TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

VOLUME 2 OF 6

Prepared for

Texas Regional Landfill Company, LP

February 2022

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Prepared by

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WCG Project No. 0771-368-11-123

This document is intended for permitting purposes only.

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JOHNSON COUNTY, TEXAS
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CONTENTS

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TURKEY CREEK LANDFILL
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MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIB
OVERLINER COMPLIANCE DEMONSTRATION

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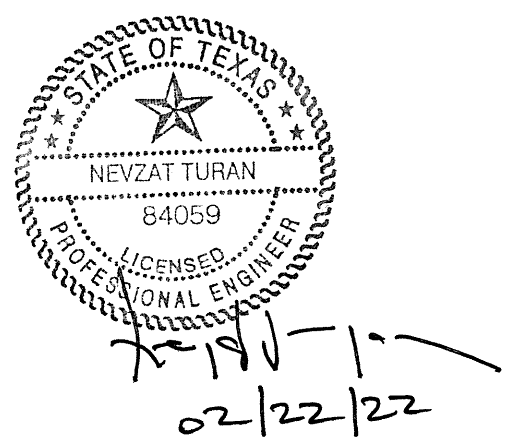
CONTENTS



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TABLES

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1 INTRODUCTION

1.1 Purpose and Scope

The proposed continued development of the Turkey Creek Landfill includes a horizontal and vertical expansion over a portion of the pre-Subtitle D area of the landfill. The purpose of this appendix is to demonstrate that the proposed alternative overliner that is designed to be installed over the existing pre-Subtitle D waste will meet the alternative liner demonstration requirements specified in Title 30 Texas Administrative Code (TAC) §330.331(a)(1). This is achieved by demonstrating that the predicted concentrations of leachate chemical constituents do not exceed maximum contaminant levels (as listed in Table 1 in §330.331(a)(1)) in the uppermost aquifer at the point of compliance (POC). The concentration of various constituents at the POC is determined as detailed in the following sections.

The two computer models used for this demonstration are (1) Hydrologic Evaluation of Landfill Performance (HELP) and (2) Multimed Exposure Assessment (MULTIMED). Section 1.2 provides a description of the containment system design, and Section 1.3 provides an overview of the overliner compliance demonstration and detailed discussions are provided in Section 3.

1.2 Containment System Design

The existing approximately 146.4-acre waste disposal area will be expanded to 172.0 acres of Subtitle D lined area (15.5 acres of pre-Subtitle D area). As shown on Figure IIIB-A-1, all 15.5 acres of the pre-Subtitle D area will have overliner installed. The overliner will separate the existing waste and the waste placed in the vertical expansion area. The overliner area comprises a relatively small area (less than 10 percent) of the overall footprint.

The waste containment system design is shown on Figure IIIB-A-2. The overliner system will consist of a geosynthetic clay liner (GCL) overlain by 40-mil LLDPE geomembrane (textured on both sides) overlain by a geocomposite leachate collection layer. A two-foot-thick compacted clay liner meeting all the requirements of standard subtitle D compacted clay bottom liner included in Appendix IIID-LQCP may be used in place of GCL component of the overliner. The leachate collection layer placed above the geomembrane will consist of a 300-mil-thick HDPE geonet with 6 oz/sy non-woven geotextile heat-bonded to both sides. A 24-inch-thick protective cover layer will be placed above the leachate collection layer.

Details for the overliner system are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. Design of the overliner leachate collection is presented in Appendix IIIC – Leachate and Contaminated Water Management Plan. Stability of the overliner system is analyzed in Appendix IIIM-A. Overliner settlement analysis is provided in Appendix IIIM-B.

1.3 Overliner Demonstration Overview

The purpose of the overliner compliance demonstration is to show that the proposed containment system design for the overliner area will meet the overliner compliance demonstration requirements set forth in §330.331(a)(1).

The overliner demonstration will show that once the overliner is installed, leachate infiltration into the waste below the overliner will be nearly eliminated. Once the Subtitle D final cover is in place, leachate generation rates will decrease in the entire pre-Subtitle D area. Figure IIIB-A-1 shows the location and extent of the overliner area. Figure IIIB-A-2 shows general section configuration of the pre-Subtitle D area and the overliner.

Section 2 provides a discussion of the site's hydrogeological conditions. The overliner compliance demonstration method is discussed in Section 3. The HELP model and MULTIMED model input parameters are discussed in Section 4, and the results of the compliance demonstration are provided in Section 5.

2 SITE HYDROGEOLOGICAL INFORMATION

2.1 Site Geology

The existing subsurface characterization of the site is supported by data from 134 previously advanced soil borings whose locations are shown on Figure IIIG-B-1 in Appendix IIIG. The subsurface has been divided into three units: the Upper Sand Unit, the Bounding Shale Unit, and the Lower Sand Unit. The subsurface units and uppermost aquifer unit at the site are discussed in the following sections.

