient capacity to handle the peak leachate rate and groundwater inflow after the temporary dewatering system is turned off.

Skyline Landfill
Leachate Collection Pipe Design

Required: Analyze the structural stability of the leachate collection and header pipes.

References:
1) *Qian, X, Koerner, R.M., and Gray, and Donald H. Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002.*
2) *Handbook of PE Pipe, Second Edition;* Plastics Pipe Institue (PPI).

Assumptions:
1) The leachate collection pipe size of 6-inch (HDPE material) will be evaluated in this calculation.
2) Heaviest construction load will be a CAT 836H compactor.
3) Maximum overburden load will occur after final closure.

Solution: ***Construction Load***

Critical construction load occurs from drum load of CAT 836H compactor driving over leachate collection trench.

$F = W/n$ and $p = F/\pi r^2$

where:

F = force per drum (lbs)		
W = equipment weight =	122,600	lbs
n = number of drums =	4	
p = contact pressure[1] =	46	psi
r = radius of contact (in)		

[1]Assumes 2 pads in contact with trench/cover

Substitute and solve for r = 14.6 inches

Determine the construction load from: $P_c = P_o + 1.5P_L$

where:
P_c = total construction load (psi)
P_o = overburden load (psi)
P_L = live load (psi)

Determine the overburden load from: $P_o = z\gamma$

where:

z = backfill depth =	24.0	in
γ = backfill unit weight =	125.0	pcf

Substitute and solve for P_o = 1.7 psi

Determine the live load from Boussinesq equation for uniform circular loads.

$$P_L = p(1 - (1 + (r/z)^2))^{-3/2}$$

Substitute and solve for P_L = 17.3 psi

Substitute and solve for P_c = 27.6 psi

Critical construction load =	**27.6 psi**

Skyline Landfill
Leachate Collection Pipe Design

Overburden Load

Critical overburden load occurs at the center of landfill after final cover has been constructed.

Layer	Thickness (ft)	γ (pcf)	Load (psf)
cover	4.5	105	472.5
solid waste	280	44	12,320.0
aggregate	2	125	250.0
Total	286.5	274	13,042.5
Average γ		46	

Load = 13,042.5 psf
Load = 90.6 psi

Critical overburden load =	**90.6 psi**

The overburden load shall be used for the design stress. Adjust the design stress to account for loss of strength due to perforations using the following equation.

$$P_D = 12P/(12 - l_p)$$

where: P_D = design stress
P = critical stress = 90.6 psi
l_p = cumulative length of perforations per foot of pipe
perforation diameter = 3/8 in
number of holes per foot = 5

Substitute and solve for l_p = 1.9 in/ft

Substitute and solve for P_D = 107.3 psi

Leachate pipe design stress =	**107.3 psi**
	15,458 psf

Structural Stability

Assume a standard dimension ratio of 17 for the analysis and predict the factor of safety for 1) compressive stress, 2) ring deflection, and 3) wall buckling using methods in Reference 2 for deep fill installations beyond 50 feet of fill.

The following equation is used to determine the pipe wall thickness.

$$SDR = D_o/t$$

where:

SDR = standard dimension ratio =	17	
D_o = pipe outside diameter =	0.548 ft	
t = pipe wall thickness =	0.39 in	

1) Estimate the factor of safety against wall crushing from the following equations.

a) $M_S = E_S(1 - \mu)/[(1 + \mu)(1 - 2\mu)/]$

where:

μ = Poisson's ratio of soil=	0.29	(Ref. 1)
E_S = secant modulus =	10,350 psi	(Ref. 1)
M_S = one-dimensional modulus =	13,563 psi	

b) $S_A = (1.43M_s r_{CENT})/(EA)$

where:

r_{CENT} = radius to centroidal axis of pipe =	3.288 in	
M_s = one-dimensional modulus of soil =	13,563 psi	
E = apparent modulus of elasticity of pipe =	44,500 psi	(Ref. 2)
A = wall thickness =	0.39 in	
S_A = hoop thrust stiffness ratio =	3.705	

c) $VAF = 0.88 - 0.71[(S_A - 1)/(S_A + 2.5)]$

where:

VAF = vertical arching factor =	0.57

d) $P_{RD} = (VAF)wH$

where:

w = unit weight of soil, pcf	
H = depth of cover, ft	
wH =	15,458 psf
P_{RD} = radial directed earth pressure =	8,819 psf

e) $S_C = P_{RD} D_o/288A$

where:

S_C = critical compressive stress =	520.5 psi

f) $FS = S_Y/S_C$

where:

S_Y = compressive yield strength of pipe =	780 psi	(Ref. 2)

Factor of safety against wall crushing =	**1.5**

2) Estimate the factor of safety against ring deflection from the following equations.

a) $\varepsilon_s = wH/E_S(100\%)$

where:

ε_s = soil strain = 1.0 %

b) $R_F = 12E_S(DR - 1)^3/E$

where:

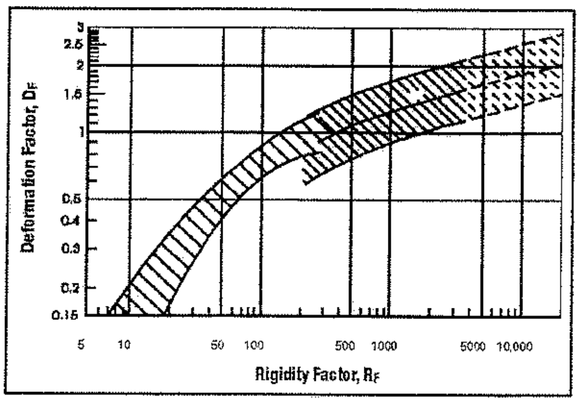
R_F = rigidity factor between pipe and soil = 11,432 psi

c) $RD_{actual} = \Delta X/D_M\ (100\%) = D_F\varepsilon_s$

where:

D_F = deflection factor (from graph below) = 2.0

Reference 2, Figure 3-6:



RD_{actual} = actual ring deflection = 2.1 %

d) $FS = RD_{allow}/RD_{actual}$

where:

RD_{allow} = allowable ring deflection = 7.5 % Ref. 2

Factor of safety against ring deflection =	**3.6**

3) Estimate the factor of safety against wall buckling from the following equations.

a) $P_{CR} = (2.4\varphi R_H/D_M)(EI)^{1/3}(E_S{*})^{2/3}$

where:

φ = calibration factor =	0.55	
R_H = geometry factor =	1.0	
E = apparent modulus of elasticity of pipe =	44,500 psi	(Ref. 2)
D_M = mean diameter = $D_o - t$	6.2 in	
I = pipe wall moment of inertia = $t^3/12$ =	0.005 in^4/in	
μ_S = Poisson's ratio of soil =	0.29	(Ref. 1)
E_S = secant modulus of soil =	10,350 psi	(Ref. 1)
$E_S{*} = E_S/(1 - \mu)$ =	14,577 psi	(Ref. 2)
P_{CR} = critical buckling pressure =	606.5 psi	

b) $FS = P_{CR}/P_E$

where:

P_E = overburden normal stress =	107.3 psi

Factor of safety against wall buckling =	**5.6**

Skyline Landfill
Leachate Riser Pipe Design

Required: Analyze the structural stability for the riser pipe.

References:
1) *Qian, X, Koerner, R.M., and Gray, and Donald H. Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002.*
2) *Handbook of PE Pipe, Second Edition;* Plastics Pipe Institue (PPI).

Assumptions:
1) The riser pipe will be 18-inch HDPE.
2) Heaviest construction load will be a CAT 836H compactor.
3) Maximum overburden load will occur after final closure.

Solution: ***Construction Load***

Critical construction load occurs from drum load of CAT 836H compactor driving over the riser pipe on the 5H:1V sidewall slope.

b = sidewall slope = 11.3 deg

The equipment forces acting on the 5H:1V sidewall are:

W_V = vertical equipment weight
W_N = normal equipment weight

$F = W/n$ and $p = F/\pi r^2$

where:
F = force per drum (lbs)
W_V = 122,600 lbs
$W_N = W_V \cos b$ = 120,223 lbs
n = number of drums = 4
p = contact pressure[1] = 45.1 psi
r = radius of contact (in)

[1]Assumes 2 pads in contact with trench/cover

Substitute and solve for r = 14.6 inches

Determine the construction load from: $P_c = P_o + 1.5P_L$

where:
P_c = total construction load (psi)
P_o = overburden load (psi)
P_L = live load (psi)

Determine the overburden load from: $P_o = z\gamma$

where:
z = backfill depth = 24.0 in
γ = backfill unit weight = 125.0 pcf

Substitute and solve for P_o = 1.7 psi

Determine the live load from Boussinesq equation for uniform circular loads.

$$P_L = p(1 - (1 + (r/z)^2))^{-3/2}$$

Substitute and solve for P_L = 16.9 psi

Substitute and solve for P_c = 27.1 psi

Critical construction load = 27.1 psi

Overburden Normal Load

Since the riser pipe is placed on the 5H:1V sidewall slope, the design load will be normal to the riser pipe (L_N) and is calculated based on the vertical overburden load (L_V).

Layer	Thickness (ft)	γ (pcf)	Load (psf)
cover	4.5	105	472.5
solid waste	140	44	6,160.0
clay	2	125	250.0
Total	146.5	274	6,882.5
Average γ		47	

b = sidewall slope = 11.3 deg

L_V = 6,882.5 psf

$L_N = L_V \cos\beta$ = 6,749.1 psf

L_V = 47.8 psi

L_N = 46.9 psi

Critical normal load = 46.9 psi

The normal load shall be used for the design stress.

Structural Stability

Assume a standard dimension ratio of 11 for the analysis and predict the factor of safety for 1) compressive stress, 2) ring deflection, and 3) wall buckling using methods in Reference 2 for deep fill installations beyond 50 feet of fill.

The following equation is used to determine the pipe wall thickness.

$$SDR = D_o/t$$

where:

SDR = standard dimension ratio =	11	
D_o = pipe outside diameter =	1.48 ft	
t = pipe wall thickness =	1.61 in	

1) Estimate the factor of safety against wall crushing from the following equations.

a) $M_S = E_S(1 - \mu)/[(1 + \mu)(1 - 2\mu)/]$

where:

μ = Poisson's ratio of soil=	0.37	(Ref. 1)
E_S = secant modulus =	1,100 psi	(Ref. 1)
M_S = one-dimensional modulus =	1,946 psi	

b) $S_A = (1.43 M_s r_{CENT})/(EA)$

where:

r_{CENT} = radius to centroidal axis of pipe =	8.88 in	
M_s = one-dimensional modulus of soil =	1,946 psi	
E = apparent modulus of elasticity of pipe =	44,500 psi	(Ref. 2)
A = wall thickness =	1.61 in	
S_A = hoop thrust stiffness ratio =	0.344	

c) $VAF = 0.88 - 0.71[(S_A - 1)/(S_A + 2.5)]$

where:

VAF = vertical arching factor =	1.04

d) $P_{RD} = (VAF)wH$

where:

w = unit weight of soil, pcf	
H = depth of cover, ft	
wH =	6,749 psf
P_{RD} = radial directed earth pressure =	7,045 psf

e) $S_C = P_{RD} D_o/288A$

where:

S_C = critical compressive stress =	269.1 psi

f) $FS = S_Y/S_C$

where:

S_Y = compressive yield strength of pipe =	780 psi	(Ref. 2)

Factor of safety against wall crushing =	**2.9**

2) Estimate the factor of safety against ring deflection from the following equations.

a) $\varepsilon_s = wH/E_S(100\%)$

where:

ε_s = soil strain = 4.3 %

b) $R_F = 12E_S(DR - 1)^3/E$

where:

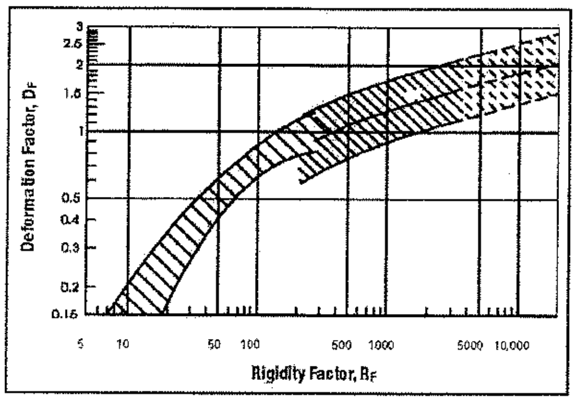
R_F = rigidity factor between pipe and soil = 297 psi

c) $RD_{actual} = \Delta X/D_M\ (100\%) = D_F\varepsilon_s$

where:

D_F = deflection factor (from graph below) = 1.0

Reference 2, Figure 3-6:



RD_{actual} = actual ring deflection = 4.3 %

d) $FS = RD_{allow}/RD_{actual}$

where:

RD_{allow} = allowable ring deflection = 7.5 % Ref. 2

Factor of safety against ring deflection =	**1.8**

3) Estimate the factor of safety against wall buckling from the following equations.

a) $P_{CR} = (2.4 \varphi R_H/D_M)(EI)^{1/3}(E_S{}^*)^{2/3}$

where:

φ = calibration factor =	0.55		
R_H = geometry factor =	1.0		
E = apparent modulus of elasticity of pipe =	44,500	psi	(Ref. 2)
D_M = mean diameter = $D_o - t$	16.1	in	
I = pipe wall moment of inertia = $t^3/12$ =	0.351	in^4/in	
μ_S = Poisson's ratio of soil =	0.37		(Ref. 1)
E_S = secant modulus of soil =	1,100	psi	(Ref. 1)
$E_S{}^* = E_S/(1 - \mu)$ =	1,746	psi	(Ref. 2)
P_{CR} = critical buckling pressure =	217.7	psi	

b) $FS = P_{CR}/P_E$

where:

P_E = overburden normal stress =	46.9	psi

Factor of safety against wall buckling = 4.6

SKYLINE LANDFILL

APPENDIX D6-B
LEACHATE GENERATION MODEL

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-12-12

Includes pages D6-B-1 through D6-B-84

LEACHATE GENERATION MODEL

HELP MODEL

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07, was used to predict the amount of runoff, evapotranspiration, drainage, leachate collection, and percolation through the liner. The HELP Model is a water balance model that uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, recirculation, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

The following stages of landfill development were modeled:

Case 1 (Sidewall LCS) – Daily cover with over 70 feet of exposed waste; 5 years
Case 2 (Floor LCS) – Active face with over 20 feet of waste; 3 years
Case 3 (Floor LCS) – Intermediate cover over 210 feet of waste; 10 years
Case 4 (Floor LCS) – Intermediate cover over 280 feet of waste; 10 years
Case 5 (Floor LCS) – Final cover over 280 feet of waste; 30 years

INPUT PARAMETERS

The HELP model input parameters for each case are summarized on page D6-B-4. The selection of each parameter is briefly described below.

Evapotranspiration Data

Default evapotranspiration data for Dallas, Texas were used in the model. The default evaporative zone depth and maximum leaf area index for bare ground was selected for Case 1. The default evaporative zone depth and maximum leaf area index for fair cover was selected for Cases 2, 3 and 4. An evaporative zone depth of 36 inches (erosion layer thickness) and maximum leaf area index for good cover was selected for Case 5.

Climate Data

The climate data used for the HELP model was synthetically generated using climate coefficients for Dallas, Texas. To improve the statistical characteristics of the daily values, the normal mean values for temperature and precipitation from the nearest National Oceanic Atmospheric Administration (NOAA) weather station (NOAA Cooperative Station ID #413133) located in Ferris, Texas, were entered.

Protective Cover

The protective cover consists of a 24-inch-thick layer of on-site soils. Geotechnical information provided in Attachment D5 – Geotechnical Design indicates that CH soils will be available for use as protective cover; therefore, default values for soil texture 28 were used to model the protective cover.

Leachate Collection Layer

The leachate collection layer will consist of a drainage geocomposite. User-defined values (designated soil texture 63) were used to model the leachate collection layer. The thickness and hydraulic conductivity values are calculated in Attachment D6, Appendix D6-A – Leachate Collection System Design Calculations. The wilting point, field capacity, and porosity were assumed to be the same as those for soil texture 20. The critical slope and drainage distance for the leachate collection system were determined from Attachment D3 – Construction Design Details, Drawing D3.4 – Leachate Collection System Plan.

Flexible Membrane Liner

The flexible membrane liner consists of a 60-mil HDPE geomembrane. Default values for soil texture 35 were used to model the flexible membrane liner. The liner will be installed and tested in accordance with the requirements of Attachment D7 – Liner Quality Control Plan (LQCP); therefore, the liner was modeled for good installation quality, one defect per acre, and a pinhole density of one-half hole per acre.

Compacted Soil Liner

The compacted soil layer consists of a 24-inch-thick layer of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec or less. Default values for soil texture 16 were used to model the compacted soil layer.

HELP MODEL OUTPUT

Output files for the HELP model are provided on pages D6-B-5 through D6-B-84. The output for each case is summarized on page D6-B-4.

Skyline Landfill
HELP SUMMARY

Case No.	*1*	*2*	*3*	*4*	*5*
Cover	Daily Cover	None - Active Face	Intermediate Cover	Intermediate Cover	Final Cover
Top	Sideslope	Sideslope	Sideslope	Topslope	Sideslope
Bottom	Sidewall	Floor	Floor	Floor	Floor
Waste Thickness	70' waste	20' waste	210' waste	280' waste	280' waste
Years	5	3	10	10	30
Ground Cover	FAIR	BARE	FAIR	FAIR	GOOD
Runoff Curve No.	88.1	81.5	88.1	87.4	80.4
Model Area (acre)	1	1	1	1	1
Runoff Area (%)	50	0	70	70	100
Maximum Leaf Area Index	0	0	3	3	3
Evaporative Zone Depth (in)	22	22	22	22	36
Erosion Layer (Upper 6")					
Layer No.					1
Type					vertical percolation
Texture No.					10
Thickness (in)					6
Erosion Layer (Lower 30")					
Layer No.					2
Type					vertical percolation
Texture No.					15
Thickness (in)					30
Drainage Layer					
Layer No.					3
Type					lateral drainage
Texture No.					20
Thickness (in)					0.20
Slope (%)					25
Flow Distance (ft)					980
Hydraulic Conductivity (cm/sec)					10.0
Infiltration Layer					
Layer No.					4
Type					barrier soil
Texture No.					16
Thickness (in)					18
Interim/Daily Cover					
Layer No.	1		1	1	5
Type	vertical percolation		vertical percolation	vertical percolation	vertical percolation
Texture No.	12		12	12	12
Thickness (in)	6		12	12	12
Solid Waste					
Layer No.	2	1	2	2	6
Type	vertical percolation	vertical percolation	vertical percolation	vertical percolation	vertical percolation
Texture No.	18	18	18	18	18
Thickness (in)	816	216	2,496	3,336	3,336
Solid Waste					
Layer No.	3	2	3	3	7
Type	lateral drainage	lateral drainage	lateral drainage	lateral drainage	lateral drainage
Texture No.	18	18	18	18	18
Thickness (in)	24	24	24	24	24
Slope (%)	20	2.2	2.2	2.2	2.2
Flow Distance (ft)	350	220	220	220	220
Protective Cover					
Layer No.	4	3	4	4	8
Type	barrier soil	barrier soil	barrier soil	barrier soil	barrier soil
Texture No.	28	28	28	28	28
Thickness (in)	24	24	24	24	24
LCS					
Layer No.	5	4	5	5	9
Type	lateral drainage	lateral drainage	lateral drainage	lateral drainage	lateral drainage
Texture No.	63	63	63	63	63
Thickness (in)	0.18	0.19	0.15	0.14	0.13
Slope (%)	20	2.2	2.2	2.2	2.2
Flow Distance (ft)	350	220	220	220	220
Hydraulic Conductivity (cm/sec)	0.23	8.09	2.04	1.37	0.73
Geomembrane					
Layer No.	6	5	6	6	10
Type	geomembrane	geomembrane	geomembrane	geomembrane	geomembrane
Texture No.	35	35	35	35	35
Thickness (in)	0.06	0.06	0.06	0.06	0.06
Installation Quality	Good - 3	Good - 3	Good - 3	Good - 3	Good - 3
Defects per acre	1	1	1	1	1
Pinholes per acre	0.5	0.5	0.5	0.5	0.5
Clay Liner					
Layer No.	7	6	7	7	11
Type	barrier soil	barrier soil	barrier soil	barrier soil	barrier soil
Texture No.	16	16	16	16	16
Thickness (in)	24	24	24	24	24
Average Lateral Drainage (cf/yr)	17,119	27,567	19,498	20,100	20.0
Peak Lateral Drainage (cf/day)	221	206	209	209	6
Max Head within lateral drainage (in)	0.13	0.02	0.09	0.14	0.00

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      F:\HELP\10101120\PRECIP.D4
TEMPERATURE DATA FILE:        F:\HELP\10101120\TEMP.D7
SOLAR RADIATION DATA FILE:    F:\HELP\10101120\RAD.D13
EVAPOTRANSPIRATION DATA:      F:\HELP\10101120\EVAP.D11
SOIL AND DESIGN DATA FILE:    F:\HELP\10101120\DESIGN1.D10
OUTPUT DATA FILE:             F:\HELP\10101120\OUT1.OUT


TIME:   9:21     DATE:  10/26/2011


******************************************************************************

     TITLE:  CASE 1 - DAILY COVER W/70' WASTE

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
           THICKNESS                     =       6.00   INCHES
           POROSITY                      =       0.4710 VOL/VOL
           FIELD CAPACITY                =       0.3420 VOL/VOL
           WILTING POINT                 =       0.2100 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.2532 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.419999997000E-04 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
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                    MATERIAL TEXTURE NUMBER  18
THICKNESS                         =     816.00   INCHES
POROSITY                          =       0.6710 VOL/VOL
FIELD CAPACITY                    =       0.2920 VOL/VOL
WILTING POINT                     =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT        =       0.2942 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER  18
THICKNESS                         =      24.00   INCHES
POROSITY                          =       0.6710 VOL/VOL
FIELD CAPACITY                    =       0.2920 VOL/VOL
WILTING POINT                     =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT        =       0.2924 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.100000005000E-02 CM/SEC
SLOPE                             =      20.00   PERCENT
DRAINAGE LENGTH                   =     350.0    FEET


                          LAYER  4
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  28
THICKNESS                         =      24.00   INCHES
POROSITY                          =       0.4520 VOL/VOL
FIELD CAPACITY                    =       0.4110 VOL/VOL
WILTING POINT                     =       0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT        =       0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.120000004000E-05 CM/SEC


                          LAYER  5
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                         =       0.18   INCHES
POROSITY                          =       0.8500 VOL/VOL
FIELD CAPACITY                    =       0.1000 VOL/VOL
WILTING POINT                     =       0.0500 VOL/VOL
INITIAL SOIL WATER CONTENT        =       0.2749 VOL/VOL
EFFECTIVE SAT. HYD. COND.         =  0.230000004000      CM/SEC
SLOPE                             =      20.00   PERCENT
DRAINAGE LENGTH                   =     350.0    FEET


                          LAYER  6
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TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 620. FEET.