2.1.1 Upper Sand Unit

At ground surface in undeveloped areas across the site is the Upper Sand unit. This site-specific stratigraphic unit is present due to the in-situ weathering of the Woodbine Formation and deposition of alluvial sediments. According to the existing site exploration data, the Upper Sand unit sediments are composed predominately of sand, clayey sand, sandy clay, clay, and silty clay, with lesser proportions of silty sand, silt, and minor occurrences of sandy gravel. The borehole data also indicate the presence of organics, gypsum, pyrite, lignite, ferrous staining, iron and calcareous nodules, as well as thin calcareous and sulfate seams and partings. These sediments exhibit a high degree of compositional heterogeneity with sudden to gradational transitions between predominate material composition and common interbedding. Site development has removed Upper Sand sediments from within the limits of waste. Predevelopment, this unit ranged in thickness from 1.5 to 44 feet, with the thinnest occurrences generally located in the northcentral and southwestern portion of the site areas, and thickest accumulations present in the vicinity of the Class 1 waste disposal area and northernmost permit boundary area. Field slug test data performed in Upper Sand unit-screened piezometer B-32 indicate a permeability of 3×10^{-4} cm/s (Baker-Shiflett, 1991).

2.1.2 Bounding Shale Unit

Beneath the Upper Sand unit, the existing borehole logs describe the Bounding Shale unit. The Bounding Shale unit is continuous beneath the permit boundary and comprised of Woodbine Formation sediments. Sediments within this unit are competent and predominately sandy shale, clayey shale, and silty shale, commonly interbedded with thin seams and laminations of silt, siltstone, sand, and sandstone. The borehole data also indicate the presence of organics, fossils, gypsum, pyrite, chert nodules, ferrous staining, glauconitic laminations, and thin lignite and limestone seams.

The top of the Bounding Shale unit occurs at depths as shallow as 1.5 feet in the higher northcentral and southwestern portion of the site area were the unit is encountered at elevations exceeding 700 ft-msl. The majority of the landfill bottom is founded in the Bounding Shale unit. This unit has a low permeability with values ranging from 4.5×10^{-9} to 2.0×10^{-5} cm/s (horizontal) and 1.9×10^{-9} to 9.1×10^{-8} cm/s (vertical). The Bounding Shale exhibits varying degrees of saturation and contains portions of the uppermost aquifer.

Throughout the majority of the site the Bounding shale sediments are described as dry in the uppermost portion, moist at deeper intervals within the shale, and wet within interbedded coarse-grained seams, laminations, and partings and within the interjecting coarse-grained lenses and seams of the Lower Sand unit. Throughout the northernmost area of the facility the Bounding Shale unit composition contains higher proportions of sand, both in matrix and as interbedded seams/laminations, which correspond to an increase in moist and wet intervals.

2.1.3 Lower Sand Unit

Within the Bounding Shale unit lies the Lower Sand unit. The Lower Sand unit is characterized as discontinuous bodies of coarse-grained sandy sediments bounded by, and interbedded within, the Bounding Shale unit. Sediments within this unit are associated with the Woodbine Formation and composed predominately of sand, sandstone, and silty sand, with lesser proportions of sandy silt, clayey silt, silt, and siltstone, and interbedded shale and clay seams and laminations. The borehole data also indicate the presence of fossils, ferrous staining, and thin lignite partings within this unit. The sand bodies within this unit are generally isolated lenticular lenses that coalesce in some areas and otherwise pinch out, or grade into, the sandy shale sediments of the Bounding Shale unit. The size of individual sand bodies varies significantly with intervals up to 25 feet thick beneath the site. The Lower Sand unit sediments are predominately moist to wet and contain the majority of the uppermost aquifer. Field slug test data from piezometers screened within the Lower Sand unit sediments indicate a site wide average permeability of 1.1×10^{-3} cm/s.

3 POINT OF COMPLIANCE DEMONSTRATION METHODS

This alternative overliner demonstration has been developed using (1) the HELP model to estimate leachate percolation through the landfill and (2) the MULTIMED model to perform pollutant fate and transport simulations between the landfill and the point of compliance. A description of the HELP and MULTIMED models is presented in the following subsections.

3.1 HELP Model

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to estimate the rate of percolation through the proposed overliner system. The percolation rate was determined for various landfill configurations as discussed in Section 3.3. The HELP Model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the landfill. The model uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, run-off, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

Percolation rates generated through the overliner by HELP model were used as inputs for the infiltration rates for the MULTIMED model. It was assumed that any leachate that passed through the overliner system would eventually percolate through the existing pre-Subtitle D waste and into the aquifer. This makes for a conservative analysis as it assumes all the leachate that passes through existing waste, pre-subtitle D in-situ clay liner, and vadose zone of in-situ soils.

3.2 MULTIMED Model

MULTIMED Model Version 1.01 was used to assess the fate and transport of contaminants between the landfill base and the point of compliance (POC). MULTIMED was developed by the Athens Environmental Research Laboratory for the EPA. MULTIMED estimates the capacity of the hydrogeologic system modeled to dilute and attenuate contaminant concentrations. The model can be used to simulate the fate and transport processes in both the unsaturated and the saturated subsurface environments. In this application, only the saturated environment was modeled to provide a conservative analysis.

The demonstration was conducted by showing that the alternative overliner design option would not allow the concentrations of the 24 EPA constituents shown in Table 2-1 (the same constituents listed in Table 1 of Title 30 TAC §330.331(a)(l)) to be exceeded at the relevant point of compliance. This is done by modeling a Dilution Attenuation Factor (DAF), which is calculated by the following equation:

$$DAF = \frac{C_O\text{, Initial Constituent Concentration of Leachate Within the Landfill}}{C_P\text{, Constituent Concentration at the POC}}$$

As noted in the above equation, the DAF represents the factor by which the constituent concentration is expected to decrease between the landfill and the POC. The required DAF for each constituent is found by dividing the input leachate concentration by the constituent maximum contaminant levels (MCLs). The input leachate concentrations are based on recommended input concentrations from Table 2, page 24 of the TCEQ's Alternative Liner Design Handbook.

A single simulation can account for all 24 constituents by assuming the constituents act as particles that do not experience carbon absorption or chemical or biological decay. This very conservative assumption discounts natural physical processes that normally act to reduce chemical concentrations. The dilution required to meet regulatory standards is a function of both the expected input leachate concentration and the MCLs. Table 2 from the TCEQ's Alternative Liner Design Handbook that trichloroethylene is the most critical constituent because it has the highest DAF. In other words, trichlorethylene requires the most dilution in order to comply with MCLs. If the input leachate concentration is assumed to be 1 mg/L, then the DAF at the POC becomes the reciprocal of the output concentration calculated by MULTIMED. The reciprocal of the MULTIMED result must then equal or exceed the most critical DAF to meet TCEQ requirements. For this demonstration, a DAF of not less than 260 will be used as this has been the historical practice of TCEQ for alternative liner demonstrations

3.3 Landfill Configurations Analyzed

Four HELP Model simulations were completed to estimate percolation rates through the alternative overliner. The highest resulting percolation rate for each HELP Model simulation was then used to estimate the DAF using MULTIMED for each case.

Table 3-2 summarizes the landfill configurations modeled using HELP. The locations used for the alternative overliner demonstration are shown on Figures IIIB-A-1 and IIIB-A-2 in Appendix IIIB-A. Section A was selected to represent the shortest distance between the alternative overliner area and the POC. Groundwater will flow northeast towards Monitor Well 21. This groundwater flow path is shown on Figure IIIB-A-1 and the Section A profile is presented on Figure IIIB-A-2 in Appendix IIIB-A.

Table 3-1
Landfill Configurations Modeled in HELP

Case	Description
Case 1: Active, 10 ft Waste	Active landfill with 10 feet of waste modeled for 1 year.
Case 2: Interim, 100 ft Waste	Interim landfill with 100 feet of waste above the overliner modeled for 10 years.
Case 3: Interim, 170 ft Waste	Interim landfill with 170 feet of waste above the overliner modeled for 10 years.
Case 4: Closed, 170 ft Waste	Closed landfill with 170 feet of waste above the overliner modeled for 30 years.

Additional HELP modeling input information is provided in Appendix IIIB-B. The percolation rates generated in the HELP model analyses were then used as input into the MULTIMED model. The MULTIMED model input is discussed further in Section 4.

4 MODEL INPUT PARAMETERS

4.1 HELP Model Input

Detailed HELP model information is presented in Appendix IIIB-B. Precipitation data was synthetically generated by the HELP model program using normal mean monthly precipitation data from the NOAA for Alvarado, Texas weather station. The average annual precipitation over the modeled 30-year period was 37.85 inches. Temperature and solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas. Landfill profile input information is provided in Appendix IIIB-B.

To maximize the head on the overliner, therefore maximizing percolation through the overliner system, the leachate collection layer's slope was set to 0.1%. This assumption was made to over estimated seepage at the bottom of the overliner, which will be used in the MULTIMED model. This assumption is conservative because the smallest anticipated overliner slope is anticipated to be 3.35% based on the overliner settlement analysis in Appendix IIIM.

4.2 MULTIMED Model Input

Detailed MULTIMED information is presented in Appendix IIIB-C. In general, environmentally conservative assumptions were made in determining the percolation rate and the dilution attenuation factor (DAF). The major assumptions used in the MULTIMED demonstrations are presented in Table 4-1. In addition, the table shows actual site conditions to provide a comparison with the assumptions made for modeling purposes.