SCS RUNOFF CURVE NUMBER	=	88.10	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.715	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.562	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.492	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	269.770	INCHES
TOTAL INITIAL WATER	=	269.770	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM DALLAS TEXAS

STATION LATITUDE	=	32.85	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	

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END OF GROWING SEASON (JULIAN DATE)        =    329
EVAPORATIVE ZONE DEPTH                     =  22.0  INCHES
AVERAGE ANNUAL WIND SPEED                  =  10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  66.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.88	2.96	3.83	3.19	4.56	3.95
1.88	2.41	2.39	4.45	2.95	3.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	50.30	57.00	64.70	73.00	80.10
84.30	84.40	77.50	67.10	56.60	46.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS AND STATION LATITUDE = 32.85 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.83	86502.922	100.00
RUNOFF	0.561	2035.091	2.35
EVAPOTRANSPIRATION	20.037	72732.641	84.08
DRAINAGE COLLECTED FROM LAYER 3	0.1871	679.349	0.79
PERC./LEAKAGE THROUGH LAYER 4	3.037410	11025.797	12.75
AVG. HEAD ON TOP OF LAYER 4	0.1700		
DRAINAGE COLLECTED FROM LAYER 5	3.0382	11028.729	12.75
PERC./LEAKAGE THROUGH LAYER 7	0.000007	0.025	0.00

AVG. HEAD ON TOP OF LAYER 6	0.0118		
CHANGE IN WATER STORAGE	0.007	27.030	0.03
SOIL WATER AT START OF YEAR	269.770	979265.750	
SOIL WATER AT END OF YEAR	269.778	979292.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.060	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.10	149193.016	100.00
RUNOFF	3.098	11245.549	7.54
EVAPOTRANSPIRATION	32.213	116933.281	78.38
DRAINAGE COLLECTED FROM LAYER 3	0.5347	1940.955	1.30
PERC./LEAKAGE THROUGH LAYER 4	6.707759	24349.166	16.32
AVG. HEAD ON TOP OF LAYER 4	0.4720		
DRAINAGE COLLECTED FROM LAYER 5	6.7257	24414.305	16.36
PERC./LEAKAGE THROUGH LAYER 7	0.000012	0.042	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0259		
CHANGE IN WATER STORAGE	-1.471	-5340.979	-3.58
SOIL WATER AT START OF YEAR	269.778	979292.750	
SOIL WATER AT END OF YEAR	268.306	973951.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.141	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.71	111477.312	100.00
RUNOFF	2.611	9477.021	8.50
EVAPOTRANSPIRATION	23.269	84464.750	75.77
DRAINAGE COLLECTED FROM LAYER 3	0.4538	1647.380	1.48
PERC./LEAKAGE THROUGH LAYER 4	5.976765	21695.656	19.46
AVG. HEAD ON TOP OF LAYER 4	0.3964		
DRAINAGE COLLECTED FROM LAYER 5	5.9894	21741.664	19.50
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.039	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0227		
CHANGE IN WATER STORAGE	-1.613	-5853.663	-5.25
SOIL WATER AT START OF YEAR	268.306	973951.750	
SOIL WATER AT END OF YEAR	266.694	968098.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.121	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141207.000	100.00
RUNOFF	3.892	14129.234	10.01
EVAPOTRANSPIRATION	29.801	108177.508	76.61
DRAINAGE COLLECTED FROM LAYER 3	0.0989	359.027	0.25
PERC./LEAKAGE THROUGH LAYER 4	4.615590	16754.592	11.87
AVG. HEAD ON TOP OF LAYER 4	0.0862		
DRAINAGE COLLECTED FROM LAYER 5	4.6156	16754.652	11.87
PERC./LEAKAGE THROUGH LAYER 7	0.000009	0.032	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0177		
CHANGE IN WATER STORAGE	0.492	1786.530	1.27

SOIL WATER AT START OF YEAR	266.694	968098.125	
SOIL WATER AT END OF YEAR	267.186	969884.625	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.51	121641.297	100.00
RUNOFF	1.427	5180.506	4.26
EVAPOTRANSPIRATION	30.149	109441.859	89.97
DRAINAGE COLLECTED FROM LAYER 3	0.0689	250.072	0.21
PERC./LEAKAGE THROUGH LAYER 4	1.867429	6778.766	5.57
AVG. HEAD ON TOP OF LAYER 4	0.0615		
DRAINAGE COLLECTED FROM LAYER 5	1.8674	6778.579	5.57
PERC./LEAKAGE THROUGH LAYER 7	0.000005	0.017	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0072		
CHANGE IN WATER STORAGE	-0.003	-9.638	-0.01
SOIL WATER AT START OF YEAR	267.186	969884.625	
SOIL WATER AT END OF YEAR	267.183	969875.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.103	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.08	2.59	4.66	3.25	3.52	3.48
	1.09	3.82	2.17	2.22	1.85	2.88
STD. DEVIATIONS	1.55	1.54	3.70	2.91	1.50	1.90
	0.78	1.81	0.92	2.17	0.82	1.71
RUNOFF						
TOTALS	0.135	0.020	0.487	0.355	0.235	0.398
	0.013	0.188	0.088	0.124	0.067	0.208
STD. DEVIATIONS	0.286	0.023	0.636	0.743	0.270	0.513
	0.029	0.258	0.110	0.201	0.067	0.228
EVAPOTRANSPIRATION						
TOTALS	1.836	1.938	3.045	2.250	3.210	2.833
	1.661	2.855	2.283	2.003	1.738	1.441
STD. DEVIATIONS	0.259	1.129	0.871	1.167	1.196	1.179
	1.315	1.020	0.740	0.865	0.529	0.550
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0410	0.0355	0.0161	0.0466	0.0995	0.0045
	0.0086	0.0027	0.0004	0.0009	0.0129	0.0001
STD. DEVIATIONS	0.0528	0.0471	0.0289	0.0655	0.1309	0.0062
	0.0191	0.0058	0.0007	0.0019	0.0287	0.0001
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.7572	0.5799	0.4945	0.6722	0.7070	0.2456
	0.2118	0.1228	0.1340	0.1762	0.2434	0.0962
STD. DEVIATIONS	0.5746	0.4330	0.5276	0.5936	0.6906	0.2565
	0.4307	0.1742	0.1331	0.2035	0.3960	0.0492
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.7450	0.5974	0.4765	0.6717	0.7135	0.2600
	0.2101	0.1293	0.1346	0.1680	0.2517	0.0894
STD. DEVIATIONS	0.5683	0.4437	0.5270	0.5881	0.6921	0.2643
	0.4170	0.1953	0.1352	0.1846	0.4140	0.0411
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.4243	0.4075	0.1671	0.4984	1.0308	0.0488
	0.0889	0.0277	0.0042	0.0096	0.1383	0.0011
STD. DEVIATIONS	0.5469	0.5404	0.2994	0.7003	1.3559	0.0665
	0.1983	0.0604	0.0074	0.0192	0.3075	0.0007

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0335	0.0295	0.0215	0.0313	0.0321	0.0121
	0.0095	0.0058	0.0063	0.0076	0.0117	0.0040
STD. DEVIATIONS	0.0256	0.0221	0.0237	0.0274	0.0312	0.0123
	0.0188	0.0088	0.0063	0.0083	0.0193	0.0018

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.61	(6.858)	122004.3	100.00
RUNOFF	2.318	(1.3280)	8413.48	6.896
EVAPOTRANSPIRATION	27.094	(5.1795)	98350.00	80.612
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.26869	(0.21239)	975.357	0.79944
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.44099	(2.00752)	16120.795	13.21330
AVERAGE HEAD ON TOP OF LAYER 4	0.237	(0.186)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	4.44727	(2.01489)	16143.585	13.23198
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001	(0.00000)	0.031	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.017	(0.008)		
CHANGE IN WATER STORAGE	-0.517	(0.9577)	-1878.14	-1.539

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	12124.199
RUNOFF	1.281	4649.0903
DRAINAGE COLLECTED FROM LAYER 3	0.01305	47.37239
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.047944	174.03555
AVERAGE HEAD ON TOP OF LAYER 4	4.190	
MAXIMUM HEAD ON TOP OF LAYER 4	8.076	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.04780	173.51024
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00026
AVERAGE HEAD ON TOP OF LAYER 6	0.067	
MAXIMUM HEAD ON TOP OF LAYER 6	0.132	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.58	2106.5435

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3887
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1852

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.9871	0.3312
2	237.0740	0.2905
3	7.0080	0.2920
4	10.8480	0.4520

5	0.0181	0.1003
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**              USAE WATERWAYS EXPERIMENT STATION                           **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      F:\HELP\10101120\PRECIP.D4
TEMPERATURE DATA FILE:        F:\HELP\10101120\TEMP.D7
SOLAR RADIATION DATA FILE:    F:\HELP\10101120\RAD.D13
EVAPOTRANSPIRATION DATA:      F:\HELP\10101120\EVAP.D11
SOIL AND DESIGN DATA FILE:    F:\HELP\10101120\DESIGN2.D10
OUTPUT DATA FILE:             F:\HELP\10101120\OUT2.OUT


TIME:  13:44      DATE:   1/27/2012


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     TITLE:  CASE 2 - ACTIVE FACE W/20' WASTE

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
            COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  18
       THICKNESS                  =    216.00   INCHES
       POROSITY                   =      0.6710 VOL/VOL
       FIELD CAPACITY             =      0.2920 VOL/VOL
       WILTING POINT              =      0.0770 VOL/VOL
       INITIAL SOIL WATER CONTENT =      0.2977 VOL/VOL
       EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC


                              LAYER  2
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
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MATERIAL TEXTURE NUMBER 18

THICKNESS	=	24.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2934	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4520	VOL/VOL
FIELD CAPACITY	=	0.4110	VOL/VOL
WILTING POINT	=	0.3110	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4520	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.120000004000E-05	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.19	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0500	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1350	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	8.09000015000	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #18 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 20.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	81.50	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.385	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	14.762	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.694	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	92.458	INCHES
TOTAL INITIAL WATER	=	92.458	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM DALLAS TEXAS

STATION LATITUDE	=	32.85	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.88	2.96	3.83	3.19	4.56	3.95
1.88	2.41	2.39	4.45	2.95	3.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	50.30	57.00	64.70	73.00	80.10
84.30	84.40	77.50	67.10	56.60	46.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.83	86502.922	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	20.423	74134.844	85.70
DRAINAGE COLLECTED FROM LAYER 2	0.0485	175.939	0.20
PERC./LEAKAGE THROUGH LAYER 3	3.368881	12229.040	14.14
AVG. HEAD ON TOP OF LAYER 3	0.2415		
DRAINAGE COLLECTED FROM LAYER 4	3.3690	12229.436	14.14
PERC./LEAKAGE THROUGH LAYER 6	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0021		
CHANGE IN WATER STORAGE	-0.010	-37.332	-0.04
SOIL WATER AT START OF YEAR	92.458	335623.594	
SOIL WATER AT END OF YEAR	92.448	335586.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.031	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.10	149193.016	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	32.110	116560.117	78.13
DRAINAGE COLLECTED FROM LAYER 2	0.2408	874.235	0.59
PERC./LEAKAGE THROUGH LAYER 3	10.051420	36486.656	24.46
AVG. HEAD ON TOP OF LAYER 3	1.1702		
DRAINAGE COLLECTED FROM LAYER 4	10.0562	36504.078	24.47
PERC./LEAKAGE THROUGH LAYER 6	0.000004	0.016	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0061		
CHANGE IN WATER STORAGE	-1.307	-4745.432	-3.18
SOIL WATER AT START OF YEAR	92.448	335586.250	
SOIL WATER AT END OF YEAR	91.141	330840.844	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.71	111477.312	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	23.409	84972.930	76.22
DRAINAGE COLLECTED FROM LAYER 2	0.2339	848.887	0.76
PERC./LEAKAGE THROUGH LAYER 3	8.832255	32061.088	28.76
AVG. HEAD ON TOP OF LAYER 3	1.1234		

DRAINAGE COLLECTED FROM LAYER 4	8.8340	32067.400	28.77
PERC./LEAKAGE THROUGH LAYER 6	0.000004	0.015	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0053		
CHANGE IN WATER STORAGE	-1.766	-6411.933	-5.75
SOIL WATER AT START OF YEAR	91.141	330840.844	
SOIL WATER AT END OF YEAR	89.374	324428.906	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.08	2.07	6.17	1.72	2.48	3.58
	1.07	5.00	1.93	1.76	1.87	3.15
STD. DEVIATIONS	0.30	1.47	4.32	1.32	0.66	2.34
	1.03	1.13	0.48	1.14	1.01	2.20
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.816	1.164	3.166	1.517	2.554	2.137
	2.210	3.669	2.147	1.759	1.865	1.311
STD. DEVIATIONS	0.352	0.526	1.205	0.908	1.004	0.722
	1.479	0.245	0.681	1.133	0.618	0.710
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0184	0.0168	0.0017	0.0308	0.0636	0.0233
	0.0047	0.0118	0.0029	0.0003	0.0001	0.0000
STD. DEVIATIONS	0.0123	0.0148	0.0029	0.0288	0.0551	0.0209
	0.0067	0.0205	0.0048	0.0005	0.0001	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	1.2964	0.8212	0.4627	0.9478	1.0449	0.8869
	0.4803	0.4969	0.4643	0.1920	0.1747	0.1492
STD. DEVIATIONS	0.0788	0.6475	0.3233	0.7192	0.8777	0.7668
	0.5118	0.7580	0.4941	0.1192	0.1967	0.0461

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	1.2941	0.8262	0.4620	0.9454	1.0452	0.8876
	0.4824	0.4971	0.4641	0.1940	0.1750	0.1467
STD. DEVIATIONS	0.0811	0.6459	0.3235	0.7170	0.8779	0.7674
	0.5110	0.7584	0.4883	0.1226	0.1965	0.0450

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	1.0470	1.0560	0.0989	1.8094	3.6197	1.3717
	0.2675	0.6736	0.1733	0.0177	0.0037	0.0018
STD. DEVIATIONS	0.7005	0.9321	0.1647	1.6963	3.1348	1.2296
	0.3796	1.1646	0.2841	0.0284	0.0052	0.0008

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0091	0.0065	0.0033	0.0069	0.0074	0.0065
	0.0034	0.0035	0.0034	0.0014	0.0013	0.0010
STD. DEVIATIONS	0.0006	0.0050	0.0023	0.0052	0.0062	0.0056
	0.0036	0.0053	0.0035	0.0009	0.0015	0.0003

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES		CU. FEET	PERCENT
PRECIPITATION	31.88	(8.694)	115724.4	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	25.314	(6.0722)	91889.30	79.404

LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.17439 (	0.10910)	633.020	0.54701
PERCOLATION/LEAKAGE THROUGH LAYER 3	7.41752 (	3.55882)	26925.592	23.26699
AVERAGE HEAD ON TOP OF LAYER 3	0.845 (	0.523)		
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.41973 (	3.56088)	26933.639	23.27394
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (	0.00000)	0.012	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.004 (	0.002)		
CHANGE IN WATER STORAGE	-1.028 (	0.9108)	-3731.57	-3.225

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	2.51	9111.300
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.00398	14.44960
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.052766	191.54001
AVERAGE HEAD ON TOP OF LAYER 3	7.025	
MAXIMUM HEAD ON TOP OF LAYER 3	10.394	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	57.2 FEET	
DRAINAGE COLLECTED FROM LAYER 4	0.05274	191.45377
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 5	0.012	
MAXIMUM HEAD ON TOP OF LAYER 5	0.023	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	2.8 FEET	
SNOW WATER	0.58	2106.5435

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3997
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1502

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	61.2514	0.2836
2	7.0080	0.2920
3	10.8480	0.4520
4	0.0190	0.1000
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     F:\HELP\10101120\PRECIP.D4
TEMPERATURE DATA FILE:       F:\HELP\10101120\TEMP.D7
SOLAR RADIATION DATA FILE:   F:\HELP\10101120\RAD.D13
EVAPOTRANSPIRATION DATA:     F:\HELP\10101120\EVAP2.D11
SOIL AND DESIGN DATA FILE:   F:\HELP\10101120\DESIGN3.D10
OUTPUT DATA FILE:            F:\HELP\10101120\OUT3.OUT


TIME:   9:27       DATE:  10/26/2011


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     TITLE:  CASE 3 - INTERMEDIATE COVER W/210' WASTE

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  12
          THICKNESS                   =     12.00   INCHES
          POROSITY                    =      0.4710 VOL/VOL
          FIELD CAPACITY              =      0.3420 VOL/VOL
          WILTING POINT               =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.2961 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	2496.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2923	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	24.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2924	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4520	VOL/VOL
FIELD CAPACITY	=	0.4110	VOL/VOL
WILTING POINT	=	0.3110	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4520	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.120000004000E-05	CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.15	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0500	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2176	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	2.03999996000	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 600. FEET.

SCS RUNOFF CURVE NUMBER	=	88.10	
FRACTION OF AREA ALLOWING RUNOFF	=	70.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.175	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.362	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.290	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	761.404	INCHES
TOTAL INITIAL WATER	=	761.404	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE = 32.85 DEGREES

MAXIMUM LEAF AREA INDEX	=	3.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.88	2.96	3.83	3.19	4.56	3.95
1.88	2.41	2.39	4.45	2.95	3.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	50.30	57.00	64.70	73.00	80.10
84.30	84.40	77.50	67.10	56.60	46.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS AND STATION LATITUDE = 32.85 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.83	86502.922	100.00
RUNOFF	0.563	2042.366	2.36
EVAPOTRANSPIRATION	21.930	79604.953	92.03
DRAINAGE COLLECTED FROM LAYER 3	0.0084	30.441	0.04
PERC./LEAKAGE THROUGH LAYER 4	1.456328	5286.471	6.11
AVG. HEAD ON TOP OF LAYER 4	0.0398		
DRAINAGE COLLECTED FROM LAYER 5	1.4475	5254.291	6.07

PERC./LEAKAGE THROUGH LAYER 7	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0034		
CHANGE IN WATER STORAGE	-0.118	-429.157	-0.50
SOIL WATER AT START OF YEAR	761.404	2763897.250	
SOIL WATER AT END OF YEAR	761.286	2763468.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.10	149193.016	100.00
RUNOFF	2.859	10379.756	6.96
EVAPOTRANSPIRATION	31.933	115918.570	77.70
DRAINAGE COLLECTED FROM LAYER 3	0.1007	365.574	0.25
PERC./LEAKAGE THROUGH LAYER 4	5.677788	20610.369	13.81
AVG. HEAD ON TOP OF LAYER 4	0.4825		
DRAINAGE COLLECTED FROM LAYER 5	5.6971	20680.441	13.86
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.024	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0134		
CHANGE IN WATER STORAGE	0.509	1849.120	1.24
SOIL WATER AT START OF YEAR	761.286	2763468.000	
SOIL WATER AT END OF YEAR	761.795	2765317.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.477	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.71	111477.312	100.00
RUNOFF	2.258	8195.598	7.35
EVAPOTRANSPIRATION	26.519	96262.492	86.35
DRAINAGE COLLECTED FROM LAYER 3	0.1020	370.126	0.33
PERC./LEAKAGE THROUGH LAYER 4	5.684355	20634.207	18.51
AVG. HEAD ON TOP OF LAYER 4	0.4948		
DRAINAGE COLLECTED FROM LAYER 5	5.6916	20660.328	18.53
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.023	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0136		
CHANGE IN WATER STORAGE	-3.860	-14011.304	-12.57
SOIL WATER AT START OF YEAR	761.795	2765317.000	
SOIL WATER AT END OF YEAR	757.935	2751305.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.047	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141207.000	100.00
RUNOFF	3.048	11063.789	7.84
EVAPOTRANSPIRATION	28.429	103197.852	73.08
DRAINAGE COLLECTED FROM LAYER 3	0.0955	346.761	0.25
PERC./LEAKAGE THROUGH LAYER 4	4.978187	18070.818	12.80
AVG. HEAD ON TOP OF LAYER 4	0.4609		
DRAINAGE COLLECTED FROM LAYER 5	4.9782	18070.787	12.80
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.020	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0118		

CHANGE IN WATER STORAGE	2.349	8527.753	6.04
SOIL WATER AT START OF YEAR	757.935	2751305.750	
SOIL WATER AT END OF YEAR	760.285	2759833.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.046	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.51	121641.297	100.00
RUNOFF	1.248	4531.736	3.73
EVAPOTRANSPIRATION	31.597	114697.070	94.29
DRAINAGE COLLECTED FROM LAYER 3	0.0035	12.528	0.01
PERC./LEAKAGE THROUGH LAYER 4	1.702909	6181.559	5.08
AVG. HEAD ON TOP OF LAYER 4	0.0168		
DRAINAGE COLLECTED FROM LAYER 5	1.7029	6181.554	5.08
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0041		
CHANGE IN WATER STORAGE	-1.042	-3781.767	-3.11
SOIL WATER AT START OF YEAR	760.285	2759833.500	
SOIL WATER AT END OF YEAR	759.243	2756051.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.164	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.77	173405.109	100.00
RUNOFF	6.048	21954.062	12.66
EVAPOTRANSPIRATION	30.168	109508.734	63.15
DRAINAGE COLLECTED FROM LAYER 3	0.1395	506.224	0.29
PERC./LEAKAGE THROUGH LAYER 4	7.178175	26056.775	15.03
AVG. HEAD ON TOP OF LAYER 4	0.6704		
DRAINAGE COLLECTED FROM LAYER 5	7.1460	25940.115	14.96
PERC./LEAKAGE THROUGH LAYER 7	0.000008	0.029	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0169		
CHANGE IN WATER STORAGE	4.269	15495.740	8.94
SOIL WATER AT START OF YEAR	759.243	2756051.750	
SOIL WATER AT END OF YEAR	763.512	2771547.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.209	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.42	164874.562	100.00
RUNOFF	3.388	12299.328	7.46
EVAPOTRANSPIRATION	31.563	114574.680	69.49
DRAINAGE COLLECTED FROM LAYER 3	0.2666	967.759	0.59
PERC./LEAKAGE THROUGH LAYER 4	7.907650	28704.768	17.41
AVG. HEAD ON TOP OF LAYER 4	1.3112		
DRAINAGE COLLECTED FROM LAYER 5	7.9133	28725.430	17.42
PERC./LEAKAGE THROUGH LAYER 7	0.000009	0.031	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0189		
CHANGE IN WATER STORAGE	2.289	8307.524	5.04

SOIL WATER AT START OF YEAR	763.512	2771547.500	
SOIL WATER AT END OF YEAR	765.800	2779855.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.186	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.41	106758.297	100.00
RUNOFF	2.340	8493.820	7.96
EVAPOTRANSPIRATION	28.273	102631.211	96.13
DRAINAGE COLLECTED FROM LAYER 3	0.2602	944.703	0.88
PERC./LEAKAGE THROUGH LAYER 4	5.709979	20727.225	19.42
AVG. HEAD ON TOP OF LAYER 4	1.2713		
DRAINAGE COLLECTED FROM LAYER 5	5.7364	20823.139	19.50
PERC./LEAKAGE THROUGH LAYER 7	0.000006	0.022	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0137		
CHANGE IN WATER STORAGE	-7.200	-26134.494	-24.48
SOIL WATER AT START OF YEAR	765.800	2779855.000	
SOIL WATER AT END OF YEAR	758.601	2753720.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.099	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.54	179830.219	100.00

RUNOFF	4.671	16954.441	9.43
EVAPOTRANSPIRATION	32.935	119555.180	66.48
DRAINAGE COLLECTED FROM LAYER 3	0.0370	134.356	0.07
PERC./LEAKAGE THROUGH LAYER 4	4.308433	15639.612	8.70
AVG. HEAD ON TOP OF LAYER 4	0.1790		
DRAINAGE COLLECTED FROM LAYER 5	4.2811	15540.541	8.64
PERC./LEAKAGE THROUGH LAYER 7	0.000005	0.019	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0101		
CHANGE IN WATER STORAGE	7.616	27645.516	15.37
SOIL WATER AT START OF YEAR	758.601	2753720.500	
SOIL WATER AT END OF YEAR	766.217	2781366.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.168	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.47	157796.109	100.00
RUNOFF	3.659	13282.372	8.42
EVAPOTRANSPIRATION	30.950	112349.148	71.20
DRAINAGE COLLECTED FROM LAYER 3	0.2223	806.920	0.51
PERC./LEAKAGE THROUGH LAYER 4	7.883866	28618.434	18.14
AVG. HEAD ON TOP OF LAYER 4	1.0962		
DRAINAGE COLLECTED FROM LAYER 5	7.8844	28620.297	18.14
PERC./LEAKAGE THROUGH LAYER 7	0.000009	0.031	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0188		
CHANGE IN WATER STORAGE	0.754	2737.123	1.73
SOIL WATER AT START OF YEAR	766.217	2781366.000	
SOIL WATER AT END OF YEAR	766.971	2784103.250	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.215	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.94	3.12	3.94	3.28	4.00	3.58
	1.99	3.22	2.46	4.24	2.94	3.65
STD. DEVIATIONS	1.26	1.46	2.82	2.44	2.23	2.00
	1.75	1.91	1.24	3.79	2.57	2.63
RUNOFF						
TOTALS	0.062	0.117	0.360	0.239	0.294	0.298
	0.211	0.170	0.095	0.607	0.300	0.254
STD. DEVIATIONS	0.177	0.127	0.481	0.405	0.467	0.311
	0.434	0.174	0.130	1.045	0.524	0.281
EVAPOTRANSPIRATION						
TOTALS	1.816	1.997	3.009	3.261	4.429	3.415
	2.325	2.670	2.328	1.690	1.136	1.354
STD. DEVIATIONS	0.386	0.575	0.739	0.881	1.527	1.718
	1.957	1.763	1.324	0.543	0.365	0.451
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0183	0.0270	0.0246	0.0172	0.0163	0.0025
	0.0000	0.0000	0.0000	0.0004	0.0062	0.0110
STD. DEVIATIONS	0.0306	0.0410	0.0378	0.0144	0.0246	0.0048
	0.0000	0.0000	0.0000	0.0006	0.0123	0.0227
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.7813	0.6512	0.9006	0.9051	0.5662	0.2235
	0.0061	0.0030	0.0032	0.1853	0.4345	0.5886
STD. DEVIATIONS	0.6508	0.5814	0.5407	0.5383	0.6573	0.3162
	0.0160	0.0086	0.0099	0.2698	0.5736	0.6225
LATERAL DRAINAGE COLLECTED FROM LAYER 5						

TOTALS	0.7807	0.6491	0.8955	0.9129	0.5689	0.2346
	0.0063	0.0030	0.0032	0.1747	0.4347	0.5844
STD. DEVIATIONS	0.6530	0.5840	0.5419	0.5372	0.6543	0.3292
	0.0160	0.0086	0.0099	0.2575	0.5720	0.6233

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.0421	1.6823	1.4004	1.0144	0.9305	0.1460
	0.0001	0.0001	0.0000	0.0210	0.3619	0.6287
STD. DEVIATIONS	1.7437	2.5444	2.1512	0.8494	1.3983	0.2848
	0.0003	0.0002	0.0001	0.0358	0.7252	1.2947

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0218	0.0198	0.0250	0.0263	0.0159	0.0068
	0.0002	0.0001	0.0001	0.0049	0.0125	0.0163
STD. DEVIATIONS	0.0182	0.0178	0.0151	0.0155	0.0183	0.0095
	0.0004	0.0002	0.0003	0.0072	0.0165	0.0174

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES		CU. FEET	PERCENT
PRECIPITATION	38.37	(8.632)	139268.6	100.00
RUNOFF	3.008	(1.5876)	10919.73	7.841
EVAPOTRANSPIRATION	29.430	(3.2952)	106829.98	76.708
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.12356	(0.09781)	448.539	0.32207
PERCOLATION/LEAKAGE THROUGH LAYER 4	5.24877	(2.26656)	19053.023	13.68078
AVERAGE HEAD ON TOP OF LAYER 4	0.602	(0.481)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.24785	(2.26847)	19049.691	13.67838

PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (	0.00000)	0.022	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.012 (	0.005)		
CHANGE IN WATER STORAGE	0.557 (	4.1169)	2020.61	1.451

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	4.25	15427.500
RUNOFF	1.362	4944.4390
DRAINAGE COLLECTED FROM LAYER 3	0.00420	15.24487
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.053423	193.92696
AVERAGE HEAD ON TOP OF LAYER 4	7.411	
MAXIMUM HEAD ON TOP OF LAYER 4	10.869	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	58.6 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.05337	193.73891
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00019
AVERAGE HEAD ON TOP OF LAYER 6	0.046	
MAXIMUM HEAD ON TOP OF LAYER 6	0.092	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.2 FEET	
SNOW WATER	1.54	5591.3433
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3946	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1495	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	3.9907	0.3326
2	734.7142	0.2944
3	7.1279	0.2970
4	10.8480	0.4520
5	0.0418	0.2784
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    F:\HELP\10101120\PRECIP.D4
TEMPERATURE DATA FILE:      F:\HELP\10101120\TEMP.D7
SOLAR RADIATION DATA FILE:  F:\HELP\10101120\RAD.D13
EVAPOTRANSPIRATION DATA:    F:\HELP\10101120\EVAP2.D11
SOIL AND DESIGN DATA FILE:  F:\HELP\10101120\DESIGN4.D10
OUTPUT DATA FILE:           F:\HELP\10101120\OUT4.OUT


TIME:   9:24     DATE:  10/26/2011


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     TITLE:  CASE 4 - INTERMEDIATE COVER W/280' WASTE

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.4710 VOL/VOL
          FIELD CAPACITY             =      0.3420 VOL/VOL
          WILTING POINT              =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2987 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
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              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  18
THICKNESS                    =   3336.00   INCHES
POROSITY                     =      0.6710 VOL/VOL
FIELD CAPACITY               =      0.2920 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2922 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER  18
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.6710 VOL/VOL
FIELD CAPACITY               =      0.2920 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2959 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
SLOPE                        =      2.20   PERCENT
DRAINAGE LENGTH              =    220.0    FEET


                          LAYER  4
                          --------

               TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER  28
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4520 VOL/VOL
FIELD CAPACITY               =      0.4110 VOL/VOL
WILTING POINT                =      0.3110 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4520 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.120000004000E-05 CM/SEC


                          LAYER  5
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              TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.14   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.1000 VOL/VOL
WILTING POINT                =      0.0500 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3733 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  1.37000000000      CM/SEC
SLOPE                        =      2.20   PERCENT
DRAINAGE LENGTH              =    220.0    FEET


                          LAYER  6
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                TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER 35
THICKNESS                    =     0.06   INCHES
POROSITY                     =     0.0000 VOL/VOL
FIELD CAPACITY               =     0.0000 VOL/VOL
WILTING POINT                =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =     0.50   HOLES/ACRE
FML INSTALLATION DEFECTS     =     1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER 7
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                TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER 16
THICKNESS                    =    24.00   INCHES
POROSITY                     =     0.4270 VOL/VOL
FIELD CAPACITY               =     0.4180 VOL/VOL
WILTING POINT                =     0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #12 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  550. FEET.

SCS RUNOFF CURVE NUMBER              =    87.40
FRACTION OF AREA ALLOWING RUNOFF     =    70.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =     1.000  ACRES
EVAPORATIVE ZONE DEPTH               =    22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =     6.349  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =    12.362  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =     3.290  INCHES
INITIAL SNOW WATER                   =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =  1006.691  INCHES
TOTAL INITIAL WATER                  =  1006.691  INCHES
TOTAL SUBSURFACE INFLOW              =     0.00   INCHES/YEAR


          EVAPOTRANSPIRATION AND WEATHER DATA
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 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          DALLAS                TEXAS

    STATION LATITUDE                        =  32.85 DEGREES
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MAXIMUM LEAF AREA INDEX	=	3.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.88	2.96	3.83	3.19	4.56	3.95
1.88	2.41	2.39	4.45	2.95	3.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	50.30	57.00	64.70	73.00	80.10
84.30	84.40	77.50	67.10	56.60	46.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS AND STATION LATITUDE = 32.85 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.83	86502.922	100.00
RUNOFF	0.481	1745.745	2.02
EVAPOTRANSPIRATION	22.016	79918.117	92.39
DRAINAGE COLLECTED FROM LAYER 3	0.0074	26.855	0.03
PERC./LEAKAGE THROUGH LAYER 4	1.347412	4891.105	5.65
AVG. HEAD ON TOP OF LAYER 4	0.0352		
DRAINAGE COLLECTED FROM LAYER 5	1.3465	4887.699	5.65

	INCHES	CU. FEET	PERCENT
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0047		
CHANGE IN WATER STORAGE	-0.021	-75.551	-0.09
SOIL WATER AT START OF YEAR	1006.691	3654287.500	
SOIL WATER AT END OF YEAR	1006.670	3654212.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.046	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.10	149193.016	100.00
RUNOFF	2.502	9080.735	6.09
EVAPOTRANSPIRATION	32.015	116215.984	77.90
DRAINAGE COLLECTED FROM LAYER 3	0.1119	406.234	0.27
PERC./LEAKAGE THROUGH LAYER 4	6.007915	21808.732	14.62
AVG. HEAD ON TOP OF LAYER 4	0.5366		
DRAINAGE COLLECTED FROM LAYER 5	6.0372	21915.068	14.69
PERC./LEAKAGE THROUGH LAYER 7	0.000009	0.034	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0212		
CHANGE IN WATER STORAGE	0.434	1575.275	1.06
SOIL WATER AT START OF YEAR	1006.670	3654212.000	
SOIL WATER AT END OF YEAR	1007.104	3655787.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.323	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.71	111477.312	100.00
RUNOFF	2.040	7404.281	6.64
EVAPOTRANSPIRATION	26.594	96534.797	86.60
DRAINAGE COLLECTED FROM LAYER 3	0.1118	405.970	0.36
PERC./LEAKAGE THROUGH LAYER 4	5.845614	21219.580	19.03
AVG. HEAD ON TOP OF LAYER 4	0.5426		
DRAINAGE COLLECTED FROM LAYER 5	5.8555	21255.480	19.07
PERC./LEAKAGE THROUGH LAYER 7	0.000009	0.033	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0208		
CHANGE IN WATER STORAGE	-3.891	-14123.412	-12.67
SOIL WATER AT START OF YEAR	1007.104	3655787.250	
SOIL WATER AT END OF YEAR	1003.213	3641664.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.165	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.90	141207.000	100.00
RUNOFF	2.746	9968.477	7.06
EVAPOTRANSPIRATION	28.557	103660.898	73.41
DRAINAGE COLLECTED FROM LAYER 3	0.0863	313.379	0.22
PERC./LEAKAGE THROUGH LAYER 4	5.073441	18416.592	13.04
AVG. HEAD ON TOP OF LAYER 4	0.4164		
DRAINAGE COLLECTED FROM LAYER 5	5.0734	18416.441	13.04
PERC./LEAKAGE THROUGH LAYER 7	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0179		

CHANGE IN WATER STORAGE	2.437	8847.903	6.27
SOIL WATER AT START OF YEAR	1003.213	3641664.000	
SOIL WATER AT END OF YEAR	1005.651	3650511.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.120	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.51	121641.297	100.00
RUNOFF	1.093	3968.862	3.26
EVAPOTRANSPIRATION	31.707	115097.172	94.62
DRAINAGE COLLECTED FROM LAYER 3	0.0038	13.748	0.01
PERC./LEAKAGE THROUGH LAYER 4	1.816706	6594.645	5.42
AVG. HEAD ON TOP OF LAYER 4	0.0185		
DRAINAGE COLLECTED FROM LAYER 5	1.8167	6594.725	5.42
PERC./LEAKAGE THROUGH LAYER 7	0.000004	0.014	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0065		
CHANGE IN WATER STORAGE	-1.111	-4033.235	-3.32
SOIL WATER AT START OF YEAR	1005.651	3650511.750	
SOIL WATER AT END OF YEAR	1004.540	3646478.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.77	173405.109	100.00
RUNOFF	5.624	20416.334	11.77
EVAPOTRANSPIRATION	30.237	109760.148	63.30
DRAINAGE COLLECTED FROM LAYER 3	0.1410	511.795	0.30
PERC./LEAKAGE THROUGH LAYER 4	7.300741	26501.689	15.28
AVG. HEAD ON TOP OF LAYER 4	0.6780		
DRAINAGE COLLECTED FROM LAYER 5	7.2534	26329.666	15.18
PERC./LEAKAGE THROUGH LAYER 7	0.000011	0.040	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0255		
CHANGE IN WATER STORAGE	4.514	16386.844	9.45
SOIL WATER AT START OF YEAR	1004.540	3646478.500	
SOIL WATER AT END OF YEAR	1009.054	3662865.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.286	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.42	164874.562	100.00
RUNOFF	3.013	10938.564	6.63
EVAPOTRANSPIRATION	31.433	114100.203	69.20
DRAINAGE COLLECTED FROM LAYER 3	0.3104	1126.708	0.68
PERC./LEAKAGE THROUGH LAYER 4	8.596177	31204.123	18.93
AVG. HEAD ON TOP OF LAYER 4	1.5232		
DRAINAGE COLLECTED FROM LAYER 5	8.6041	31232.939	18.94
PERC./LEAKAGE THROUGH LAYER 7	0.000013	0.046	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0306		
CHANGE IN WATER STORAGE	2.060	7476.019	4.53

SOIL WATER AT START OF YEAR	1009.054	3662865.500	
SOIL WATER AT END OF YEAR	1011.113	3670341.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.089	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.41	106758.297	100.00
RUNOFF	2.146	7789.861	7.30
EVAPOTRANSPIRATION	28.593	103793.773	97.22
DRAINAGE COLLECTED FROM LAYER 3	0.2423	879.476	0.82
PERC./LEAKAGE THROUGH LAYER 4	5.621681	20406.701	19.11
AVG. HEAD ON TOP OF LAYER 4	1.1842		
DRAINAGE COLLECTED FROM LAYER 5	5.6611	20549.777	19.25
PERC./LEAKAGE THROUGH LAYER 7	0.000008	0.030	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0201		
CHANGE IN WATER STORAGE	-7.233	-26254.135	-24.59
SOIL WATER AT START OF YEAR	1011.113	3670341.500	
SOIL WATER AT END OF YEAR	1003.881	3644087.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.486	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.54	179830.219	100.00

RUNOFF	4.228	15349.200	8.54
EVAPOTRANSPIRATION	33.085	120098.758	66.78
DRAINAGE COLLECTED FROM LAYER 3	0.0399	144.749	0.08
PERC./LEAKAGE THROUGH LAYER 4	4.438931	16113.317	8.96
AVG. HEAD ON TOP OF LAYER 4	0.1928		
DRAINAGE COLLECTED FROM LAYER 5	4.3983	15965.860	8.88
PERC./LEAKAGE THROUGH LAYER 7	0.000007	0.026	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0155		
CHANGE IN WATER STORAGE	7.788	28271.416	15.72
SOIL WATER AT START OF YEAR	1003.881	3644087.250	
SOIL WATER AT END OF YEAR	1011.669	3672358.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.210	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.47	157796.109	100.00
RUNOFF	3.312	12021.162	7.62
EVAPOTRANSPIRATION	31.080	112821.648	71.50
DRAINAGE COLLECTED FROM LAYER 3	0.2391	867.905	0.55
PERC./LEAKAGE THROUGH LAYER 4	8.031520	29154.418	18.48
AVG. HEAD ON TOP OF LAYER 4	1.1759		
DRAINAGE COLLECTED FROM LAYER 5	8.0315	29154.338	18.48
PERC./LEAKAGE THROUGH LAYER 7	0.000012	0.044	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0286		
CHANGE IN WATER STORAGE	0.807	2930.542	1.86
SOIL WATER AT START OF YEAR	1011.669	3672358.750	
SOIL WATER AT END OF YEAR	1012.476	3675289.250	

SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.467	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.94	3.12	3.94	3.28	4.00	3.58
	1.99	3.22	2.46	4.24	2.94	3.65
STD. DEVIATIONS	1.26	1.46	2.82	2.44	2.23	2.00
	1.75	1.91	1.24	3.79	2.57	2.63
RUNOFF						
TOTALS	0.055	0.102	0.323	0.217	0.265	0.266
	0.197	0.149	0.083	0.563	0.276	0.222
STD. DEVIATIONS	0.161	0.116	0.434	0.375	0.438	0.285
	0.408	0.158	0.115	0.990	0.492	0.250
EVAPOTRANSPIRATION						
TOTALS	1.815	1.996	3.009	3.267	4.443	3.447
	2.339	2.686	2.343	1.694	1.139	1.354
STD. DEVIATIONS	0.387	0.576	0.737	0.884	1.589	1.749
	1.975	1.774	1.340	0.548	0.352	0.453
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0182	0.0271	0.0271	0.0182	0.0172	0.0034
	0.0000	0.0000	0.0000	0.0003	0.0063	0.0116
STD. DEVIATIONS	0.0312	0.0408	0.0401	0.0121	0.0259	0.0068
	0.0000	0.0000	0.0000	0.0006	0.0124	0.0228
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.7693	0.6916	0.9014	0.9739	0.5767	0.2515
	0.0216	0.0001	0.0033	0.1834	0.4329	0.6023
STD. DEVIATIONS	0.6425	0.5668	0.5619	0.5145	0.6577	0.3796
	0.0389	0.0002	0.0104	0.2684	0.5656	0.6376
LATERAL DRAINAGE COLLECTED FROM LAYER 5						

TOTALS	0.7703	0.6881	0.8928	0.9881	0.5781	0.2685
	0.0216	0.0001	0.0033	0.1679	0.4329	0.5961
STD. DEVIATIONS	0.6451	0.5708	0.5647	0.5190	0.6558	0.3985
	0.0388	0.0002	0.0104	0.2501	0.5631	0.6388

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.0359	1.6885	1.5437	1.0695	0.9775	0.1992
	0.0004	0.0000	0.0001	0.0198	0.3709	0.6586
STD. DEVIATIONS	1.7771	2.5323	2.2836	0.7118	1.4770	0.3983
	0.0007	0.0000	0.0002	0.0345	0.7306	1.2966

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0320	0.0313	0.0371	0.0424	0.0240	0.0115
	0.0009	0.0000	0.0001	0.0070	0.0186	0.0248
STD. DEVIATIONS	0.0268	0.0259	0.0235	0.0223	0.0272	0.0171
	0.0016	0.0000	0.0004	0.0104	0.0242	0.0265

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.37 (8.632)	139268.6	100.00
RUNOFF	2.719 (1.4775)	9868.32	7.086
EVAPOTRANSPIRATION	29.532 (3.2827)	107200.16	76.974
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.12939 (0.10478)	469.682	0.33725
PERCOLATION/LEAKAGE THROUGH LAYER 4	5.40801 (2.39591)	19631.090	14.09585
AVERAGE HEAD ON TOP OF LAYER 4	0.630 (0.515)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.40777 (2.39648)	19630.199	14.09521

PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (	0.00000)	0.030	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.019 (	0.009)		
CHANGE IN WATER STORAGE	0.579 (	4.1819)	2100.17	1.508

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	4.25	15427.500
RUNOFF	1.298	4710.7847
DRAINAGE COLLECTED FROM LAYER 3	0.00420	15.25512
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.053432	193.95773
AVERAGE HEAD ON TOP OF LAYER 4	7.416	
MAXIMUM HEAD ON TOP OF LAYER 4	10.875	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	58.6 FEET	
DRAINAGE COLLECTED FROM LAYER 5	0.05330	193.47041
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00027
AVERAGE HEAD ON TOP OF LAYER 6	0.069	
MAXIMUM HEAD ON TOP OF LAYER 6	0.136	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.5 FEET	
SNOW WATER	1.54	5591.3433

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3973
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1495

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	3.9894	0.3325
2	980.0308	0.2938
3	7.3056	0.3044
4	10.8480	0.4520
5	0.0546	0.3902
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

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**                                                                            **
**                                                                            **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                 **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                         **
**              USAE WATERWAYS EXPERIMENT STATION                             **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                            **
**                                                                            **
********************************************************************************
********************************************************************************


PRECIPITATION DATA FILE:      F:\HELP\10101120\PRECIP.D4
TEMPERATURE DATA FILE:        F:\HELP\10101120\TEMP.D7
SOLAR RADIATION DATA FILE:    F:\HELP\10101120\RAD.D13
EVAPOTRANSPIRATION DATA:      F:\HELP\10101120\EVAP3.D11
SOIL AND DESIGN DATA FILE:    F:\HELP\10101120\DESIGN5.D10
OUTPUT DATA FILE:             F:\HELP\10101120\OUT5.OUT