By making the assumptions listed in Table 4-1, a single MULTIMED simulation accounts for all 24 constituents identified by the EPA as requiring landfill design protection criteria because the constituent concentration at the POC is independent of chemical-specific properties. The model result is then expressed in terms of the DAF, which is defined as the ratio of the input concentration to the concentration at the POC. MULTIMED can be used to find the DAF by using an input concentration of 1.0 mg/L. The DAF is the reciprocal of the resulting concentration at the POC. The POC for this study is shown on Figure IIIB-A-1 (Appendix IIIB-A).

The required minimum DAFs for the 24 EPA constituents are given in Table 2, page 24 of the TCEQ's *Alternate Liner Design Handbook*. The largest DAF listed in Table 2 is 260. Therefore, if MULTIMED modeling results in a DAF higher than 260 for a generic chemical that is conservatively modeled with no carbon absorption, no biodegradation, and no decay, it can be concluded that the proposed overliner is acceptable. The actual DAF for a specific chemical would be higher than the result calculated by MULTIMED under these circumstances, since real-world physical processes of absorption, biodegradation, and decay would act to reduce chemical concentrations at the POC to less than those predicted by MULTIMED.

Table 4-1
Major Assumptions Used to Determine
MULTIMED Model Input Parameters

Input Parameters	Assumption	Actual Site Condition
Extent of Landfill Area	Assumed 150 feet of waste is placed in the pre-Subtitle D portion of the landfill (15.5 acres).	Waste thickness is assumed to be the same (highest) for the entire pre-Subtitle D area. The majority of the pre-Subtitle D area does not have this much waste placed in it.
Initial Moisture Content of Waste	The initial moisture content for the pre-Subtitle D waste was selected to be 38%.	Typical initial waste moisture contents are expected to be between 25% and 38%.
Aquifer Hydraulic Conductivity	1.0×10^{-3} cm/s	This is the maximum measured hydraulic conductivity reported for the uppermost groundwater zone (refer to Appendix IIIG). Assuming that leachate enters the aquifer at the limits of waste and travels to the point of compliance at the maximum measured aquifer hydraulic conductivity significantly over-estimates actual site conditions.
Recharge Rate	5% groundwater recharge was assumed.	Groundwater recharge will occur at the site from precipitation events and flow of groundwater onto the site from upland areas.
Aquifer Hydraulic Gradient	0.016 ft/ft	Figure IIIG-D-1 – Groundwater Potentiometric Surface Contour Map in Appendix IIIG-D shows the groundwater map across the pre-Subtitle D area. To provide for a conservative analysis, a maximum slope across the waste disposal area to the point of compliance is assigned to the aquifer hydraulic gradient in this area.
Unsaturated Zone Thickness	0	Unsaturated zone above the groundwater table exist at the site. The attenuating effects of these zone has been conservatively not considered in this demonstration.
Organic Carbon Content	1×10^{-6}	The attenuating effects of carbon absorption have been conservatively ignored in this model by using 1×10^{-6} as a minimum fraction organic content.
Model Source Type	Steady State	Assumed leachate loaded directly onto the groundwater surface continuously. This is also a very conservative assumption.
Biodegradation	No biodegradation	Biodegradation is active in hydrogeologic environments.
Chemical Decay	No chemical decay	Chemical decay will occur with most contaminants.

5 RESULTS

The HELP and MULTIMED models were used to evaluate the design of the overliner system by estimating constituent concentrations at the POC for the highest percolation rate through the bottom liner discussed in Section 3.3. Conservatively, the constituent concentrations at the base of the landfill liner and at the POC were used to calculate the DAF. Per TCEQ guidance information, the overliner must provide a DAF of more than 260 in all scenarios. Table 5-1 below summarizes the collected DAF.

Table 5-1
Summary of Calculated DAF Values

Location	Chemical Concentration at POC (mg/L)	Calculated DAF
Section A – Closed Condition	8.289×10^{-5}	12,064

The results demonstrate that the proposed overliner system meets TCEQ requirements. The DAFs calculated by the use of HELP and MULTIMED are well in excess of the 260 minimum criterion. The actual DAFs are expected to be higher than the DAFs predicted by this modeling investigation because the model input was conservatively estimated as discussed in previous sections of this report.