TIME: 15:40     DATE:  1/30/2012


********************************************************************************

     TITLE:  CASE 5 - FINAL COVER W/280' WASTE

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      NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =      6.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2574 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------
```

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =      30.00    INCHES
POROSITY                   =      0.4750 VOL/VOL
FIELD CAPACITY             =      0.3780 VOL/VOL
WILTING POINT              =      0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.3137 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   0.999999997000E-06 CM/SEC
```

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

```
THICKNESS                  =      0.20     INCHES
POROSITY                   =      0.8500 VOL/VOL
FIELD CAPACITY             =      0.0100 VOL/VOL
WILTING POINT              =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   10.0000000000      CM/SEC
SLOPE                      =      25.00    PERCENT
DRAINAGE LENGTH            =     980.0     FEET
```

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

```
THICKNESS                  =      18.00    INCHES
POROSITY                   =      0.4270 VOL/VOL
FIELD CAPACITY             =      0.4180 VOL/VOL
WILTING POINT              =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   0.100000001000E-06 CM/SEC
```

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 12

```
THICKNESS                  =      12.00    INCHES
POROSITY                   =      0.4710 VOL/VOL
FIELD CAPACITY             =      0.3420 VOL/VOL
WILTING POINT              =      0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.3420 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   0.419999997000E-04 CM/SEC
```

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	3336.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	24.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 28

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4520	VOL/VOL
FIELD CAPACITY	=	0.4110	VOL/VOL
WILTING POINT	=	0.3110	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4520	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.120000004000E-05	CM/SEC

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.13	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0500	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.730000019000	CM/SEC
SLOPE	=	2.20	PERCENT
DRAINAGE LENGTH	=	220.0	FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

```
THICKNESS                    =     0.06    INCHES
POROSITY                     =     0.0000 VOL/VOL
FIELD CAPACITY               =     0.0000 VOL/VOL
WILTING POINT                =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =     0.50    HOLES/ACRE
FML INSTALLATION DEFECTS     =     1.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

```
THICKNESS                    =    24.00    INCHES
POROSITY                     =     0.4270 VOL/VOL
FIELD CAPACITY               =     0.4180 VOL/VOL
WILTING POINT                =     0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
GOOD STAND OF GRASS, A SURFACE SLOPE OF 25.%
AND A SLOPE LENGTH OF 980. FEET.

```
SCS RUNOFF CURVE NUMBER            =    80.40
FRACTION OF AREA ALLOWING RUNOFF   =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
EVAPORATIVE ZONE DEPTH             =    36.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =    10.954  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =    16.638  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =     8.766  INCHES
INITIAL SNOW WATER                 =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =  1024.975  INCHES
TOTAL INITIAL WATER                =  1024.975  INCHES
TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

```
STATION LATITUDE                =  32.85 DEGREES
MAXIMUM LEAF AREA INDEX         =   3.00
```

START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	36.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.88	2.96	3.83	3.19	4.56	3.95
1.88	2.41	2.39	4.45	2.95	3.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	50.30	57.00	64.70	73.00	80.10
84.30	84.40	77.50	67.10	56.60	46.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DALLAS TEXAS AND STATION LATITUDE = 32.85 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.83	86502.922	100.00
RUNOFF	4.006	14541.173	16.81
EVAPOTRANSPIRATION	19.020	69044.211	79.82
DRAINAGE COLLECTED FROM LAYER 3	0.0001	0.292	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000231	0.839	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000231	0.839	0.00

AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0002	0.837	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	0.803	2916.141	3.37
SOIL WATER AT START OF YEAR	1024.975	3720661.000	
SOIL WATER AT END OF YEAR	1025.779	3723577.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.268	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.10	149193.016	100.00
RUNOFF	13.384	48582.824	32.56
EVAPOTRANSPIRATION	27.158	98584.164	66.08
DRAINAGE COLLECTED FROM LAYER 3	0.0175	63.366	0.04
PERC./LEAKAGE THROUGH LAYER 4	0.001690	6.136	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.001690	6.136	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0017	6.133	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	0.539	1956.797	1.31
SOIL WATER AT START OF YEAR	1025.779	3723577.000	
SOIL WATER AT END OF YEAR	1026.318	3725533.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

	INCHES	CU. FEET	PERCENT
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.282	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.71	111477.312	100.00
RUNOFF	9.871	35833.043	32.14
EVAPOTRANSPIRATION	23.535	85430.656	76.64
DRAINAGE COLLECTED FROM LAYER 3	0.0193	70.159	0.06
PERC./LEAKAGE THROUGH LAYER 4	0.002267	8.229	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.002267	8.229	0.01
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0023	8.226	0.01
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	-2.718	-9865.074	-8.85
SOIL WATER AT START OF YEAR	1026.318	3725533.750	
SOIL WATER AT END OF YEAR	1023.600	3715668.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.296	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT

PRECIPITATION	38.90	141207.000	100.00
RUNOFF	13.143	47707.805	33.79
EVAPOTRANSPIRATION	24.143	87637.898	62.06
DRAINAGE COLLECTED FROM LAYER 3	0.0083	30.260	0.02
PERC./LEAKAGE THROUGH LAYER 4	0.001948	7.071	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.001948	7.071	0.01
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0019	7.069	0.01
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.604	5823.863	4.12
SOIL WATER AT START OF YEAR	1023.600	3715668.750	
SOIL WATER AT END OF YEAR	1025.205	3721492.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.109	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.51	121641.297	100.00
RUNOFF	6.132	22260.891	18.30
EVAPOTRANSPIRATION	27.265	98972.789	81.36
DRAINAGE COLLECTED FROM LAYER 3	0.0055	20.028	0.02
PERC./LEAKAGE THROUGH LAYER 4	0.002881	10.458	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.002881	10.458	0.01

AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0029	10.455	0.01
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	0.104	377.091	0.31
SOIL WATER AT START OF YEAR	1025.205	3721492.750	
SOIL WATER AT END OF YEAR	1025.308	3721869.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.040	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.77	173405.109	100.00
RUNOFF	21.741	78919.453	45.51
EVAPOTRANSPIRATION	24.097	87473.711	50.44
DRAINAGE COLLECTED FROM LAYER 3	0.0254	92.330	0.05
PERC./LEAKAGE THROUGH LAYER 4	0.002413	8.759	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.002413	8.759	0.01
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0024	8.756	0.01
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.904	6910.825	3.99
SOIL WATER AT START OF YEAR	1025.308	3721869.750	
SOIL WATER AT END OF YEAR	1027.212	3728780.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.038	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.42	164874.562	100.00
RUNOFF	19.328	70159.203	42.55
EVAPOTRANSPIRATION	26.421	95909.742	58.17
DRAINAGE COLLECTED FROM LAYER 3	0.1479	536.765	0.33
PERC./LEAKAGE THROUGH LAYER 4	0.016576	60.172	0.04
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.016576	60.172	0.04
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0166	60.168	0.04
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-0.493	-1791.072	-1.09
SOIL WATER AT START OF YEAR	1027.212	3728780.500	
SOIL WATER AT END OF YEAR	1026.719	3726989.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.248	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.41	106758.297	100.00

RUNOFF	7.661	27809.158	26.05
EVAPOTRANSPIRATION	23.926	86851.617	81.35
DRAINAGE COLLECTED FROM LAYER 3	0.0806	292.654	0.27
PERC./LEAKAGE THROUGH LAYER 4	0.010035	36.428	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.010035	36.428	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0100	36.425	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-2.268	-8231.752	-7.71
SOIL WATER AT START OF YEAR	1026.719	3726989.500	
SOIL WATER AT END OF YEAR	1024.451	3718757.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.192	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	49.54	179830.219	100.00
RUNOFF	20.525	74505.039	41.43
EVAPOTRANSPIRATION	26.333	95588.531	53.15
DRAINAGE COLLECTED FROM LAYER 3	0.0003	1.090	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000634	2.302	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000634	2.302	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		

DRAINAGE COLLECTED FROM LAYER 9	0.0006	2.300	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	2.681	9733.469	5.41
SOIL WATER AT START OF YEAR	1024.451	3718757.750	
SOIL WATER AT END OF YEAR	1027.133	3728491.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.214	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.47	157796.109	100.00
RUNOFF	18.609	67550.609	42.81
EVAPOTRANSPIRATION	24.214	87895.227	55.70
DRAINAGE COLLECTED FROM LAYER 3	0.0220	79.904	0.05
PERC./LEAKAGE THROUGH LAYER 4	0.001821	6.610	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.001821	6.610	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0018	6.607	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	0.624	2263.433	1.43
SOIL WATER AT START OF YEAR	1027.133	3728491.250	
SOIL WATER AT END OF YEAR	1027.756	3730754.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0001	0.316	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.35	128320.508	100.00
RUNOFF	12.967	47070.633	36.68
EVAPOTRANSPIRATION	24.021	87196.172	67.95
DRAINAGE COLLECTED FROM LAYER 3	0.1018	369.425	0.29
PERC./LEAKAGE THROUGH LAYER 4	0.007293	26.475	0.02
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.007293	26.475	0.02
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0073	26.472	0.02
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	-1.747	-6341.865	-4.94
SOIL WATER AT START OF YEAR	1027.756	3730754.750	
SOIL WATER AT END OF YEAR	1026.009	3724412.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.333	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85	137395.469	100.00

RUNOFF	9.998	36291.945	26.41
EVAPOTRANSPIRATION	27.452	99651.164	72.53
DRAINAGE COLLECTED FROM LAYER 3	0.1183	429.369	0.31
PERC./LEAKAGE THROUGH LAYER 4	0.009519	34.553	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.009519	34.552	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0095	34.549	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	0.272	988.147	0.72
SOIL WATER AT START OF YEAR	1026.009	3724412.750	
SOIL WATER AT END OF YEAR	1026.281	3725401.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.287	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.36	124726.805	100.00
RUNOFF	12.100	43922.316	35.21
EVAPOTRANSPIRATION	23.123	83934.836	67.29
DRAINAGE COLLECTED FROM LAYER 3	0.1044	378.871	0.30
PERC./LEAKAGE THROUGH LAYER 4	0.010295	37.371	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.010295	37.371	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		

DRAINAGE COLLECTED FROM LAYER 9	0.0103	37.368	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-0.977	-3546.251	-2.84
SOIL WATER AT START OF YEAR	1026.281	3725401.000	
SOIL WATER AT END OF YEAR	1025.304	3721854.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.337	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.20	84215.992	100.00
RUNOFF	3.152	11443.418	13.59
EVAPOTRANSPIRATION	21.145	76755.305	91.14
DRAINAGE COLLECTED FROM LAYER 3	0.0002	0.870	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000221	0.804	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0002	0.802	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	-1.098	-3984.714	-4.73
SOIL WATER AT START OF YEAR	1025.304	3721854.750	
SOIL WATER AT END OF YEAR	1024.193	3717821.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.013	48.521	0.06

ANNUAL WATER BUDGET BALANCE	0.0001	0.312	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.47	121496.062	100.00
RUNOFF	7.379	26785.553	22.05
EVAPOTRANSPIRATION	22.748	82575.375	67.97
DRAINAGE COLLECTED FROM LAYER 3	0.0002	0.657	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000283	1.027	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000283	1.027	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0003	1.026	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000000	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	3.343	12133.603	9.99
SOIL WATER AT START OF YEAR	1024.193	3717821.500	
SOIL WATER AT END OF YEAR	1027.549	3730003.500	
SNOW WATER AT START OF YEAR	0.013	48.521	0.04
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.153	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.56	103672.797	100.00
RUNOFF	10.368	37635.098	36.30

EVAPOTRANSPIRATION	21.172	76852.961	74.13
DRAINAGE COLLECTED FROM LAYER 3	0.0187	67.709	0.07
PERC./LEAKAGE THROUGH LAYER 4	0.001354	4.916	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.001354	4.916	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0013	4.779	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	-2.999	-10887.784	-10.50
SOIL WATER AT START OF YEAR	1027.549	3730003.500	
SOIL WATER AT END OF YEAR	1024.550	3719115.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.028	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.85	151915.516	100.00
RUNOFF	14.770	53614.969	35.29
EVAPOTRANSPIRATION	25.696	93275.180	61.40
DRAINAGE COLLECTED FROM LAYER 3	0.0114	41.268	0.03
PERC./LEAKAGE THROUGH LAYER 4	0.003231	11.729	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.003231	11.729	0.01
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0033	11.860	0.01

PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.370	4972.196	3.27
SOIL WATER AT START OF YEAR	1024.550	3719115.750	
SOIL WATER AT END OF YEAR	1025.920	3724088.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.028	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.39	164765.703	100.00
RUNOFF	18.273	66332.750	40.26
EVAPOTRANSPIRATION	26.004	94394.508	57.29
DRAINAGE COLLECTED FROM LAYER 3	0.0001	0.283	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000364	1.322	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000364	1.322	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0004	1.319	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.112	4036.780	2.45
SOIL WATER AT START OF YEAR	1025.920	3724088.000	
SOIL WATER AT END OF YEAR	1027.032	3728124.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.47	121496.094	100.00
RUNOFF	9.774	35479.559	29.20
EVAPOTRANSPIRATION	25.641	93076.117	76.61
DRAINAGE COLLECTED FROM LAYER 3	0.1517	550.765	0.45
PERC./LEAKAGE THROUGH LAYER 4	0.009210	33.431	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.009210	33.431	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0092	33.428	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-2.106	-7643.738	-6.29
SOIL WATER AT START OF YEAR	1027.032	3728124.750	
SOIL WATER AT END OF YEAR	1024.926	3720481.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.045	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.66	122185.812	100.00
RUNOFF	8.608	31248.016	25.57

EVAPOTRANSPIRATION	22.683	82338.453	67.39
DRAINAGE COLLECTED FROM LAYER 3	0.0000	0.164	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000160	0.582	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000160	0.582	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0002	0.580	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	2.369	8598.651	7.04
SOIL WATER AT START OF YEAR	1024.926	3720481.000	
SOIL WATER AT END OF YEAR	1027.295	3729079.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.054	0.00

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.33	164547.906	100.00
RUNOFF	12.888	46784.434	28.43
EVAPOTRANSPIRATION	32.495	117957.562	71.69
DRAINAGE COLLECTED FROM LAYER 3	0.1023	371.318	0.23
PERC./LEAKAGE THROUGH LAYER 4	0.010467	37.994	0.02
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.010467	37.994	0.02
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0105	37.990	0.02

PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-0.166	-603.523	-0.37
SOIL WATER AT START OF YEAR	1027.295	3729079.750	
SOIL WATER AT END OF YEAR	1027.128	3728476.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.119	0.00

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.67	133112.094	100.00
RUNOFF	15.840	57499.602	43.20
EVAPOTRANSPIRATION	20.326	73782.508	55.43
DRAINAGE COLLECTED FROM LAYER 3	0.2825	1025.410	0.77
PERC./LEAKAGE THROUGH LAYER 4	0.014627	53.095	0.04
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.014627	53.095	0.04
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0146	53.093	0.04
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	0.207	751.523	0.56
SOIL WATER AT START OF YEAR	1027.128	3728476.250	
SOIL WATER AT END OF YEAR	1027.335	3729227.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.046	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.64	133003.187	100.00
RUNOFF	9.668	35094.918	26.39
EVAPOTRANSPIRATION	30.227	109725.227	82.50
DRAINAGE COLLECTED FROM LAYER 3	0.0987	358.458	0.27
PERC./LEAKAGE THROUGH LAYER 4	0.011552	41.934	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.011552	41.934	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0116	41.930	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-3.366	-12217.352	-9.19
SOIL WATER AT START OF YEAR	1027.335	3729227.750	
SOIL WATER AT END OF YEAR	1023.970	3717010.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	43.32	157251.609	100.00
RUNOFF	13.721	49808.328	31.67
EVAPOTRANSPIRATION	28.293	102705.383	65.31

DRAINAGE COLLECTED FROM LAYER 3	0.0020	7.203	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000347	1.261	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000347	1.261	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0003	1.259	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.303	4729.590	3.01
SOIL WATER AT START OF YEAR	1023.970	3717010.250	
SOIL WATER AT END OF YEAR	1025.273	3721740.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.149	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.31	164475.312	100.00
RUNOFF	15.822	57434.301	34.92
EVAPOTRANSPIRATION	28.173	102268.242	62.18
DRAINAGE COLLECTED FROM LAYER 3	0.0015	5.345	0.00
PERC./LEAKAGE THROUGH LAYER 4	0.000677	2.457	0.00
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000677	2.457	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0007	2.454	0.00
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00

AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.313	4764.818	2.90
SOIL WATER AT START OF YEAR	1025.273	3721740.000	
SOIL WATER AT END OF YEAR	1026.585	3726504.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.143	0.00

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.31	117285.320	100.00
RUNOFF	6.843	24838.297	21.18
EVAPOTRANSPIRATION	25.887	93968.148	80.12
DRAINAGE COLLECTED FROM LAYER 3	0.0761	276.244	0.24
PERC./LEAKAGE THROUGH LAYER 4	0.005748	20.865	0.02
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.005748	20.865	0.02
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0057	20.862	0.02
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	-0.501	-1818.102	-1.55
SOIL WATER AT START OF YEAR	1026.585	3726504.750	
SOIL WATER AT END OF YEAR	1026.084	3724686.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.131	0.00

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.88	162914.375	100.00
RUNOFF	19.468	70669.531	43.38
EVAPOTRANSPIRATION	24.264	88076.773	54.06
DRAINAGE COLLECTED FROM LAYER 3	0.0152	55.226	0.03
PERC./LEAKAGE THROUGH LAYER 4	0.002315	8.402	0.01
AVG. HEAD ON TOP OF LAYER 4	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.002315	8.402	0.01
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0023	8.399	0.01
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0000		
CHANGE IN WATER STORAGE	1.131	4104.576	2.52
SOIL WATER AT START OF YEAR	1026.084	3724686.750	
SOIL WATER AT END OF YEAR	1027.215	3728791.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.138	0.00

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.31	149955.281	100.00
RUNOFF	18.158	65914.742	43.96
EVAPOTRANSPIRATION	22.933	83247.672	55.51

DRAINAGE COLLECTED FROM LAYER 3	0.1215	441.005	0.29
PERC./LEAKAGE THROUGH LAYER 4	0.013921	50.533	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.013921	50.532	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0139	50.530	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	0.083	301.318	0.20
SOIL WATER AT START OF YEAR	1027.215	3728791.250	
SOIL WATER AT END OF YEAR	1027.298	3729092.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.61	165564.297	100.00
RUNOFF	16.746	60787.238	36.72
EVAPOTRANSPIRATION	29.015	105325.914	63.62
DRAINAGE COLLECTED FROM LAYER 3	0.1696	615.625	0.37
PERC./LEAKAGE THROUGH LAYER 4	0.014924	54.176	0.03
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.014924	54.175	0.03
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0149	54.172	0.03
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.003	0.00

AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-0.336	-1219.010	-0.74
SOIL WATER AT START OF YEAR	1027.298	3729092.500	
SOIL WATER AT END OF YEAR	1026.962	3727873.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.355	0.00

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.05	138121.516	100.00
RUNOFF	10.215	37078.930	26.85
EVAPOTRANSPIRATION	28.955	105107.500	76.10
DRAINAGE COLLECTED FROM LAYER 3	0.1096	397.794	0.29
PERC./LEAKAGE THROUGH LAYER 4	0.008040	29.186	0.02
AVG. HEAD ON TOP OF LAYER 4	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.008040	29.186	0.02
AVG. HEAD ON TOP OF LAYER 8	0.0000		
DRAINAGE COLLECTED FROM LAYER 9	0.0080	29.182	0.02
PERC./LEAKAGE THROUGH LAYER 11	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 10	0.0001		
CHANGE IN WATER STORAGE	-1.237	-4491.859	-3.25
SOIL WATER AT START OF YEAR	1026.962	3727873.500	
SOIL WATER AT END OF YEAR	1025.725	3723381.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.25	2.75	3.51	3.07	4.08	3.98
	2.62	2.29	2.73	4.49	2.70	3.53
STD. DEVIATIONS	1.54	1.58	2.09	1.89	1.92	2.58
	2.05	1.70	1.53	3.74	2.05	2.53
RUNOFF						
TOTALS	0.808	1.129	1.448	0.804	0.853	1.308
	0.522	0.281	0.333	2.280	1.019	1.921
STD. DEVIATIONS	1.081	1.093	1.690	1.098	1.201	1.434
	1.006	0.522	0.537	3.003	1.533	2.091
EVAPOTRANSPIRATION						
TOTALS	0.751	1.021	1.701	3.260	6.322	3.069
	2.285	1.923	2.087	1.334	0.828	0.633
STD. DEVIATIONS	0.160	0.219	0.206	0.583	1.139	1.418
	1.295	1.281	1.017	0.457	0.172	0.162
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0035	0.0489	0.0079
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0002	0.0000	0.0000	0.0088	0.0582	0.0201
	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0006	0.0042	0.0005
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0012	0.0041	0.0014
	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0006	0.0042	0.0005

	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0012	0.0041	0.0014
	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0004	0.0042	0.0006
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0008	0.0042	0.0016
	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0003	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0003	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	38.01 (6.991)	137970.2	100.00

RUNOFF	12.705	(5.0180)	46120.12	33.428
EVAPOTRANSPIRATION	25.212	(3.0482)	91520.12	66.333
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.06042	(0.06974)	219.329	0.15897
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00550	(0.00532)	19.971	0.01447
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00550	(0.00532)	19.970	0.01447
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00550	(0.00532)	19.968	0.01447
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 10	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.025	(1.7028)	90.69	0.066

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.31	19275.299
RUNOFF	4.349	15787.5312
DRAINAGE COLLECTED FROM LAYER 3	0.03320	120.49900
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.003302	11.98532
AVERAGE HEAD ON TOP OF LAYER 4	0.005	
MAXIMUM HEAD ON TOP OF LAYER 4	0.291	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00036
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.003302	11.98496

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AVERAGE HEAD ON TOP OF LAYER  8            0.001

MAXIMUM HEAD ON TOP OF LAYER  8            0.007

LOCATION OF MAXIMUM HEAD IN LAYER  7
      (DISTANCE FROM DRAIN)                0.0 FEET

DRAINAGE COLLECTED FROM LAYER  9           0.00153           5.55139

PERCOLATION/LEAKAGE THROUGH LAYER 11       0.000000          0.00004

AVERAGE HEAD ON TOP OF LAYER 10            0.004

MAXIMUM HEAD ON TOP OF LAYER 10            0.004

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               97.7 FEET

SNOW WATER                                 3.14          11399.3437

MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4399

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.2435

 ***  Maximum heads are computed using McEnroe's equations.  ***

      Reference:  Maximum Saturated Depth over Landfill Liner
                  by Bruce M. McEnroe, University of Kansas
                  ASCE Journal of Environmental Engineering
                  Vol. 119, No. 2, March 1993, pp. 262-270.

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            FINAL WATER STORAGE AT END OF YEAR   30
       ----------------------------------------------------------------------
              LAYER          (INCHES)          (VOL/VOL)
              -----          --------          ---------
                1             1.6196            0.2699

                2            10.0843            0.3361

                3             0.0020            0.0100

                4             7.6860            0.4270

                5             4.1040            0.3420

                6           974.1121            0.2920

                7             7.0080            0.2920

                8            10.8480            0.4520

                9             0.0130            0.1000
```

10	0.0000	0.0000
11	10.2480	0.4270
SNOW WATER	0.000	

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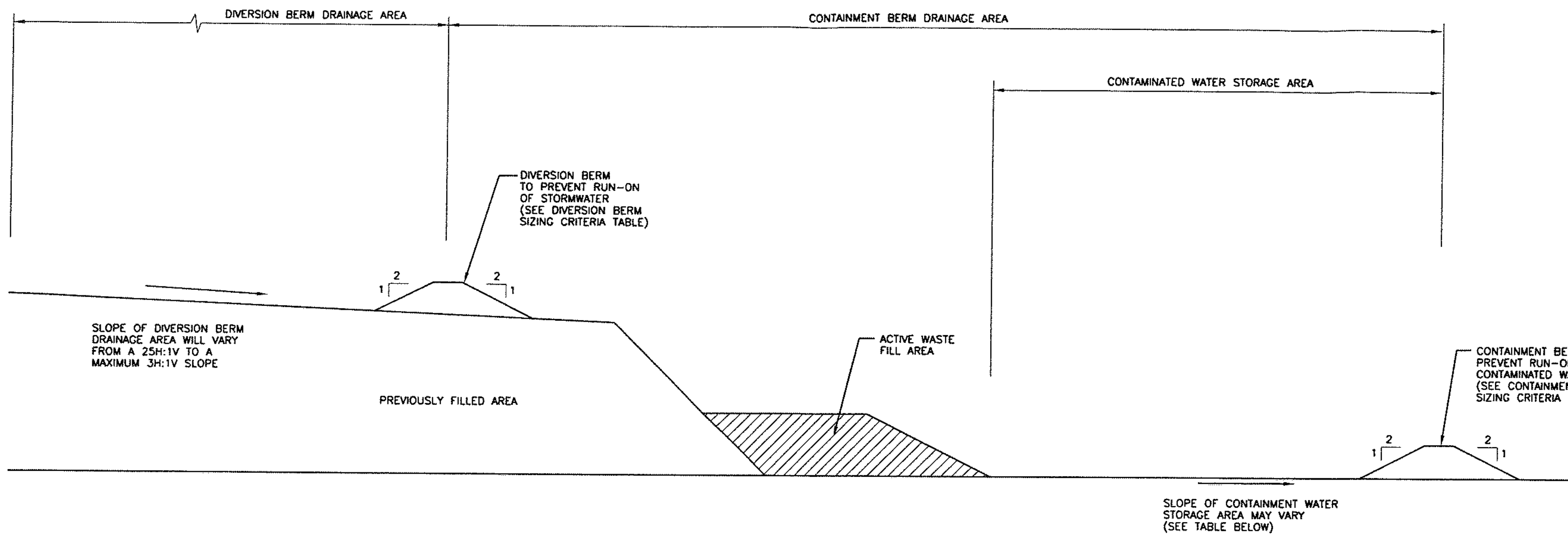
SKYLINE LANDFILL

APPENDIX D6-C
CONTAINMENT/DIVERSION BERM DESIGN

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-12-12

Includes pages D6-C-1 through D6-C-3



CONTAINMENT BERM SIZING CRITERIA

CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAINMENT WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.35 0.25 0.20	1 % 2 % 4 %	1.5 2.2 3.5
1.0	0.50 0.35 0.25	1 % 2 % 4 %	2.2 3.0 4.4
1.5	0.60 0.40 0.30	1 % 2 % 4 %	2.6 3.5 5.2

NOTE: CONTAINMENT BERMS WILL BE SIZED TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. THE CRITERIA ARE BASED ON A MINIMUM DOWNSLOPE CONTAINMENT BERM LENGTH OF 100 FEET AND A FREEBOARD OF 0.5 FT.

DIVERSION BERM SIZING CRITERIA

DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 4%			MAXIMUM 33%		
	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	FLOW RATE (CFS)	FLOW DEPTH (FT)	REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	3.3	0.5	1.5	3.3	0.9	1.9
1.0	6.5	0.6	1.6	6.5	1.1	2.1
1.5	9.8	0.7	1.7	9.8	1.3	2.3

NOTE: DIVERSION BERMS WILL BE SIZED TO DIVERT STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT AND A FREEBOARD OF 1 FT.

STATE OF TEXAS
DAVID L. CLARK
81905
REGISTERED PROFESSIONAL ENGINEER
4-12-12

ISSUED FOR PERMITTING PURPOSES ONLY

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

CONTAMINATED WATER RUNON/RUNOFF DETAILS

WASTE MANAGEMENT OF TEXAS, INC.
SKYLINE LANDFILL
MAJOR PERMIT AMENDMENT

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

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

DSN. SAB	DATE : 04/12	DRAWING
DWN. SRC	SCALE : GRAPHIC	D6-C1
CHK. DLC	DWG : D6_C1.dwg	

J:\101\01\120\ATT D\D6_C1.dwg Layout: Layout1 User: scundiff

Skyline Landfill
Diversion Berm Design

Required: Determine the necessary dimensions of the diversion berms.

Method:

1. Determine the flow using the Rational Method.
2. Calculate flow capacity using Manning's Method.

References:

1. Texas Department of Transportation, Hydraulic Design Manual, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution: Diversion berms will be designed to pass the 25-year, 24-hour storm event.
The Rational Method (Q = CIA) was used to determine the runoff.

25-Year Rainfall Depth (Pd) =	1.42 in	(Ref. 2, extrapolated for 10 min)
Time of Concentration (tc) =	10 min	(conservative minimum value)
Rainfall Intensity (I) =	8.5 in/hr	(Ref. 1, I = Pd/tc)
Runoff Coefficient (C) =	0.7	
Running berm slope =	0.5 %	
Manning's n =	0.03	
Right side slope =	2 :1	

Drainage Area (A) (ac)	0.5		1.0		1.5	
Peak Flow (cfs)	3.0		6.0		8.9	
Berm Evaluation						
Left Side Slope	3:1	25:1	3:1	25:1	3:1	25:1
Flow Depth (ft)	0.9	0.5	1.1	0.6	1.3	0.7
Flow Area (sf)	2.0	3.4	3.0	4.9	4.2	6.6
Wetted Perimeter (ft)	4.9	13.6	5.9	16.4	7.0	19.1
Velocity (fps)	2.0	1.4	2.2	1.6	2.5	1.7
Berm Capacity (cfs)	4.0	4.7	6.8	7.6	10.6	11.5

Skyline Landfill
Containment Berm Design

Required: Size containment berms to contain contaminated water around the working face.

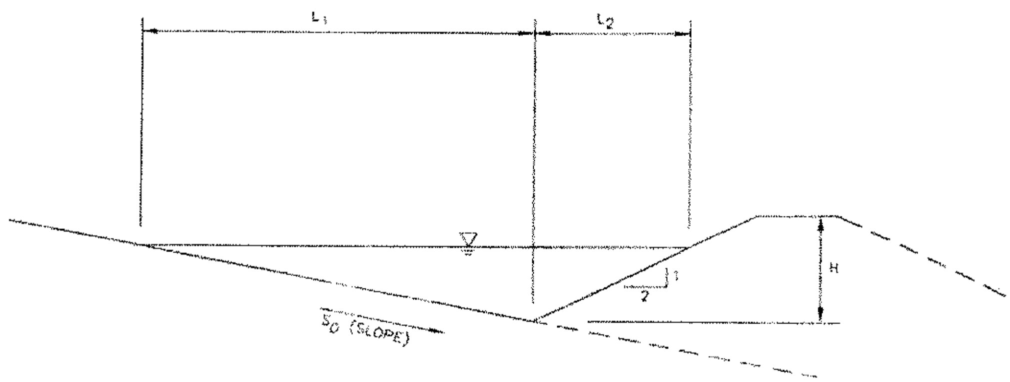
References: 1) Technical Paper No. 40: Rainfall Frequency Atlas of the United States.

Solution: Determine the storage volume required for the 25-year, 24-hour rainfall for Dallas County.

$V_R = CAR$

where: V_R = required storage volume (cf)
C = runoff coeffecient = 0.7
A = drainage area (acres)
R = 25-year, 24-hour rainfall = 7.4 in Ref. 1

Size the storage area from the following figure:



$A_s = (L_1 + L_2)H / 2$ Storage Area = $W(L_1 + L_2)$

where: A_s = cross section area (sf) W = storage width (ft)
$L_1 = H / S_o$
$L_2 = 2H$

Drainage area ac	Required Volume cf	W ft	Storage Area ac	S_o ft/ft	L_1 ft	L_2 ft	H ft	As sf	Vs cf
0.5	9,402	100	0.35	0.01	152	3.0	1.5	118.5	11,854
0.5	9,402	100	0.25	0.02	109	4.4	2.2	123.3	12,334
0.5	9,402	100	0.20	0.04	87	7.0	3.5	163.9	16,394
1	18,803	100	0.50	0.01	218	4.4	2.2	241.9	24,193
1	18,803	100	0.35	0.02	152	6.1	3.0	241.7	24,174
1	18,803	100	0.25	0.04	109	8.7	4.4	256.2	25,616
1.5	28,205	100	0.60	0.01	261	5.2	2.6	348.4	34,838
1.5	28,205	100	0.40	0.02	174	7.0	3.5	315.7	31,574
1.5	28,205	100	0.30	0.04	131	10.5	5.2	368.9	36,887

SKYLINE LANDFILL

APPENDIX D6-D
SECONDARY CONTAINMENT VOLUME CALCULATIONS

STATE OF TEXAS
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4-12-12

Includes pages D6-D-1 through D6-D-2

Skyline Landfill
SECONDARY CONTAINMENT CALCULATION

Required:

1. Verify that the secondary containment area will contain a worst-case release from the two existing storage tanks and precipitation from the 25-year, 24-hour rainfall event.

References:

1. Texas Department of Transporation, *Hydraulic Design Manual*, Revised October 2011.
2. United States Geologic Survey, *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, 2004.

Solution:

a) ***Provided Volume***

Calculate the provided secondary containment volume.

Containment Area Dimensions

Length of containment area =	L =	400 ft
Width of containment area =	W =	200 ft
Containment area =	A =	80,000 sf
Containment berm height =	h =	3 ft

$V_{CONTAINMENT} = A \times h$

$V_{CONTAINMENT} =$ 240,000 cf

Freeboard

Freeboard =	f =	0.5 ft

$V_{FREEBOARD} = f \times A$

$V_{FREEBOARD} =$ 40,000 cf

Provided Secondary Containment Volume

$V_{PROVIDED} = V_{CONTAINMENT} - V_{FREEBOARD}$

$\mathbf{V_{PROVIDED} =}$ **200,000 cf**

b) ***Required Volume***

Calculate the required secondary containment volume, which is the sum of rainfall volume and storage tank volume above freeboard level.

Rainfall Volume

Calculate the rainfall volume that will collect in the containment area during the 25 year, 24-hour rainfall event.

From Reference 2, the 25-year, 24-hour rainfall event is 7.4 inches for Dallas County, Texas.

25-year, 24-hour rianfall depth =	D =	7.40 in.	(Ref. 2)
Containment area =	A =	80,000 sf	

$V_{RAINFALL} = D \times A$

$V_{RAINFALL} =$ 49,333 cf

Prep by: SAB
Date: 4/9/12

Chkd by: DLC
Date: 4/9/12

Skyline Landfill
SECONDARY CONTAINMENT CALCULATION

Storage Tank1 Volume

Tank diameter =	$d =$	14.0 ft
Tank area =	$A_{TANK} =$	154 sf
Tank height =	$h_t =$	29 ft
Height above freeboard level =	$h_{tf} =$	26.5 ft
Tank volume above freeboard =	$V_{TANK1} =$	$h_{tf} \times A_{TANK}$
	$V_{TANK1} =$	4,077 cf

Storage Tank2 Volume

Tank diameter =	$d =$	12.0 ft
Tank area =	$A_{TANK} =$	113 sf
Tank height =	$h_t =$	20 ft
Height above freeboard level =	$h_{tf} =$	17.5 ft
Tank volume above freeboard =	$V_{TANK2} =$	$h_{tf} \times A_{TANK}$
	$V_{TANK2} =$	1,978 cf

Total Tank Volume Above Freeboard Level

$$V_{TANKS} = V_{TANK1} + V_{TANK2}$$
$$V_{TANKS} = 6{,}055 \text{ cf}$$

Required Secondary Containment Volume

$$V_{REQUIRED} = V_{RAINFALL} + V_{TANKS}$$
$$\mathbf{V_{REQUIRED} = 55{,}389 \text{ cf}}$$

c) ***Conclusion***

$$\mathbf{V_{PROVIDED} = 200{,}000 \text{ cf}}$$
$$\mathbf{V_{REQUIRED} = 55{,}389 \text{ cf}}$$

Therefore, the provided secondary containment area will contain the required worst-case release from the two storage tanks and precipitation from the 25-year, 24-hour rainfall event.

SKYLINE LANDFILL
CITY OF FERRIS
DALLAS AND ELLIS COUNTIES, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 42D

PERMIT AMENDMENT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN
ATTACHMENT D7
LINER QUALITY CONTROL PLAN

Prepared for

Waste Management of Texas, Inc.

April 2012

STATE OF TEXAS
DAVID L. CLARK
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4-12-12

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CONTENTS

30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

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CONTENTS (Continued)

30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

CONTENTS (Continued)

30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

4-12-12

TABLES

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-12-12

1 INTRODUCTION

30 TAC §330.339

1.1 Purpose

This Liner Quality Control Plan (LQCP) has been prepared in accordance with 30 TAC §330.339 to establish procedures for the design, construction, testing, and documentation of the liner and leachate collection system.

1.2 Definitions

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

ASTM – American Society for Testing and Material

BER – Ballast Evaluation Report

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.

GLER – Geomembrane Liner Evaluation Report

Geotechnical Professional (GP) – The GP is the authorized representative of the operator 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).

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.

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

Quality Control – Quality control includes the activities that implement the quality assurance program. The GP, CQA monitor, and contractor will perform quality control.

Seasonal High Water Table – The seasonal high water table is the highest measured water level within the construction area.

SLER – Soil Liner Evaluation Report

1.3 Sequence of Construction Activities

Generally construction of lined areas at the Skyline Landfill will proceed in the following sequence of activities:

- The area will be excavated to the proposed subgrade elevations.
- A temporary dewatering system, if required, will be installed as described in Section 3.3.
- The subgrade elevations will be verified.
- The compacted soil liner will be constructed, tested, and verified in accordance with Section 4.
- The geomembrane liner will be constructed, tested, and verified in accordance with Section 5.
- The leachate collection system will be constructed and verified in accordance with Section 6. All soil testing and evaluation of constructed soil liners will be complete prior to installing the leachate collection system.
- The protective cover will be constructed and verified in accordance with Section 7.
- The Soils and Liner Evaluation Report will be submitted to the TCEQ.
- The Geomembrane Liner Evaluation Report will be submitted to the TCEQ.

2 LINER SYSTEM

30 TAC §330.331

2.1 Composite Liner and Leachate Collection Systems

The components of the composite liner system are listed from top to bottom in Table D7-1. Details of the composite liner system are provided in Attachment D3 – Construction Design Details.

Table D7-1
Skyline Landfill
Components of the Composite Liner System

Liner System Component	Description	Thickness
Protective Cover	General earthfill	24 inches
Leachate Collection Layer	Single-sided geocomposite on floor Double-sided geocomposite on side slopes	0.2 inches
Geomembrane Liner	Smooth HDPE geomembrane on floor Textured HDPE geomembrane on side slopes	60 mil
Compacted Soil Liner	Compacted soil with a coefficient of permeability less than or equal to 1×10^{-7} cm/sec	24 inches

The leachate collection layer will be graded to drain to a collection trench along the centerline of each cell. The leachate collection trench will consist of perforated HDPE pipe encased in aggregate. The leachate collection trench will convey leachate to a sump located along the toe of the side slope. A description of the leachate collection system is provided in Attachment D6 – Leachate and Contaminated Water Management Plan, and details of the leachate collection system are provided in Attachment D3 – Construction Design Details.

2.2 Construction Monitoring

Continuous on-site monitoring is necessary to confirm that the components of the liner system are constructed in accordance with this LQCP. In accordance with 30 TAC §330.339(a)(2), the CQA monitor shall provide continuous on-site observation and field sampling and testing as required during the following construction activities:

- Temporary dewatering system installation
- Subgrade preparation

- Compacted soil liner placement, processing, compaction, and testing
- Geomembrane liner deployment, trial welds, seaming, testing, and repairing
- Leachate collection layer deployment and seaming
- Anchor trench backfill
- 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 LQCP. The GP shall make sufficient site visits to observe critical construction activities and to verify that the construction and quality assurance activities are performed in accordance with this LQCP.

3 EARTHWORK

30 TAC §§330.337, 330.339

3.1 General

The proposed grading plan for the remaining cells to be constructed at the Skyline Landfill (Attachment D1 – Landfill Unit Design – Site Layout Plan, Drawing D1.3 – Excavation Plan) provides for the landfill floor to slope at 1 percent to the perimeter sidewalls, which will slope at 5H:1V. The fill area will be divided into cells, each of which has a 2 percent cross slope to a leachate collection trench along the centerline of the cell. Collection trenches will slope to sumps located along the perimeter of the landfill. Earthwork activities and testing will be documented in the SLER in accordance with Section 9.2.

3.2 Materials

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

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.

Compacted Soil Liner

Compacted soil liner materials consist of soil that is free from debris, rubbish, solid waste, organic matter, and meets the requirements of Section 4.2.

Protective Cover

Protective cover materials consist of soil that is free from debris, rubbish, solid waste, organic matter, and meets the requirements of Section 7.2.

Leachate Aggregate

Drainage aggregate consists of natural or manufactured granular material that meets the requirements of Section 6.2.4.

Anchor Trench Backfill

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

Daily and Intermediate Cover

Daily and intermediate cover materials consist of soil that has 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.

Unsuitable Materials

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

3.3 Construction Below Groundwater

3.3.1 Highest Measured Water Elevations

The highest measured water elevations will be used as the design groundwater elevations. The most recent groundwater elevations must be reviewed before the construction of each cell and, if necessary, the highest measured water elevations will be adjusted upward.

3.3.2 Temporary Dewatering

As shown in Attachment D3 – Construction Design Details, Drawing D3.7 – Temporary Dewatering Plan, the excavation for Phase 3 will extend below the highest recorded groundwater elevations in the Stratum I materials in two areas, including portions of the side slope in Cells 13, 14, and 18. Consequently, the liners will be constructed below the highest measured groundwater elevations only in the two locations shown in Drawing D3.7. Areas where the liner is to be constructed below the highest measured groundwater elevations will be dewatered during and after construction by a temporary dewatering system. The temporary dewatering system on the side slopes will consist of geocomposite blanket drains and prefabricated composite drains encased in sand-filled trenches or drainage pipe encased in aggregate. The side slope dewatering trenches will discharge into open sumps beyond the lined areas or closed sumps beneath the lined areas. The groundwater will be pumped from the sumps into the perimeter drainage system. The temporary dewatering system will be operated until sufficient ballast has been placed to offset the hydrostatic forces.

The anticipated location of the temporary dewatering system based on the information from the boring logs is shown in Attachment D3 – Construction Design Details, Drawing D3.7 – Temporary Dewatering Plan. The actual location of the dewatering system will be adjusted based upon where the Stratum I and II interface is exposed in the subgrade. The design procedures and typical details of the temporary dewatering system are provided in Attachment D7, Appendix D7-B – Temporary Dewatering

System. Design and installation of the temporary dewatering system will be documented in the Soils and Liner Evaluation Report (SLER) in accordance with Attachment D7. The facility will submit a Ballast Evaluation Report (BER) to the TCEQ once it is determined that ballasting or dewatering is no longer necessary. If the TCEQ does not provide a response within 14 days of the date of receipt of the BER, the facility will discontinue dewatering or ballasting operations.

3.4 Excavation

A description of the materials that will be encountered in the excavations is provided in Attachment D5 – Geotechnical Design.

The slope stability analyses are provided in Attachment D5, Appendix D5-B – Slope Stability Analyses. The slope stability analyses are only valid for the conditions that were analyzed. Any changes to the excavation plan, dewatering system, ballast system, liner system, final cover system, or landfill completion plan will necessitate that the slope stability analyses be revised to reflect the actual conditions. Interim 3H:1V waste slopes shall not exceed 210 feet in height. Temporary construction slopes shall not be steeper than the interim slopes and concentrated loadings such as heavy equipment and soil stockpiles should not be placed near the crest of slopes unless additional slope stability analyses are performed.

4 COMPACTED SOIL LINER

30 TAC §330.339

4.1 General

The compacted soil liner component of the composite liner system consists of a 24-inch-thick layer of compacted, relatively homogeneous, cohesive material. The CQA monitor shall provide continuous on-site observation during compacted soil liner placement, compaction, and testing in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during compacted soil liner construction to document the construction activities, testing, and thickness verification in the SLER, in accordance with Section 9.2.

4.2 Materials

Compacted soil liner material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material. The required compacted soil liner material properties are summarized in Table D7-2.

Table D7-2
Skyline Landfill
Compacted Soil 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 soil liner materials are listed in Section 4.8.1.

4.3 Subgrade Preparation

Prior to placing soil liner material, the subgrade should be proof-rolled 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 backfilled with compacted general fill.

The subgrade elevations shall be verified in accordance with the requirements of Section 4.8.3 prior to the placement of compacted soil liner.