APPENDIX IIIB-A

IIIB-A-1 Excavation and Overliner Plan

IIIB-A-2 Typical Profile – Waste Containment System

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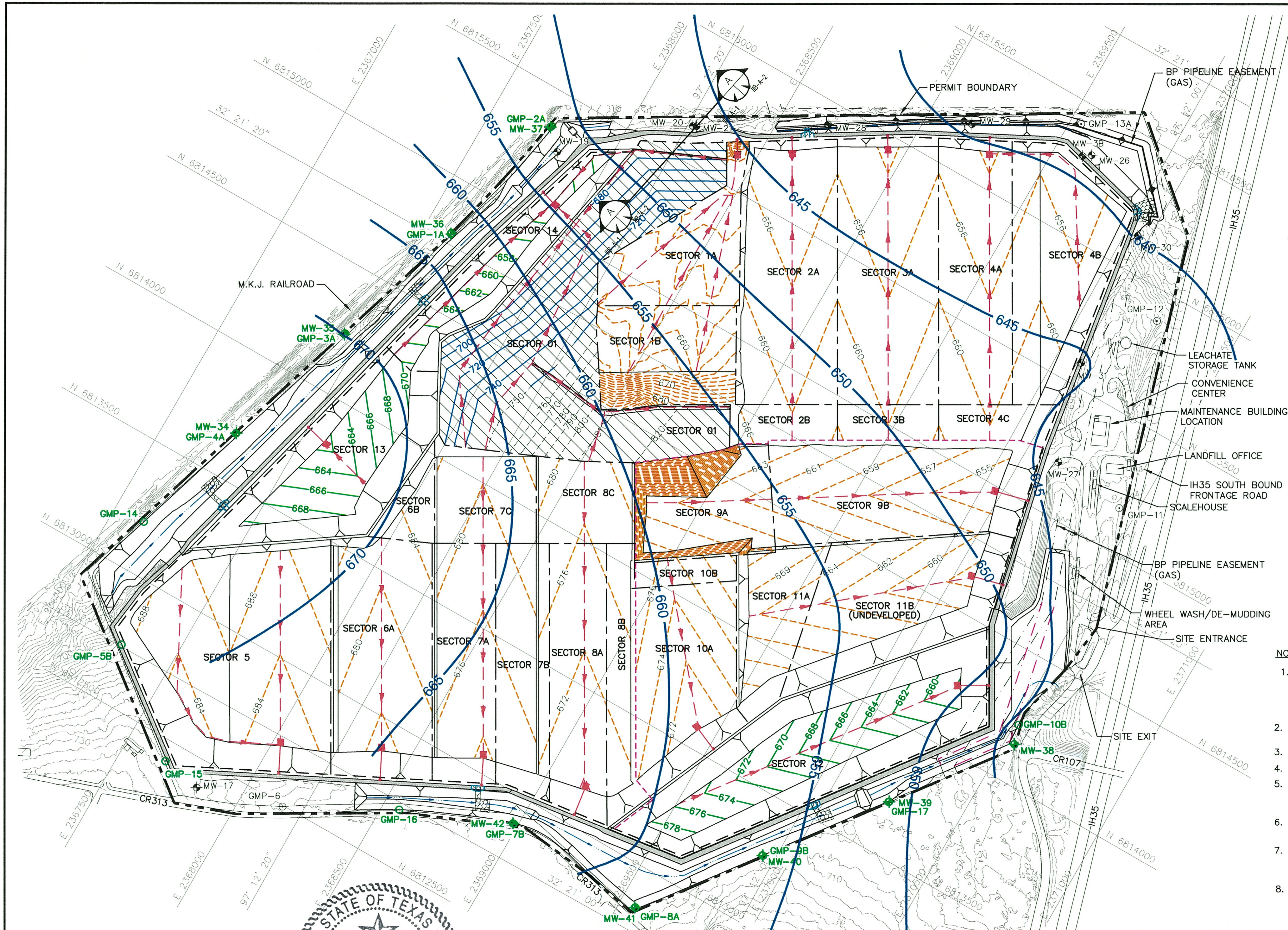

SCALE IN FEET: 0 200 400

LEGEND

(line)	PERMIT BOUNDARY
(line)	LIMITS OF WASTE
(line)	LIMIT OF CLASS 1 WASTE DISPOSAL AREA
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
(line)	EASEMENT
(line)	RELOCATED EASEMENT
(line)	SECTOR BOUNDARY
800	OVERLINER CONTOUR
670	PERMITTED/EXISTING TOP OF LINER CONTOUR
662	PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
(line)	PERMITTED/UNDEVELOPED LEACHATE LINE
(symbol)	LEACHATE COLLECTION SUMP
MW-7	EXISTING GROUNDWATER MONITORING WELL
GMP-12	EXISTING GAS MONITORING PROBE
MW-7	PROPOSED GROUNDWATER MONITORING WELL
GMP-17	PROPOSED GAS MONITORING PROBE
(hatch)	PRE SUBTITLE D AREA
670	UPPERMOST AQUIFER GROUNDWATER POTENTIOMETRIC SURFACE ELEVATION CONTOUR IN FT-MSL (SEE NOTE 8)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 648 FT-MSL.
5. SUBTITLE D AREA LCS PIPES SLOPE WITH A MINIMUM OF 0.8% TO SUMPS. OVERLINER LCS PIPES SLOPE WITH A MINIMUM 1.0% TO SUMPS.
6. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.5 THROUGH I/IIA.7.
7. CLASS 1 NON HAZARDOUS INDUSTRIAL WASTE (NOT CLASSIFIED AS SUCH DUE TO ASBESTOS CONTENT) WILL BE DISPOSED OF ONLY IN SECTORS 9A, 9B, 10A, 10B, AND 11.
8. GROUNDWATER ELEVATIONS GAUGED BY WCG DURING THE SEPTEMBER 2021 SEMIANNUAL GROUNDWATER DETECTION MONITORING SAMPLING EVENT AND POSTED IN FT-MSL BY EACH MONITOR WELL LOCATION.