4.4 Placement and Processing

The compacted soil subgrade and surface of each lift should be roughened prior to placement of the next lift of compacted soil liner. The soil liner 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 10 percent by weight. The surface of the top lift shall contain no material larger than 3/8 inch.

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 worked into the material. Water used for the soil liner compaction must not be contaminated by waste or any objectionable material.

4.5 Compaction

The soil liner 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. Soil liner shall not be compacted with a bulldozer, rubber-tired roller, flat-wheel roller, scraper, truck, or any track equipment unless it is used to pull a footed roller. The compactor should weigh at least 40,000 pounds. The lift thickness shall be controlled to achieve penetration into the top of the previously compacted lift; therefore, the lift thickness should not be greater than the pad or prong length. Cleaning devices on the roller must be in place and maintained to prevent the prongs or pad feet from becoming clogged to the point that they cannot achieve full penetration.

The compactor should 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, recompacted, and retested, and passing tests must be achieved 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 recompacted. Following compaction and fine grading of the final lift, the surface of the compacted soil liner shall be smooth drum rolled.

4.6 Protection

The completed compacted soil liner must be protected from drying, desiccation, rutting, erosion, and ponded water until the geomembrane 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 soil liners shall be cut back on either a slope or steps to prevent the formation of a vertical joint. Details of the existing liner tie-in are shown in Attachment D3 – Construction Design Details.

4.8 Testing and Verification

4.8.1 Preconstruction Testing

Table D7-3 lists the minimum testing required for material proposed for use as compacted soil liner.

Table D7-3
Skyline Landfill
Compacted Soil Liner 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 the required 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 that is required after individual lifts are constructed. Table D7-4 lists the minimum testing required for material used as compacted soil liner.

Table D7-4
Skyline Landfill
Compacted Soil Liner Material Construction Tests

Test	Standard	Frequency
Field Density	ASTM D 2922	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 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[1]	ASTM D 5084 or COE EM 1110-2-1906 Appendix VII	1/100,000 sf per 6-inch lift
Moisture Content	ASTM D 2216	1/100,000 sf per 6-inch lift

[1]In the event that field permeability testing procedures are alternatively used for construction testing, field permeability tests will be performed in accordance with ASTM D5093 or procedures approved by the executive director, or in accordance with guidance furnished by the executive director.

The Atterberg limits of the in-place compacted soil liner must be compared to the Atterberg limits of the Proctor curve sample to assure that the Proctor curve 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 soil liner shall be determined by standard survey methods. Prior to the placement of liner material, the subgrade elevations will be determined at a minimum rate of 1 survey point per 5,000 sf of lined area. After the compacted soil liner is completed, the top of the liner elevations will be determined at the same locations as the subgrade elevations.

5 GEOMEMBRANE LINER

30 TAC §§330.331, 330.339

5.1 General

The geomembrane liner (GM) component of the composite liner system consists of a 60-mil-thick HDPE geomembrane placed over the compacted soil liner. Smooth GM will be placed on the floor liner and GM that is textured on both sides will be placed over the sidewall liner. The CQA monitor shall provide continuous on-site observation during GM deployment, trial welds, seaming, testing, and repairing in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during the GM installation to document the installation and testing in the GLER, in accordance with Section 9.3.

5.2 Materials

5.2.1 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 in the most current revision of the Geosynthetics Research Institute (GRI) Standard GM13. A copy of GRI-GM13 is included in Attachment D7, Appendix D7-E – GRI-GM13.

Manufacturer quality control testing procedures and frequencies for GM are listed in Section 5.5.1. Third party conformance testing procedures and frequencies for GM are listed in Section 5.5.2.

5.2.2 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.

5.3 Preparation

The surface of the compacted soil liner shall be protected in accordance with Section 4.6 until the GM is installed. Prior to installation of the GM, the compacted soil liner shall be tested and verified in accordance with Section 4.8, and the GP or CQA monitor and geosynthetics installer shall inspect the surface of the soil liner to verify that:

- The soil liner surface has been smooth drum rolled.

- The soil liner surface is free of irregularities, soft areas, or loose soil.

- The soil liner surface is free of stones, protrusions, or objects that could damage the GM.

The geosynthetics installer must accept the condition of the compacted soil liner and sign a subgrade acceptance form prior to the installation of the GM.

5.4 Installation

5.4.1 Deployment and Placement

The following activities must take place prior to GM deployment:

- The manufacturer's quality control and third party conformance tests should be completed and approved by the GP in accordance with the requirements of Section 5.5.

- The GP or CQA monitor and geosynthetics installer shall approve the subgrade in accordance with the requirements of Section 5.3.

- The geosynthetics 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 compacted soil liner. GM must not be deployed during periods of rain or high winds and shall not be deployed on top of frozen subgrade. The installer must only deploy the amount of GM that can be seamed on the same day. The GM shall be installed in direct and uniform contact with the compacted soil liner.

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 wearing shoes that could damage the GM 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 side slopes 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.
- Record weather conditions.
- Observe the condition of the subgrade and note any deficiencies. All deficiencies shall be repaired and be approved by the CQA monitor.
- Observe the condition of the GM 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 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 side slopes and that the textured material extends a minimum of 5 feet past the toe of the slope.

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 Seaming

Only welding apparatus and operators that have completed approved trial welds in accordance with Section 5.5.3 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.
- 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 5.4.4.
- 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 than one hour before extrusion welding and the extrudiate has been purged from extrusion welders.
- Observe that there are no horizontal seams on side slopes and that the textured material extends a minimum of 5 feet past the toe of the slope.

5.4.3 Anchor Trenches

The GM anchor trench shall be left open until the seaming is completed. Expansion and contraction of the GM should 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.

5.4.4 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 5.5.4.

5.5 Testing and Verification

5.5.1 Manufacturer's Quality Control Testing

The GM manufacturer shall test the geomembrane and raw materials in accordance with GRI Standard GM13 to assure the quality of the GM.

5.5.2 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 D7-5. Conformance samples may be taken at the manufacturing plant or at the project site and will be forwarded to a third party laboratory for testing. Material property requirements are provided in Section 5.2.1. Minimum conformance testing requirements are provided in Table D7-5.

Table D7-5
Skyline Landfill
GM Conformance Tests

Test	Standard	Frequency
Sheet Thickness	ASTM D 5199, 1593, or 5994	1 per 50,000 sf and every resin lot (1)
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 or 5596	1 per 100,000 sf and every resin lot
Tensile Properties	ASTM D 638	1 per 100,000 sf and every resin lot

[1]Additional thickness testing at laboratory performed in lieu of field thickness testing.

5.5.3 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 1-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 D7-6 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.

5.5.4 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 that 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. 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 it does not, the seam is probably blocked. After the blockage has been located, the seam shall be pressure tested on both sides of the blockage. 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 perform the tests properly.
- Observe that the entire length of each seam is tested and record the results of the test.
- 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 stratified test location per 500 linear feet of seam. Repairs over 10 feet long shall be included in the total seam length. Destructive test samples should be 45 inches long by 12 inches wide with the seam centered along the length of the sample.

Two coupons should 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 D7-6. 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 D7-6. 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 D7-6
Skyline Landfill
GM Seam Properties

Test	Standard	Frequency	Minimum Criteria
Shear	ASTM D 4437	1 sample per 500 feet of seam	Four of five 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 five specimens must be greater than or equal to 95% of sheet strength but not less than 120 ppi.
Peel	ASTM D 4437	1 sample per 500 feet of seam	Four of five 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 five 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. All specimens shall exhibit Film Tear Bond.

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.

5.5.5 Thickness Verification

The CQA monitor shall perform thickness verification tests on each panel unless thickness conformance tests are performed at a frequency of 1 per 50,000 sf. If field thickness testing is required, thickness verification shall be performed with a micrometer at a minimum of one measurement per 5 feet along the leading edge of the panel. A minimum of five tests is required for each panel. No measurement may be less than 90 percent of the nominal panel thickness. The CQA monitor shall record panel numbers, panel dimensions, roll numbers destructive test numbers, and repair numbers.

6 LEACHATE COLLECTION SYSTEM

30 TAC §330.333

6.1 General

The leachate collection system consists of the collection layer, collection trenches, piping, and sumps. Details of the leachate collection system design are provided in Attachment D3 – Construction Design Details. The design capacity calculations are provided in Attachment D6 – Leachate and Contaminated Water Management Plan, Appendix D6-A – Leachate Collection System Design Calculations. Material properties are described in Section 6.2. The CQA monitor shall provide on-site observation during leachate collection layer and piping installation in accordance with 30 TAC §330.339(a)(2). The GP shall make sufficient site visits during the leachate collection system installation to document the installation in the GLER, in accordance with Section 9.3.

6.2 Materials

6.2.1 Geocomposite

The leachate collection layer consists of geocomposite drainage net installed above the GM. 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 D7-7.

Table D7-7
Skyline Landfill
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	150 lb
	Puncture Strength	ASTM D 4833	80 lb
HDPE Drainage Net	Specific Gravity	ASTM D 1505	0.93 g/cm^3
	Thickness	ASTM D 5199	0.20 inch
	Carbon Black	ASTM D 1603	Minimum 2%, maximum 3%
	Tensile Strength	ASTM D 5035	40 lb/in
Floor Geocomposite	Transmissivity	ASTM D 4716	4 x 10^{-4} m^2/sec
Sidewall Geocomposite	Transmissivity	ASTM D 4716	3 x 10^{-5} m^2/sec

Manufacturer quality control testing procedures and frequencies for geocomposite are listed in Section 6.5.1.

6.2.2 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 D7-8.

Table D7-8
Skyline Landfill
Geotextile Properties

Test	Standard	Required Property
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	150 lb
Tear Strength	ASTM D 4533	60 lb
Puncture Strength	ASTM D 4833	80 lb

Manufacturer quality control testing procedures and frequencies for geotextile are listed in Section 6.5.1.

6.2.3 Leachate Pipe

The leachate piping includes perforated collection trench pipes and the solid sidewall riser pipes. The leachate piping shall meet the cell classification PE345434C in accordance with ASTM D 3350. The pipe shall have the minimum SDR rating and perforation schedule shown on the plans and specifications.

6.2.4 Leachate Aggregate

Leachate aggregate will be placed in the collection trenches and in the sumps. The aggregate shall consist of manufactured or natural materials having the properties listed in Table D7-9. Alternate gradations may be approved by the GP.

Table D7-9
Skyline Landfill
Leachate Aggregate Properties

Test	Standard	Required Property	
Gradation	ASTM D 422	Sieve 1 1/2" 1/2" 3/8"	% Passing 90-100 20-50 0-15
Hydraulic Conductivity	ASTM D 2434	$\geq 1 \times 10^{-2}$ 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 6.5.2.

6.2.5 Delivery and Storage

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

6.3 Preparation

Prior to installation of the leachate collection layer the soil liner and GM shall be tested and verified in accordance with Sections 4.8 and 5.5. The CQA monitor shall observe that the surface to receive the geocomposite is free of debris, stones, and dirt and verify that the geocomposite conformance documentation has been submitted and approved.

6.4 Installation

6.4.1 Geocomposite

Double-sided geocomposite shall be installed on sidewalls and single-sided geocomposite shall be installed on the floor. 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 wearing shoes that could damage the geocomposite or GM 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. Additional geotextile will be used at end seams to cover holes made by installation of the plastic fasteners. This material shall be sewn or heat bonded to the geotextile on the geocomposite. The installer shall take precautions to prevent burning holes in the geotextile when using heat bonding techniques.

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 geocomposite or GM do not smoke, wear shoes that could damage the geocomposite or GM, or engage in activities that could damage the geocomposite or GM.
- Observe that the deployment method minimizes wrinkles in the geocomposite and GM.
- 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 repaired or removed and replaced by the installer.

6.4.2 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 geocomposite without damaging or stretching it, and deployment equipment must not damage the underlying geosynthetics. Smoking and wearing shoes that could damage the geotextile, geocomposite, or GM shall not be permitted on the geotextile and only low-ground pressure supporting equipment shall be allowed on the geotextile, geocomposite, or GM. Adjacent rolls shall be overlapped and sewn or heat bonded together. The installer shall take precautions to prevent burning holes in the geotextile when using heat bonding techniques.

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 geotextile, geocomposite, or GM do not smoke, wear shoes that could damage the geotextile, geocomposite, or GM, or engage in activities that could damage the geotextile, geocomposite, or GM.
- Observe that the deployment method minimizes wrinkles in the geotextile, geocomposite, and GM.
- 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 repaired or removed and replaced by the installer.

6.4.3 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, Table D7-14 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 geotextile, geocomposite, or GM do not smoke, wear shoes that could damage the geotextile, geocomposite, or GM, or engage in activities that could damage the geotextile, geocomposite, or GM.
- Observe that construction equipment does not damage pipes, geotextile, geocomposite, or GM.

- 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 removed and replaced by the installer.

6.4.4 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.

6.5 Testing and Verification

6.5.1 Manufacturer's Testing

The geocomposite manufacturer shall test the geocomposite to assure the quality of the geocomposite. Material property requirements are provided in Section 6.2.1. Minimum manufacturer's testing requirements are provided in Table D7-10. The manufacturer's testing shall be conducted at a minimum frequency of 1 test per 100,000 sf of material.

Table D7-10
Skyline Landfill
Geocomposite Manufacturer's Tests

Material	Test	Standard
Geotextile	Weight	ASTM D 5261
	Apparent Opening Size	ASTM D 4751
	Grab Strength	ASTM D 4632
	Puncture Strength	ASTM D 4833
HDPE Drainage Net	Specific Gravity	ASTM D 1505
	Thickness	ASTM D 5199
	Carbon Black	ASTM D 1603
Geocomposite	Transmissivity	ASTM D 4716

The geotextile manufacturer shall test the geotextile to assure the quality of the geotextile. Material property requirements are provided in Section 6.2.2. Minimum manufacturer's testing requirements are provided in Table D7-11. The manufacturer's testing shall be conducted at a minimum frequency of 1 test per 100,000 sf of material.

Table D7-11
Skyline Landfill
Geotextile Manufacturer's Tests

Test	Standard
Weight	ASTM D 5261
Apparent Opening Size	ASTM D 4751
Grab Strength	ASTM D 4632
Tear Strength	ASTM D 4533
Puncture Strength	ASTM D 4833

The leachate piping manufacturer shall provide a certification that the pipe meets the cell classification PE345434C in accordance with ASTM D 3350, and the minimum SDR rating and perforation schedule shown on the plans and specifications.

6.5.2 Construction Testing

The leachate aggregate shall be tested to assure that the aggregate meets the specifications. Material property requirements are provided in Section 6.2.4. Minimum construction testing requirements are provided in Table D7-12.

Table D7-12
Skyline Landfill
Leachate Aggregate Construction 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.

6.5.3 Verification

The as-built location of the leachate piping shall be determined and reported in the GLER. All components of the leachate collection system shall be verified and documented in the GLER in accordance with Section 9.3.

7 PROTECTIVE COVER

30 TAC §330.339

7.1 General

The protective cover component of the composite liner system consists of a 24-inch-thick layer of soils placed over the leachate collection layer. The drainage aggregate 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 in accordance with 30 TAC §330.339(a)(2). 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 9.3.

7.2 Materials

Protective cover material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material, or any material that could damage the underlying geosynthetics. Since drainage aggregate chimneys will be provided above the LCS trenches, there are no permeability requirements for protective cover materials.

7.3 Preparation

Prior to placing the protective cover material, the top of compacted soil liner elevations shall be verified in accordance with the requirements of Section 4.8.3 and all testing on the underlying geosynthetics shall be completed.

7.4 Placement

The 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 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, protective cover shall be placed from the bottom to the top, not across or down. Protective cover shall not be placed over geosynthetics that are stretched across the toes of slopes. The minimum separation distances between construction equipment and the geosynthetics are listed in Table D7-13.

Table D7-13
Skyline Landfill
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
< 4	12
4 - 8	18
8 - 16	24
> 16	36

Any geosynthetic material that, in the opinion of the CQA monitor, has been damaged by the protective cover placement must be repaired and retested in accordance with Sections 5.4 and 6.4.

7.5 Testing and Verification

7.5.1 Testing

If the protective cover is counted as ballast against hydrostatic forces, the field density of the in-place protective cover shall be determined at a rate of 1 test per 10,000 sf. The in-place field density will be determined for information only, and there is no minimum compaction requirement for protective cover.

7.5.2 Thickness Verification

The as-built thickness of the protective cover shall be determined by standard survey methods. Prior to the placement of protective cover, the top of compacted soil liner elevations will be determined at a minimum rate of 1 survey point per 5,000 sf 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 compacted soil liner elevations.

8 BALLAST

30 TAC §330.337

8.1 General

The highest measured water elevations are presented in Attachment D7, Appendix D7-A – Highest Measured Water Levels and represent the highest groundwater elevations that have been encountered at the site. The highest measured water elevations will be used as the design groundwater elevations. The most recent groundwater elevations must be reviewed before the construction of each cell and, if necessary, the highest measured water elevations must be adjusted upward. Lined areas will be dewatered during and after construction using a temporary dewatering system as described in Section 3.3.2.

Long-term hydrostatic uplift pressures will be resisted by the weight of the materials placed above the geomembrane liner in accordance with §330.337. Ballast includes the weight of the leachate collection system, protective cover, and compacted waste. The ballast will be documented in the BER in accordance with Section 9.4.

8.2 Ballast Geometry

For each new lined area, the GP will prepare calculations to determine the geometry of the ballast that is required to prevent hydrostatic uplift of the liner system with a minimum factor of safety of 1.5. Procedures for calculating the height of compacted waste or additional protective cover soil above the liner system needed to ballast hydrostatic pressure are provided in Attachment D7, Appendix D7-C – Ballast Calculations, along with example calculations.

8.3 Ballast Materials

Ballast will consist of protective cover, leachate aggregate, infiltration layer, erosion layer, and solid waste. Material properties for protective cover are listed in Section 7.2 and material properties for leachate aggregate are listed in Section 6.2.4. Solid waste ballast will consist of waste accepted at the site in accordance with Part IV – Site Operating Plan. Large, bulky items must be excluded from the initial 5 feet of waste ballast.

8.4 Ballast Placement

Landfill personnel will be on site full time during the placement of the first 5 feet of waste over the liner system. They will verify and document that the initial 5 feet of waste does not contain large, bulky items which could damage the liner system or which cannot be compacted to the required density. Waste ballast must be compacted to a density of not less than 1,200 lb/cy or 44 pcf. The site manager will document that the waste used for ballast has been compacted with multiple passes of a wheeled compactor that weighs in excess of 40,000 pounds. The form to be used by the landfill manager is included in Attachment D7, Appendix D7-D – Waste-for-Ballast Placement Record. This documentation will be placed in the site operating record and attached to the BER.

8.5 Testing and Verification

Where protective cover is used as ballast, it will be tested in accordance with Section 7.5.1 and test results will be used to calculate the required ballast thickness. Where protective cover is not tested, the protective cover will be assumed to have a density of 90 percent of the maximum dry density of the material. Waste ballast compaction will be verified by the site manager and documented on the Waste-for-Ballast Placement Record. The GP will verify that the temporary dewatering system prevented uplift forces on the liner during construction of the liner. The verification will include observations of water levels in the dewatering sumps or survey data as deemed appropriate by the GP. The site manager will document that the dewatering system remained operational until ballast was placed. The documentation will be placed in the site operating record.

Once the calculated height of compacted waste has been achieved for each cell area, the temporary dewatering system no longer needs to remain operational and the groundwater can be allowed to rebound against the bottom of the liner system. Before submittal of the BER, the GP will review compaction information and density of material used as ballast, and the thickness of all materials used in Ballast Calculations. A BER must be submitted to the TCEQ in accordance with Section 9.4 to document that adequate ballast height has been achieved and to request that the temporary dewatering system operations be discontinued.

9 DOCUMENTATION

30 TAC §330.341

9.1 Reports

Each report shall be submitted in triplicate to the Municipal Solid Waste Division and shall be prepared in accordance with the methods and procedures contained in this LQCP. The evaluated area should not be used for the receipt of solid waste until acceptance is received from the executive director. The executive director may respond to the permittee either verbally or in writing within 14 days from the date on which the SLER document is date-stamped by the Municipal Solid Waste Division. Verbal acceptance may be obtained from the executive director, which will be followed by written concurrence. If no response, either written or verbal, is received within 14 days, the SLER or GLER shall be considered accepted and the owner or operator may continue facility construction or operations. Each report must be signed and, where applicable, sealed by the individual performing the evaluation and countersigned by the site operator or his authorized representative.

Markers will be placed to identify all disposal areas for which a SLER has been submitted and accepted by the executive director. These markers shall be located so that they are not destroyed during operations.

The surface of a liner should 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 SLER evaluator, who shall then submit a letter report on his findings to the executive director. Any required repairs shall be performed properly. A new SLER shall be submitted on the new construction for all liners that need repair due to damage.

9.2 Soils and Liner Evaluation Report

After construction of the compacted soil liner, the GP will submit a Soils and Liner Evaluation Report (SLER) to the TCEQ on behalf of the owner. Preparation and submission of the SLER shall be in accordance with TCEQ MSWR. The purpose of the SLER is to document that the construction methods and test procedures are consistent with this LQCP, the TCEQ MSWR, and the project specifications.

At a minimum, the SLER will contain the following:

- A summary of all construction activities
- A summary of 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
- A statement of compliance with the LQCP
- An updated seasonal high water table map
- A detailed description of the temporary dewatering system
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

9.3 Geomembrane Liner Evaluation Report

After construction of the geosynthetics portion of the liner, the GP will submit a Geomembrane Liner Evaluation Report (GLER) to the TCEQ on behalf of the owner. Preparation and submission of the GLER shall be in accordance with TCEQ MSWR. The purpose of the GLER is to document that the construction methods and test procedures are consistent with this LQCP, the TCEQ MSWR, and the project specifications.

At a minimum, the GLER will contain the following:

- A summary of all construction activities
- A summary of all laboratory and field test results
- Sampling and testing location
- A description of significant construction problems and the resolution of these problems
- Record drawings
- A statement of compliance with the LQCP
- An updated seasonal high water table map
- A brief description of the temporary dewatering system
- Calculations for the required ballast thickness
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

9.4 Ballast Evaluation Report

For areas where waste is used for ballast, a Ballast Evaluation Report (BER) will be completed and submitted to the TCEQ. The purpose of the BER is to document that sufficient ballast has been placed to offset the potential long-term hydrostatic uplift forces that may exist below the liner system. The BER will provide documentation that the temporary groundwater control system is no longer required. The BER shall include the following information:

- Names and phone numbers of contact persons.
- Evaluation by the GP documenting that detrimental uplift has not occurred within the liner system. The evaluation shall include survey data as deemed pertinent by the GP.
- Certification from the owner of the type of waste placed in the lower 5 feet and documentation of the compaction from the Site Operating Record (see form in Attachment D7, Appendix D7-D – Waste-for-Ballast Placement Record).
- Survey of the top of waste to document that the required thickness has been placed.
- Documentation that any dewatering system used to lower the groundwater level during liner construction was in effect throughout the completion of the ballast placement.
- Documentation that the seasonal high water elevation has not increased from that presented in Attachment D7, Appendix D7-A – Highest Measured Water Levels, or that additional ballast has been provided to compensate for upward changes in the high water table during ballast placement.
- The signature and seal of the registered professional engineer performing the evaluation and the signature of the owner's authorized representative.

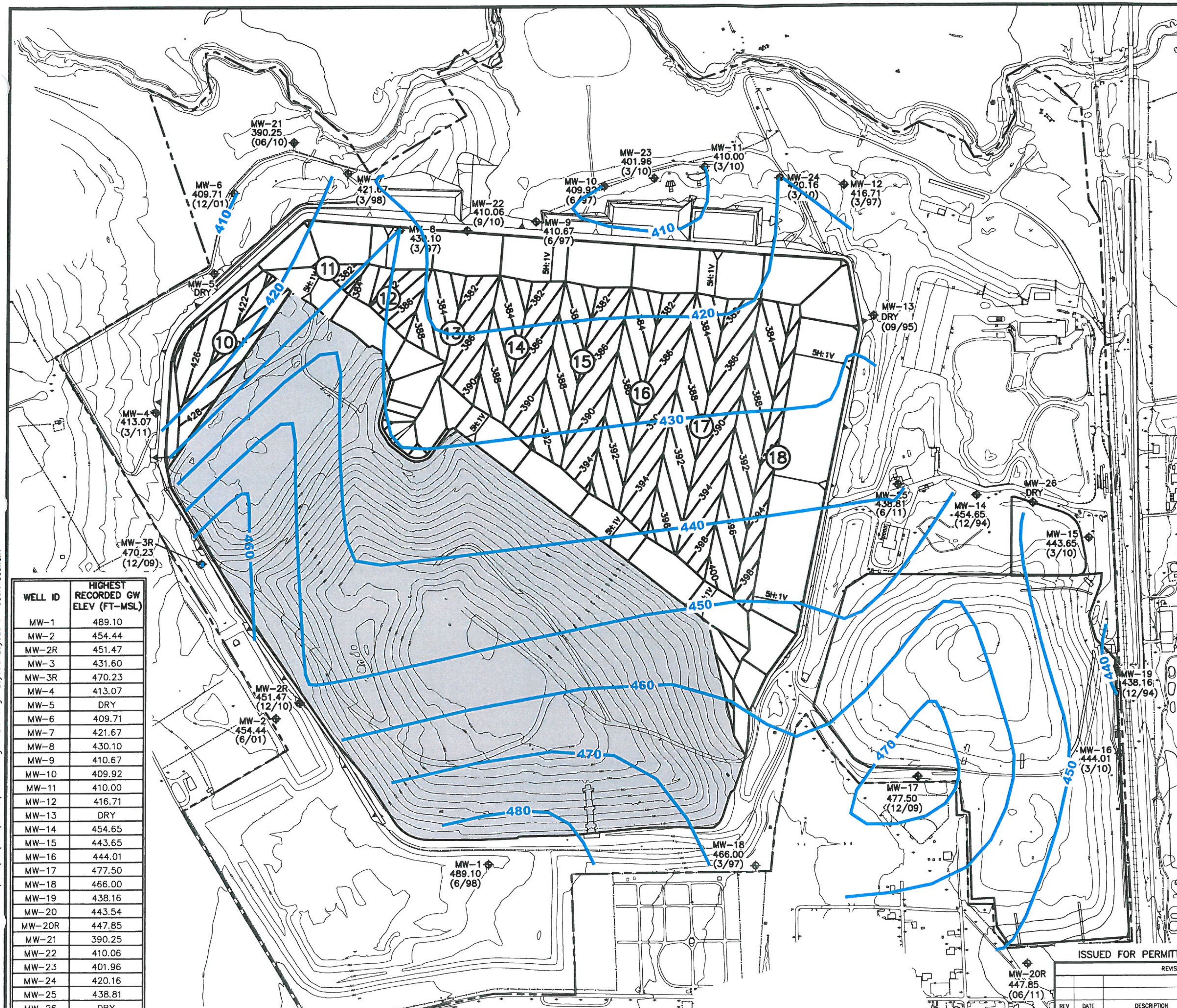
If adequate ballast is placed on a liner as part of the construction process it will be documented in the GLER. If it is documented in the GLER that adequate ballast is present to counteract any hydrostatic uplift, a separate BER will not be required or submitted for that particular liner installation.

SKYLINE LANDFILL

APPENDIX D7-A
HIGHEST MEASURED WATER LEVELS

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

4-12-12



WELL ID	HIGHEST RECORDED GW ELEV (FT-MSL)
MW-1	489.10
MW-2	454.44
MW-2R	451.47
MW-3	431.60
MW-3R	470.23
MW-4	413.07
MW-5	DRY
MW-6	409.71
MW-7	421.67
MW-8	430.10
MW-9	410.67
MW-10	409.92
MW-11	410.00
MW-12	416.71
MW-13	DRY
MW-14	454.65
MW-15	443.65
MW-16	444.01
MW-17	477.50
MW-18	466.00
MW-19	438.16
MW-20	443.54
MW-20R	447.85
MW-21	390.25
MW-22	410.06
MW-23	401.96
MW-24	420.16
MW-25	438.81
MW-26	DRY

J:\101\01\120\ATT D\D7A-1-HighGWElev.dwg Layout: Layout 1 User: scundiff

0 300 600
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LANDFILL FOOTPRINT
- 550 EXISTING GROUND CONTOUR
- 470 GROUNDWATER CONTOUR
- 420 PROPOSED EXCAVATION CONTOUR
- PHASE BOUNDARY
- CELL BOUNDARY
- (10) CELL DESIGNATION
- LINED AREA
- MW-20 MONITORING WELL

NOTE:

1. EXISTING CONTOURS COMPILED BY AEROMETRIC FROM AERIAL PHOTOGRAPHY. FLOWN MARCH 6, 2011. COORDINATE SYSTEM IS BASED ON TEXAS STATE PLANE NAD 27, TEXAS NORTH CENTRAL ZONE, US FEET.
2. THE HIGHEST RECORDED GROUNDWATER CONTOURS ARE BASED ON GROUNDWATER OBSERVATIONS ON THE DATES SHOWN. THIS IS NOT A POTENTIOMETRIC SURFACE MAP.

STATE OF TEXAS
DAVID L. CLARK
81905
REGISTERED PROFESSIONAL ENGINEER
4-12-12

ISSUED FOR PERMITTING PURPOSES ONLY

HIGHEST RECORDED GROUNDWATER ELEVATIONS

WASTE MANAGEMENT OF TEXAS, INC. SKYLINE LANDFILL MAJOR PERMIT AMENDMENT

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

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

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

DSN.	SAB	DATE :	04/12	DRAWING
DWN.	SRC	SCALE :	GRAPHIC	D7A-1
CHK.	DLC	DWG :	D7A-1-HighGWElev.dwg	

Skyline Landfill
Historic Water Levels – Monitoring Wells (Continued)

Sampling Date	MW-14	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20	MW-20R	MW-21	MW-22	MW-23	MW-24	MW-25	MW-26
Dec-94	454.65		432.96	453.65	459.26	438.16	434.37							
Mar-95	451.96	424.80	442.36	460.17	463.50	437.38	438.72							
Jun-95	450.21	425.96	443.08	461.91	465.23	436.75	438.93							
Sep-95	450.18	426.01	441.25	461.36	463.27	436.57	437.58							
Dec-95	448.78	425.21	437.20	461.26	461.44	436.51	436.67							
Mar-96	447.36	425.37	437.16	462.60	461.27	436.88	440.40							
Jun-96	447.11		438.74	462.71	461.31	435.88	434.84							
Sep-96	449.63	425.34	440.02	462.68	463.39	436.60	437.19							
Dec-96	449.89	425.05	440.94	463.04	464.80	437.11	438.18							
Mar-97	449.61	424.95	441.01	462.96	466.00	436.40	439.45							
Jun-97	449.23	426.80	441.80	463.42	463.74	435.50	438.64							
Sep-97		426.47												
Dec-97	450.06	429.94	441.42	464.47	462.91	437.80	440.03							
Mar-98		426.80												
Jun-98	448.94	427.63	442.26	465.14	462.37	436.60	441.87							
Sep-98		426.25												
Jun-01	452.19	431.92	442.76	469.69	461.76	435.67	443.54							
Aug-01		427.80	438.26											
Dec-01	452.84	427.16	438.96	468.76	460.53	436.60	439.80							
Jun-02	451.42	428.56	443.34	471.62	462.24	434.92	441.32							
Dec-02	451.14	428.07	441.13	470.52	459.80	436.00	438.36							
Jun-03	452.07	432.60	442.25	470.71	461.34	434.58	DRY							
Aug-03		427.86												
Dec-03	450.69	DRY	440.04	469.12	458.88	435.26								
Jun-04	452.87	429.44	442.99	470.17	461.81	434.70		438.97						
Dec-04	452.02	433.63	443.25	471.54	462.49	436.43		439.93						
Jun-05	451.23	436.56	442.19	470.44	461.04	434.19		439.63						
Dec-05	448.33	428.25	435.62	470.02	457.90	435.02		437.35						
Jun-06	450.77	426.30	437.64	469.56	458.90	433.97		437.99						
Dec-06	451.00	426.47	437.56	469.39	458.24	435.87		437.03						
Mar-07	452.46	427.28	440.44	469.82	459.56	435.65		436.03						
Jun-07	454.26	443.40	442.41	476.64	461.38	434.83		435.58						
Dec-07	452.91	442.52	441.82	470.79	462.05	435.91		440.83						
Jun-08	452.66	441.58	442.73	471.89	462.49	434.50		444.92						
Dec-08	449.41	433.80	437.63	470.42	459.08	435.20		440.88						
Jun-09	453.34	441.87	438.36	470.83	460.90	434.27		440.83						
Sep-09	451.72	432.46	439.08	469.36	459.87	433.90		436.03						
Dec-09	454.31	443.38	443.53	477.50	463.02	435.38		437.03						
Mar-10	454.15	443.65	444.01			435.04			DRY	DRY	401.96	420.16	437.93	DRY
Jun-10	452.54	440.98	442.05	474.64	462.22	433.76		445.28	390.25	398.46	400.34	416.99	437.83	DRY
Sep-10		434.05							388.90	410.06	398.57	415.97	438.66	DRY
Dec-10	451.51	430.78	440.01	473.22	464.60	435.20		447.71	389.63	400.81	398.42	417.78	438.42	DRY
Jan-11				472.09										
Mar-11									388.35	400.26	399.61	419.82	438.80	DRY
May-11														
Jun-11	451.14	439.63	440.49	471.27	461.32	434.08		447.85	DRY	DRY	398.11	416.92	438.81	DRY
Sep-11									DRY	403.21	396.41	410.80	437.89	DRY

SKYLINE LANDFILL

APPENDIX D7-B
TEMPORARY DEWATERING SYSTEM

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-12-12

Includes pages D7-B-1 through D7-B-4

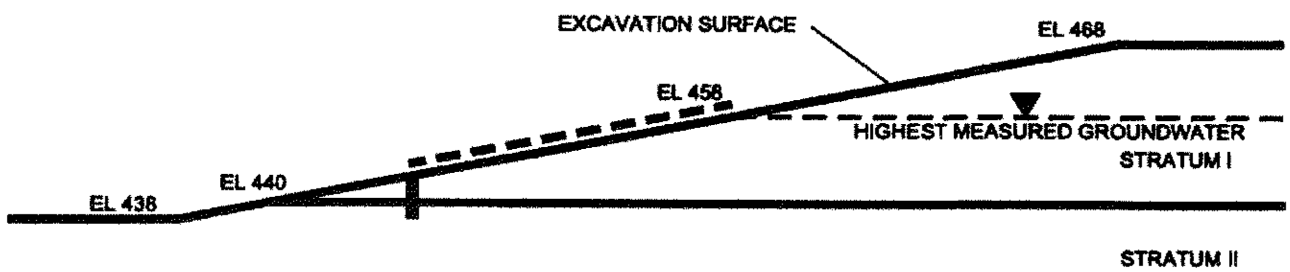
Skyline Landfill
Temporary Dewatering Inflow Rate

Required: Determine the inflow rate to the sidewall drain of the temporary dewatering system:

References: *Dewatering and Groundwater Control*, UFC 3-220-05, January 2004 (replaces TM 5-818-5).

Assumptions: The temporary dewatering system will be designed for the highest recorded water levels (see Drawing D7A-1).
The dewatering system plan and details are shown on Drawings D3.7 And D3.8.
The boundary of the uppermost ground water bearing unit (GWBU) is at the top of Stratum II.

Solution: ***Sidewall Drain***
The sidewall drain consists of a geocomposite blanket that discharges into the composite trench drain. The geocomposite will extend to the highest measured water level. The critical section will occur in Cell 18 where Stratum I daylights in the excavation sideslope and the highest measured groundwater level is the highest. The critical sidewall drain section is shown below.



H_1 = design water height =	18 ft
H_2 = trench drain height =	3 ft
H = saturated layer thickness ($H_1 - H_2$) =	15 ft
L = length of trench drain	950 ft

Use Darcy's equation to estimate the inflow into the toe drain.

$Q = KiA$

where:

Q = design flowrate	
K = hydraulic conductivity of GWBU =	1.00E-07 cm/sec
=	3.28E-09 fps
i = average hydraulic gradient (see Appendix E6) =	0.023 ft/ft
A = flow area (H x L) =	14250 sf

Q = 1.08E-06 cfs

Skyline Landfill
Temporary Dewatering System

Required: Size the following elements of the temporary dewatering system:
1) Composite Drains
2) Pump

References: 1) *KTC-97-5, SPR-92-143, "Performance and Cost Effectiveness of Pavement Edge Drains",* L. John Fleckenstein, Kentucky Transportation Center, 1997.

Assumptions:
1) The dewatering system plan and details are shown on Drawings D3.7 And D3.8.
2) The largest flow in a composite drain will be the trench drain on the Cell 18 sideslope.
3) Flow rates are from the inflow rate calculations.

Solution

1) Maximum flowrate equals combined underdrain and sidewall flowrate.

Q = maximum flowrate = 1.08E-06 cfs
= 4.83E-04 gpm

Flow capacity of 12" ADS Composite Drain = 39.0 gpm

2) Use the maximum flowrate to the sump to size the pump with a 1.5 factor of safety.

Q_p = pumping rate = 7.24E-04 gpm

Skyline Landfill
Temporary Dewatering Geosynthetic Design

Required: Determine the minimum geosynthetic properties for temporary dewatering system:
1) Geotextile for the composite drain.
2) Gecomposite for the sidewall drain.

References: 1) *Designing with Geosynthetics,* Fourth Edition; Robert M. Koerner.

Assumptions: 1) The adjacent soils will have at least 50% finer than the No. 200 sieve.

Solution: 1) *Geotextile*

Calculate the required permittivity from the equation:

$$\Psi_{req} = q / \Delta hA$$

where: Ψ_{req} = permittivity

q = peak inflow rate =	1.08E-06 cfs
Δh = maximum allowable head =	3.0 ft
L = trench length =	950 ft
H = drain height =	1.0 ft
A = inflow area = L x 2H =	1900.0 sf

Substitute and solve for required permittivity = 1.8865E-10 sec^{-1}

Calculate the allowabe permittivity from Reference 1, Equation 2.25.

$$\Psi_{req} = \Psi_{all} \ (1 / RF_{SCB} \ X \ RF_{CR} \ X \ RF_{IN} \ X \ RF_{CC} \ X \ RF_{BC})$$

where:

RF_{SCB} = soil clogging/binding reduction factor =	7.0 (Ref. 1, Table 2.12)
RF_{CR} = creep reduction factor =	1.5 (Ref. 1, Table 2.12)
RF_{IN} = intrusion reduction factor =	1.2 (Ref. 1, Table 2.12)
RF_{CC} = chemical clogging reduction factor =	1.0 (Ref. 1, Table 2.12)
RF_{BC} = biological clogging reduction factor =	1.0 (Ref. 1, Table 2.12)

Substitute and solve for allowable permittivity = 2.4E-09 sec^{-1}

Determine the appropriate soil retention criteria from Reference 1, Figure 2.4.

For fine-grained, non-dispersive soils the AOS must be less than 0.21mm.

2) *Geocomposite*

Required transmissivity (T_{req}) = inflow rate / max drainage width

where: inflow rate =	1.08E-06 cfs
max drainage width =	120 ft
T_{req} =	8.96E-09 ft^2/sec

Skyline Landfill
Temporary Dewatering Geosynthetic Design

Calculate the allowable transmissivity from Reference 1, Equation 4.5.

$$T_{all} = T_{req} \, (RF_{SCB} \, X \, RF_{CR} \, X \, RF_{IN} \, X \, RF_{CC} \, X \, RF_{BC})$$

where:	RF_{SCB} = soil clogging/binding reduction factor =	7.0 (Ref. 1, Table 2.12)
	RF_{CR} = creep reduction factor =	1.5 (Ref. 1, Table 2.12)
	RF_{IN} = intrusion reduction factor =	1.2 (Ref. 1, Table 2.12)
	RF_{CC} = chemical clogging reduction factor =	1.0 (Ref. 1, Table 2.12)
	RF_{BC} = biological clogging reduction factor =	1.0 (Ref. 1, Table 2.12)

T_{all} =	**1.13E-07**	**ft^2/sec**
=	**1.05E-08**	**m^2/sec**

SKYLINE LANDFILL

APPENDIX D7-C
BALLAST CALCULATIONS

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
4-12-12

Includes pages D7-C-1 through D7-C-6

LINER BALLAST CALCULATIONS

The required ballast thickness shall be calculated by the GP and included in the GLER. The ballast calculation shall be based on the as-built conditions and the updated highest groundwater elevations. The required ballast thickness shall be calculated as follows:

A. Review and update, as necessary, the water level elevations (see Attachment D7, Appendix D7-A – Highest Measured Water Levels). Adjust the seasonal high water table upward, if necessary, across the area being lined using the highest measured water levels derived from the most recent piezometer water level readings. Determine the design water level for the area being analyzed. The lined area may be subdivided into more than one area as appropriate for changes in groundwater table elevations and/or subgrade elevations across the lined area.

B. Determine the hydrostatic uplift pressure on the base of the bottom and sidewall liner system including normal, vertical, and horizontal components of the uplift pressure as follows:

1. Bottom Liner: Determine the maximum hydrostatic uplift pressures acting normal to the base of the bottom liner system using the unit weight of water, γ_W, times the vertical distance from the excavation to the design water level, H.

$$P_N = \gamma_W H$$

2. Sidewall Liner: Determine the maximum hydrostatic uplift pressures acting normal, vertical, and horizontal to the base of the sidewall liner system using the following steps.

(a) Determine the maximum normal uplift pressure on the sidewall liner using the unit weight of water times the vertical distance from the base of the layer to the design water level, H.

$$P_N = \gamma_W H$$

(b) Determine the maximum vertical uplift pressure on the sidewall liner using the normal uplift pressure times the cosine of the slope angle.

$$P_V = P_N \cos \beta$$

(c) Determine the maximum horizontal uplift pressure on the sidewall liner using the normal uplift pressure times the sine of the slope angle.

$$P_H = P_N \sin \beta$$

C. Determine the resisting pressure against uplift of the bottom and sidewall liner system including normal, vertical, and horizontal components of the resisting pressures as follows:

1. Bottom Liner: Determine the normal resisting pressure at the GM using the unit weight of the protective cover times the thickness of the protective cover.

$$R_N = (\gamma_{pc}\, T_{pc})$$

Where: γ_{pc} = Wet unit weight of the protective cover
T_{pc} = Thickness of the protective cover

The unit weight of the protective cover shall be determined from field measured unit weights.

2. Sidewall Liner:

(a) Determine the vertical resisting pressure of the sidewall liner using the unit weight of the protective cover material times the vertical thickness of the protective cover layer. This is equal to the normal resisting pressure divided by the cosine of the slope angle.

$$R_v = R_N / \cos\beta$$

(b) Determine the horizontal resisting pressure of the sidewall liner using the coefficient of at-rest earth pressure of the liner system components times the vertical resisting pressure.

$$R_H = K_O\, R_V$$

The coefficient of at-rest earth pressure, K_O, is based on the assumed angle of internal friction, ϕ, of the material resisting hydrostatic pressures (compacted soil).

(c) Determine the normal resisting pressure of the sidewall liner system using the normal components of the horizontal and vertical resisting pressures calculated in steps (a) and (b) above.

$$R_N = R_H \sin\beta + R_V \cos\beta$$

D. Evaluate the factor of safety against uplift of the bottom and sidewall liner system due to hydrostatic pressures.

1. Bottom Liner: Determine the factor of safety against uplift of the bottom liner system due to hydrostatic forces acting normal to the base of the bottom liner system.

$$FS = R_N / P_N$$

If the factor of safety is greater than or equal to 1.2, the protective cover provides sufficient ballast to offset the hydrostatic uplift forces.

If the factor of safety is less than 1.2, additional ballast in the form of solid waste or additional soil will be necessary to offset the hydrostatic forces. See Step E for determining the geometry of solid waste or additional ballast.

2. Sidewall Liner:

Determine the factor of safety against uplift of the sidewall liner system due to hydrostatic pressures acting normal, vertical, and horizontal to the sidewall liner system.

$$FS_N = R_N / P_N$$

$$FS_V = R_V / P_V$$

$$FS_H = R_H / P_H$$

If the factors of safety are greater than or equal to 1.2, the protective cover provides sufficient ballast to offset the hydrostatic forces.

If the factor of safety is less than 1.2 for any of the components (normal, vertical, or horizontal), additional ballast in the form of solid waste or additional soil will be necessary to offset the hydrostatic forces. See Step E for determining the geometry of solid waste or additional soil ballast.

E. Use a factor of safety of 1.5 against uplift of the liner and ballast system for solid waste ballast and a factor of safety of 1.2 for soil ballast.

Assume a unit weight of 44 pcf for solid waste and a unit weight of 100 pcf for soil if field measurements are not available, or if conditions indicate the field measurements are no longer applicable.