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DATE: 02/2022
FILE: 0771-368-11
CAD: IIIB-A-1-EXCAVATION PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
EXCAVATION/OVERLINER PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE IIIB-A-1

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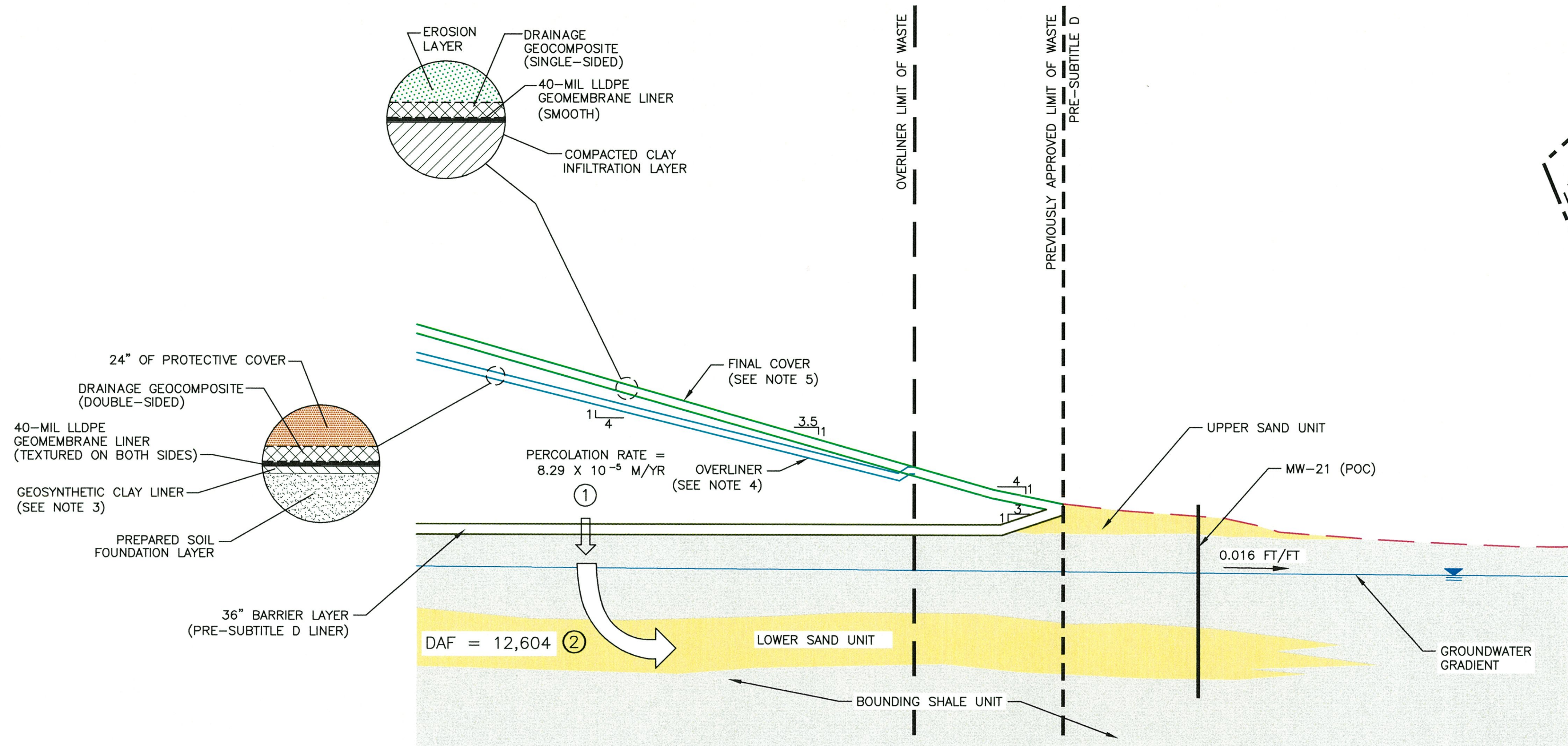
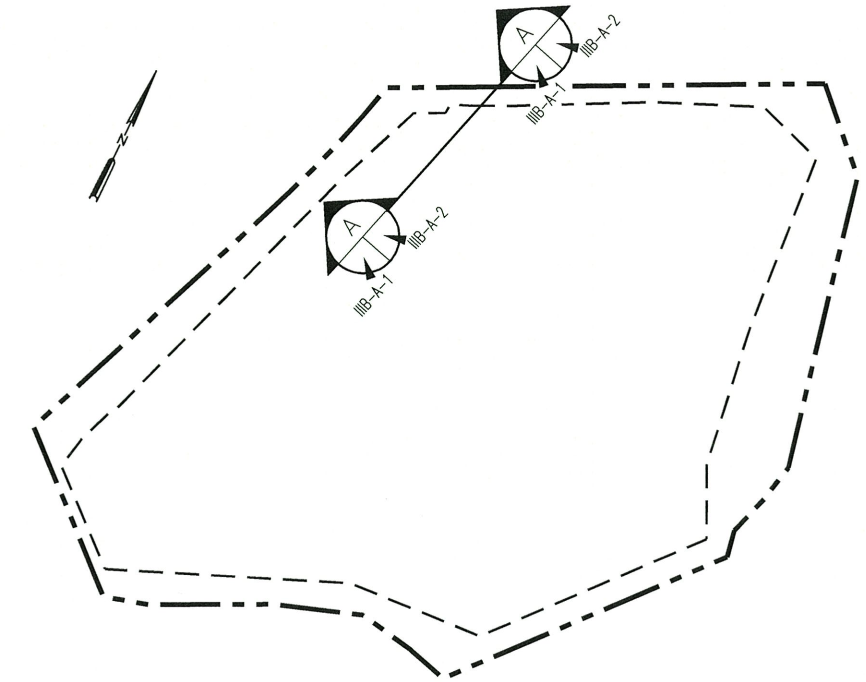
WASTE CONTAINMENT SYSTEM DESIGN