1. Bottom Liner

The factor of safety against uplift of the liner and ballast system is calculated as follows:

$$FS = (R_N + B_N) / P_N$$

Where R_N = Normal protective cover pressure
B_N = Normal ballast pressure
B_N = $H * \gamma$
FS = 1.5 for waste, 1.2 for soil

Solving the above equation for the height of ballast:

$$H = (FS\ P_N - R_N) / \gamma$$

2. Sidewall Liner

The factor of safety against uplift of the liner and ballast system is calculated as follows:

(a) $FS = (R_V + B_V) / P_V$

Where R_V = Vertical protective cover pressure
B_V = Vertical ballast pressure
B_V = H * γ
FS = 1.5 for waste, 1.2 for soil

Solving the above equation for the height of ballast:

$$H = (FS\ P_V - R_V) / \gamma$$

(b) $FS = (R_H + B_H) / P_H$

Where R_H = Horizontal protective cover pressure
B_H = Horizontal ballast pressure
B_H = $B_V * K_0$
B_H = H * γ * 0.7
FS = 1.5 for waste, 1.2 for soil

Solving the above equation for the height of ballast:

$$H = (FS\ P_H - R_H) / \gamma * k_0$$

Example calculations are provided on pages D7-C-5 through D7-C-6.

Required: Evaluate the long-term hydrostatic uplift pressures on the liner system and determine the ballast requirements.

References: 1) *Guidance Handbook for Liners Constructed Below the Groundwater Table,* TNRCC, 1995.

Assumptions:
1) The design water elevations are shown on Drawing D7A-1.
2) All cells must be re-evaluated based on updated groundwater data prior to construction.
3) Assume normal and vertical forces to be the same in the bottom, and design for normal forces.
4) Uplift is evaluated at the clay liner geomembrane interface.
5) Groundwater is present in Stratum I but not in Stratum II.

Solution:

Calculations are shown for the toe of the southern end of Cell 18 where the exposed Stratum I material has the highest groundwater potential.The results for other locations (Cell 13/14) are provided in the table at the end of the calculations.

The forces acting upon the liner system are:

P_N = normal pressure	R_N = normal resistance
P_V = vertical pressure	R_V = vertical resistance
P_H = horizontal pressure	R_H = horizontal resistance

1) Determine the uplift pressure upon the FML at the bottom and at the toe of the slopes.

γ_w = unit weight of water =	62.4 pcf
Groundwater elevation =	458 ft-msl
Liner elevation =	442 ft-msl
H = design water level above liner =	16 ft
b = sidewall slope =	11.3 deg

Bottom $P_N = H\gamma_w =$ 998.4 psf

Slope

$P_N = H\gamma_w =$ 998.4 psf

$P_H = P_N \sin\beta =$ 195.6 psf

$P_V = P_N \cos\beta =$ 979.0 psf

2) Determine the resistance pressure at the bottom and on the slope.

Protective cover:

γ = density (92% std proctor or field data) =	115.0 pcf
T_N = normal thickness =	2.0 ft
T_V = vertical thickness =	2.0 ft
ϕ = angle of internal friction =	11.3 deg

Waste:

γ_{waste} = density =	44.0 pcf
T_V = vertical thickness =	75.0 ft

Infiltration:

γ = density (95% std proctor or field data) =	120.0 pcf
T_V = vertical thickness =	1.5 ft

Erosion:

γ = density (90% std proctor or field data) =	110.0 pcf
T_V = vertical thickness =	3.0 ft

Bottom $R_N = \Sigma T_N \gamma =$ 4040.0 psf

Slope

$R_H = k_o R_V =$ 2022.3 psf where k_o assumed at 0.5

$R_V = \Sigma T_V \gamma =$ 4044.5 psf

$R_N = R_V \cos\beta + R_H \sin\beta =$ 4362.4 psf

3) Determine the factors of safety against uplift and evaluate the need for additional ballast.

Bottom $FS_N = R_N / P_N =$ 4.0

Slope $FS_H = R_H / P_H =$ 10.3
$FS_V = R_V / P_V =$ 4.1
$FS_N = R_N / P_N =$ 4.4

4) Based on the above calculation, the critical condition occurs at the toe of the slope.
Evaluate the normal factor of safety for other points on the liner. The normal resistance provided by the protective cover and final cover system is the same for all points in the lined area.

R_N (cover soils) = 740 psf

Cell	GM EL	GW EL	H	Hwaste	R_N	P_N	FS
Cell 13/14	406.0	413.0	7.0	61.0	3424.0	436.8	7.8

5) Check the height of waste in each sector when the underdrain will no longer be needed. The normal resistance provided by the protective cover is the same for all points in the lined area.

R_N (cover soil) 230 psf

Cell	GM EL	GW EL	H	FS	P_N	R_N	Hwaste [1]
Cell 18	442.0	458.0	16.0	1.5	998.4	1497.6	28.8
Cell 13/14	406.0	413.0	7.0	1.5	436.8	655.2	9.7

[1] The height of waste is specific to the evaluation point, not the landfill floor. A Ballast Evaluation Report will be submitted to the TCEQ prior to decomissioning the underdrain system.

SKYLINE LANDFILL

APPENDIX D7-D
WASTE-FOR-BALLAST PLACEMENT RECORD

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

4-12-12

WASTE-FOR-BALLAST PLACEMENT RECORD

This form is to be completed by the landfill manager for all landfilled areas requiring waste-for-ballast. One form will be developed for each area as addressed in a Soil and Liner Evaluation Report (SLER). The Professional of Record (POR) may reference this form in order to certify that the placement of ballast is in compliance with the LQCP.

GENERAL INFORMATION

Area documented by this record (provide site grid coordinates of each corner):

____

____

____

____

SLER approval date for this area: ____________

Date of initial waste placement: ____________

Date of completion of first 5 feet of waste in place over entire area: ____________

Total required waste-for-ballast thickness for this area:
(Note: Calculations for determining the required thickness of waste-as-ballast will be included with the SLER for this area.) ____________

Date when minimum required thickness of waste was achieved: ____________

Actual waste-for-ballast thickness demonstrated by this record: ____________

WASTE EQUIPMENT USED

☐ 40,000-pound minimum gross weight wheeled compactor.
Specify equipment used:____________________________

FIRST LIFT CONSIDERATIONS

☐ No brush, large, bulky, elongated or other waste items which could damage the underlying liner system have been placed within the first 5 feet of waste above the top of the protective cover.

☐ A 5-foot lift of loose waste (acceptable waste defined above) has been maintained between the waste compaction equipment and the top of the liner protective cover in all fill areas to allow uniform compaction of the waste material.

☐ Describe type(s) of waste placed in the first 5 feet of waste over the top of the liner protective cover.

____

____

WASTE COMPACTION METHODS FOR THE TOTAL WASTE-FOR-BALLAST THICKNESS

☐ Loose waste layer thickness was less than 2-feet-thick prior to compaction to allow uniform compaction of the acceptable waste material (i.e., no brush, large bulky items).

☐ Compaction was achieved over the entire area evaluated using a minimum of three passes of at least one track for each loose waste layer.

☐ The slope of the compacted waste layers was less than (flatter) 4 horizontal to 1 vertical.

SIGNATURE OF PERMITTEE

The waste overlying the area described in this record has been placed and compacted as described in this record and in accordance with the site Soils and Liner Quality Control Plan and Site Operating Plan.

______________________________________ Waste Management of Texas, Inc.
Signature

____
Typed or Printed Name

____
Title

____
Date Signed

Note: This completed form will be placed in the Operating Record and will be available for TCEQ review.

SKYLINE LANDFILL

APPENDIX D7-E
GRI-GM13

Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
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Revision 10: April 11, 2011
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"

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 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
- D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
- D 7466 Test Method for Measuring the Asperity Height of Textured 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

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)
- Trouser Tear (see Note 7)

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 is a GRI test currently included in this standard. Since this topic is not covered in ASTM standards, this is necessary. It is the following:

- UV Fluorescent Light Exposure

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 4218 *(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 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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 20 kN/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	
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.	20,000 kg
									per GRI GM-10
Carbon Black Content - %	D 4218 *(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 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

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)*	D 7466	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 4218 *(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 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.

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)*	D 7466	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 4218 *(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 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle 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.
Revision 9:	June 1, 2009: Replaced GRI-GM12 test for asperity height of textured geomembranes with ASTM D 7466.
Revision 10	April 11, 2011: Added alternative carbon black content test methods

SKYLINE LANDFILL
CITY OF FERRIS
DALLAS AND ELLIS COUNTIES, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 42D

PERMIT AMENDMENT APPLICATION

PART III – FACILITY INVESTIGATION AND DESIGN
ATTACHMENT D8
FINAL COVER QUALITY CONTROL PLAN

Prepared for

Waste Management of Texas, Inc.

April 2012

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

4-12-12

Prepared by

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CONTENTS

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CONTENTS (CONTINUED)

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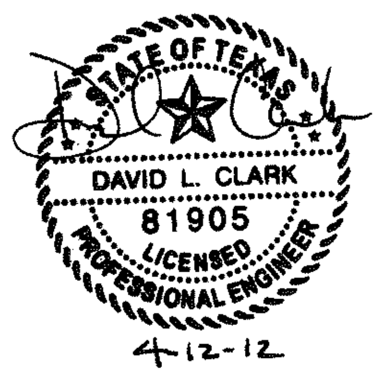
APPENDIX D8-A

Geocomposite Transmissivity Calculation



TABLES

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

4-12-12

1 INTRODUCTION

30 TAC §330.457

1.1 Purpose

This Final Cover Quality Control Plan (FCQCP) has been prepared in accordance with 30 TAC §330.457. This FCQCP establishes the procedures for the design, construction, testing, and documentation of the final cover system.

1.2 Definitions

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

ASTM – 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.

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).

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.

Owner's Representative – The owner's representative is an official representative of the owner responsible for planning, organizing, and controlling the design and construction activities.

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

Quality Control – Quality control includes the activities that implement the quality assurance program. The GP, CQA monitor, and contractor will perform quality control.

2 FINAL COVER SYSTEM

30 TAC §330.457

2.1 Final Cover System

The alternate final cover system will consist of an infiltration layer, a drainage layer, and an erosion control layer. The infiltration layer will consist of a minimum of 18 inches of compacted soil with a coefficient of permeability of less than or equal to 1×10^{-7} cm/sec. The drainage layer will consist of a double-sided geocomposite. The erosion layer will consist of a minimum of 36 inches of soil, of which the upper 6 inches is capable of sustaining native plant growth. The final cover will be vegetated following the construction of the final cover to minimize erosion.

The final cover plan is included in Attachment D3 – Construction Design Details, Drawing D3.9. Details of the final cover system are provided in Drawing D3.10. The components of the final cover system are listed from top to bottom in Table D8-1.

Table D8-1
Skyline Landfill
Components of the Final Cover System

ALTERNATE FINAL COVER SYSTEM		
Cover System Component	**Description**	**Thickness**
Erosion Layer	Soil that is capable of sustaining native plant growth	36 inches
Drainage Layer	Double-sided geocomposite	0.2 inches
Infiltration Layer	Compacted soil with a maximum coefficient of permeability less than or equal to 1×10^{-7} cm/sec	18 inches

2.2 Construction Monitoring

Continuous on-site monitoring is necessary to assure that the components of the final cover system are constructed in accordance with this FCQCP. The CQA monitor shall provide continuous on-site observation during the following construction activities:

- Infiltration layer placement, processing, compaction, and testing
- Drainage layer deployment and seaming
- Erosion layer placement
- Any work that could damage the installed components of the final cover system

The GP will document and certify that the final cover system was constructed in accordance with this FCQCP. The GP shall make sufficient site visits to observe critical construction activities and to verify that the construction and quality assurance activities are performed in accordance with this FCQCP.

3 INTERMEDIATE COVER AND GRADING

§330.165(c)

3.1 General

The proposed landfill completion plan for the Skyline Landfill is provided in Attachment D3 – Construction Design Details, Drawing D3.9. The final lift of waste will be covered by intermediate cover that is placed in accordance with Part IV – Site Operating Plan.

3.2 Materials

Intermediate cover will consist of general fill that has not previously come into contact with waste.

3.3 Slopes

The slope stability analyses are provided in Attachment D5 – Geotechnical Design, Appendix D5-B – Slope Stability Analyses. The slope stability analyses are only valid for the conditions that were analyzed. Any changes to the final cover system or landfill completion plan will require that the slope stability analyses be revised to reflect the actual conditions. Interim 3H:1V waste slopes shall not exceed 210 feet in height. Temporary construction slopes shall not be steeper than the interim slopes and concentrated loadings, such as heavy equipment and soil stockpiles, and shall not be placed near the crest of slopes unless additional slope stability analyses are performed.

3.4 Testing and Verification

Intermediate cover placement and grading will be observed and documented by the landfill staff in accordance with Part IV – Site Operating Plan.

4 INFILTRATION LAYER

30 TAC §330.457

4.1 General

The infiltration layer consists of an 18-inch-thick layer of compacted, relatively homogeneous, cohesive material. The CQA monitor shall provide continuous on-site observation during infiltration layer placement, processing, compaction, and testing. The GP shall make sufficient site visits during infiltration layer construction to document the construction activities, testing, and thickness verification in the Final Cover System Report, in accordance with Section 7.

4.2 Materials

Infiltration layer material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material. The required infiltration layer material properties are summarized in Table D8-2.

Table D8-2
Skyline Landfill
Infiltration Layer 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	Less than or equal to 1×10^{-7} cm/sec

Preconstruction testing procedures and frequencies for infiltration layer materials are listed in Section 4.8.1.

4.3 Subgrade Preparation

Prior to placing infiltration layer material, the subgrade should be proof rolled 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 compacted and then be proof rolled again.

The subgrade elevations shall be verified in accordance with the requirements of Section 4.8.3 prior to the placement of infiltration layer.

4.4 Placement and Processing

The infiltration layer subgrade and surface of each lift should be roughened prior to placement of the next lift of the infiltration layer. The infiltration layer material should be placed in maximum 8-inch loose lifts to produce a 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 10 percent by weight.

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 worked into the material. Waste or any objectionable material must not contaminate compaction water.

4.5 Compaction

The infiltration layer shall be compacted with a pad/tamping-foot or prong-foot roller. A footed roller is necessary to bond the lifts, distribute the water, and blend the soil matrix through kneading action. The infiltration 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 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 maintained to prevent the prongs or pad feet from becoming clogged to the point that they cannot achieve full penetration.

The compactor shall make at least 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, recompacted, and retested, and passing tests must be achieved 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 recompacted. Following compaction and fine grading of the final lift, the surface of the infiltration layer shall be smooth drum rolled.

4.6 Protection

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

4.7 Tie In to Existing Covers

The edge of existing infiltration layers shall be cut back on either a slope or step to prevent the formation of a vertical joint. Details for the tie in to existing cover are provided in Attachment D3, Drawing D3.3 – Liner Details.

4.8 Testing and Verification

4.8.1 Preconstruction Testing

Table D8-3 lists the minimum testing required for material proposed for use as the infiltration layer.

Table D8-3
Skyline Landfill
Infiltration 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

Table D8-4 lists the minimum testing required for material used as the infiltration layer.

Table D8-4
Skyline Landfill
Infiltration Layer Material Construction Tests

Test	Standard	Frequency
Field Density	ASTM D 2922	1/8,000 sf per 6-inch lift
Plasticity Index	ASTM D 4318	1 per acre
Liquid Limit	ASTM D 4318	1 per acre
Percent Passing No. 200 Mesh Sieve	ASTM D 1140	1 per acre
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 acre

The Atterberg limits of the in-place infiltration layer must be compared to the Atterberg limits of the Proctor curve sample to assure that the Proctor curve 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.

4.8.3 Thickness Verification

The as-built thickness of the infiltration layer shall be determined by standard survey methods. Prior to the placement of infiltration 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 infiltration layer is completed, the top of infiltration layer elevations will be determined at the same locations as the subgrade elevations.

5 DRAINAGE LAYER

30 TAC §330.457

5.1 General

The drainage layer consists of a double-sided geocomposite. The CQA monitor shall provide on-site observation during geocomposite drainage layer installation. The GP shall make sufficient site visits during geocomposite drainage layer installation to document the installation in the Final Cover Evaluation Report.

5.2 Materials

5.2.1 Geocomposite

Double-sided geocomposite (nonwoven geotextile bonded to the top and bottom of HDPE drainage net) will be installed on all slopes. The geocomposite shall have the minimum properties listed in Table D8-5.

Table D8-5
Skyline Landfill
Geocomposite Properties

Material	Test	Standard	Required Property
Geotextile	Material Apparent Opening Size	 ASTM D 4751	Nonwoven polypropylene or polyester 70 sieve
HDPE Drainage Net	Specific Gravity Thickness Carbon Black	ASTM D 1505 ASTM D 5199 ASTM D 1603	0.93 g/cm^3 0.2 inch (200 mil) Minimum 2%, maximum 3%
Geocomposite	Transmissivity	ASTM D 4716	5 x 10^{-4} m^2/sec

Manufacturer quality control testing procedures for geocomposite are listed in Section 5.5.

5.2.2 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 to the geocomposite rolls. Rolls should not be pushed, slid, or 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.

5.3 Preparation

Prior to installation of the drainage layer, the infiltration layer shall be tested and verified in accordance with Section 4.8. The CQA monitor shall observe that the surface to receive the geocomposite is free of debris, stones, and dirt and verify that the conformance documentation has been submitted and approved.

5.4 Installation

Double-sided geocomposite shall be installed on all slopes. 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 infiltration layer. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and wearing shoes that could damage the geocomposite shall not be permitted on the geocomposite and only low-ground pressure supporting equipment shall be allowed on the geocomposite. 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.

During drainage layer 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 geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or infiltration layer.
- Observe that the deployment method minimizes wrinkles in 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 repaired or removed and replaced by the installer.

5.5 Testing and Verification

The manufacturer shall test the geocomposite to assure the quality of the drainage layer materials. Material property requirements are provided in Section 6.2. Minimum manufacturer's testing requirements are provided in Table D8-6. Manufacturer's testing shall be performed at a minimum frequency of one test per 100,000 sf.

Table D8-6
Skyline Landfill
Geocomposite Manufacturer's Tests

Material	Test	Standard
Geotextile	Weight	ASTM D 5261
	Apparent Opening Size	ASTM D 4751
HDPE Drainage Net	Specific Gravity	ASTM D 1505
	Thickness	ASTM D 5199
	Carbon Black	ASTM D 1603
Geocomposite	Transmissivity	ASTM D 4716

6 EROSION LAYER

30 TAC §330.457

6.1 General

The erosion layer consists of a 36-inch-thick layer of soil with the upper six inches capable of sustaining native plant growth. The CQA monitor shall provide continuous on-site observation during erosion layer placement to assure that erosion layer placement does not damage underlying geocomposite or infiltration layer. The GP shall make sufficient site visits during erosion layer placement to document the construction activities and thickness verification in the Final Cover Evaluation Report.

6.2 Materials

Erosion layer material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, and organic material, or any material that could damage the underlying geocomposite. The required erosion layer material properties are summarized in Table D8-7.

Table D8-7
Skyline Landfill
Erosion Layer 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

6.3 Preparation

Prior to placing the erosion layer material, the top of infiltration layer elevations shall be verified in accordance with the requirements of Section 4.8.3 and all testing on the underlying geocomposite shall be completed.

6.4 Placement

The erosion layer shall be placed in a manner that minimizes the potential to damage the underlying geocomposite. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geocomposite. The erosion layer shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geocomposite. On side slopes, erosion layer shall be placed from the bottom to the top, not across or down. Erosion layer shall not be placed over geocomposite that are stretched across the toes of slopes. The minimum separation distance between construction equipment and the geocomposite are listed in Table D8-8.

The erosion layer will be vegetated following the application of final cover in order to minimize erosion.

Table D8-8
Skyline Landfill
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
< 4	12
4 - 8	18
8 - 16	24
> 16	36

Any geocomposite that, in the opinion of the CQA monitor, has been damaged by the erosion layer placement must be repaired and retested in accordance with Sections 5 and 6.

6.5 Testing and Verification

6.5.1 Preconstruction Testing

Table D8-9 lists the minimum testing required for material proposed for use as the infiltration layer.

Table D8-9
Skyline Landfill
Erosion 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

6.5.2 Thickness Verification

The as-built thickness of the erosion layer shall be determined by standard survey methods. Prior to the placement of erosion layer, the top of infiltration layer elevations will be determined at a minimum rate of 1 survey point per 5,000 square feet of lined area. After the erosion layer is completed, the top of the erosion layer elevations will be determined at the same locations as the top of infiltration layer elevations.

7 DOCUMENTATION

After construction of the final cover system, the GP will submit a Final Cover Evaluation Report to the TCEQ on behalf of the owner. The purpose of the Final Cover Evaluation Report is to document that the construction methods and test procedures are consistent with this FCQCP.

At a minimum, the Final Cover Evaluation Report will contain the following:

- A summary of all construction activities
- A summary of 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
- A statement of compliance with the FCQCP
- The seal and signature of the GP and assistant GP, if applicable, in accordance with the Texas Engineering Practice Act

SKYLINE LANDFILL

APPENDIX D8-A
GEOCOMPOSITE TRANSMISSIVITY CALCULATION

STATE OF TEXAS
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LICENSED
PROFESSIONAL ENGINEER
4-12-12

Includes page D8-A-1

Skyline Landfill
Geocomposite Design

Required: Determine the minimum transmissivity for the final cover geocomposite.

References:

1) Giroud, J.P., Zornberg, J.G., and Zhao, A., 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layer", *Geosynthetics International,* Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp. 285-380.

Assumptions:

1) The liquid supply to the geocomposite will be limited to the hydraulic conductivity of the overlying erosion layer since the rate of infiltrating stormwater cannot exceed the soil's hydraulic conductivity.

Solution:

1) Calculate the ultimate transmissivity value for the final cover geocomposite from Reference 1.

$$T_{ult} = q_h L / \sin\beta \quad \text{[Ref 1., Eq. 35]}$$

where:

q_h = rate of liquid supply
L = horizontal drainage layer distance
β = slope angle of drainage layer, measured from horizontal

q_h = hydraulic conductivity of overlying erosion layer
= 1×10^{-6} cm/sec
= 0.0036 in/hour

Slope Designation	q_h in/hour	L ft	Sideslope %	β deg	[illegible] T_{ult} m²/sec	[illegible] T_{ult} m²/sec
Topslope	0.0036	720	2.5	1.4	2.3E-04	5.0E-04
Sideslope	0.0036	980	25	14.0	3.1E-05	5.0E-04