KEY MAP

LEGEND

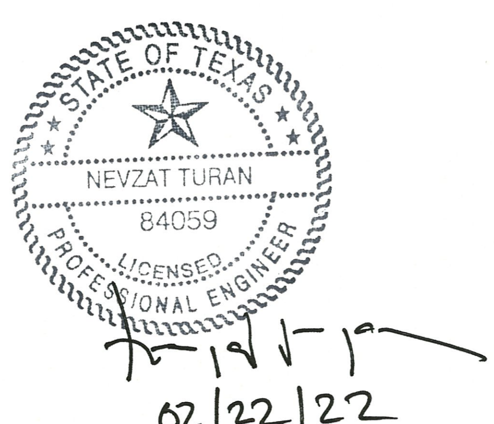
- PROPOSED PERMIT BOUNDARY
- LIMITS OF WASTE
- OVERLINER LIMITS OF WASTE
- PROPOSED FINAL COVER
- PROPOSED OVERLINER
- PRE-SUBTITLE D LINER
- EXISTING GRADE
- GROUNDWATER
- BOUNDING SHALE
- SAND UNIT

MULTIMED INFORMATION	
AVERAGE AQUIFER THICKNESS	5.2 M (17 FT)
HYDRAULIC CONDUCTIVITY	315.6 M/YR (1.0 X 10^{-3} CM/S)
HYDRAULIC GRADIENT	0.016 FT/FT
DISTANCE TO POINT OF COMPLIANCE	14.7 M (38.5 FT)

TYPICAL SECTION (A)

NOTES:

1. TYPICAL GEOLOGIC PROFILE DEVELOPED FROM CROSS-SECTIONS INCLUDED IN APPENDIX IIIG.
2. GROUNDWATER ELEVATIONS GAUGED BY WCG DURING THE SEPTEMBER 2021 SEMIANNUAL GROUNDWATER DETECTION MONITORING SAMPLING EVENT AND POSTED IN FT-MSL BY EACH MONITOR WELL LOCATION.
3. TWO-FOOT-THICK COMPACTED LAYER LINER MEETING THE SPECIFICATIONS OF A BOTTOM CLAY LINER MAY BE USED.
4. OTHER THAN A SMALL CURRENTLY APPROVED TOP DECK AREA WITH 5% SLOPE, MAJORITY OF THE OVERLINER AREA IS LOCATED OVER THE LANDFILL SIDE SLOPES.
5. REFER TO APPENDIX IIIJ – CLOSURE PLAN FOR FINAL COVER INFORMATION.



DEMONSTRATION PROCEDURE – INTERIM LANDFILL

(1) CALCULATE PERCOLATION RATE FROM INTERIM LANDFILL USING HELP.
(2) CALCULATE DILUTION ATTENUATION FACTOR (DAF) USING MULTIMED.

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DATE: 02/2022
FILE: 0771-368-11
CAD: FIG IIIB-A-2-WASTE CONTAINMENT.DWG
DRAWN BY: JDW
DESIGN BY: BPY
REVIEWED BY: NT

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS		
NO.	DATE	DESCRIPTION

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MAJOR PERMIT AMENDMENT
WASTE CONTAINMENT SYSTEM

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE IIIB-A-2

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APPENDIX IIIB-B

HELP MODEL ANALYSIS

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Includes pages IIIB-B-1 through IIIB-B-45

HELP MODEL ANALYSIS

The following HELP model simulations were run to obtain percolation rates through the overliner.

Table 1
Landfill Configurations

Case	Description
Case 1: Active, 10 ft Waste	Active landfill with 10 feet of waste modeled for 1 year
Case 2: Interim, 100 ft Waste	Interim landfill with 100 feet of waste above the overliner modeled for 10 years.
Case 3: Interim, 170 ft Waste	Interim landfill with 170 feet of waste above the overliner modeled for 10 years.
Case 4: Closed, 170 ft Waste	Closed landfill with 170 feet of waste above the overliner modeled for 30 years.

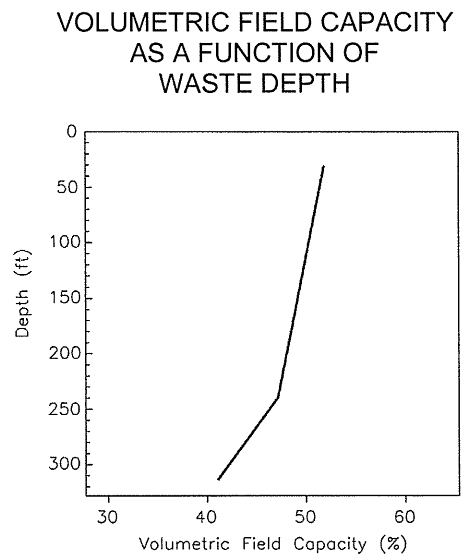
The evaporative zone depth and leaf area index were chosen to be 10 inches and 0.0, respectively, for the active case; 10 inches and 2.0, respectively, for the interim cases; and 12 inches and 4.5, respectively, for the closed cases. The Soil Conservation Service (SCS) runoff curve numbers were calculated by HELP based on soil data and expected ground cover, surface slope, and slope length. The HELP Model output results can be found starting on page IIIB-B-6.

Climate Data Input

Precipitation data was synthetically generated by the HELP model program using normal mean monthly precipitation data from the NOAA for Alvarado, Texas weather station. The average annual precipitation over the modeled 30-year period was 37.85 inches. Temperature and solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas.

Field Capacity And Moisture Content

The porosity values for each layer other than the waste were provided by HELP. The field capacity and porosity values for the waste layer were obtained from "Retention of Free Liquids in Landfills Undergoing Vertical Expansion" (Zornberg, Jorge G., et al., 1999) and varies based on average waste column thickness, as shown in the following graph.



For a conservative analysis, the initial moisture content was set at field capacity for all profile layers except the waste layer. The initial moisture content for the waste layer was selected to be 25 percent for the 10-foot-thick waste column case. A moisture content of 25 percent is typical for recently placed waste. For the remaining cases, the initial moisture content for the waste layer was selected to be 38 percent to account for the fact that the waste will be in place for a longer period of time and the moisture content could increase.

Landfill Profile Information

The various landfill layers that are included in this demonstration are discussed below.

Pre-Subtitle D Liner

The pre-Subtitle D liner consists of a 36-inch-thick shale barrier layer with a hydraulic conductivity of $1.0x10^{-7}$.

Overliner System

The overliner consists of a 40-mil LLDPE geomembrane overlying a geosynthetic clay liner (GCL). The geomembrane liner was modeled for good installation quality, four construction defects per acre, and a production pinhole density of four holes/acre. Default soil characteristics from the HELP Model were selected for the LLDPE geomembrane hydraulic conductivity.

Overliner Leachate Collection System

The overliner LCS includes a drainage geocomposite collection layer consisting of a 300-mil geonet with a 6 oz/sy geotextile heat-bonded to both sides. The calculations for determining the hydraulic conductivity of the geocomposite are included in Appendix IIIC-A. The geocomposite is modeled at a 0.1 percent slope to maximize the head on the overliner system. The slope length for all conditions is 300 feet.

Protective Cover

The overliner protective cover consists of a 24-inch-thick layer of soil placed over the leachate collection system. The hydraulic conductivity of the protective cover was modeled as 1.2×10^{-4} cm/s.

Waste

The overliner area cases include waste layers of 10 feet, 100 feet, and 170 feet. Default wilting point values were selected from HELP to represent municipal solid waste. The waste column was split into two layers. The top 125-foot layer was modeled with a hydraulic conductivity of 1×10^{-3} cm/s. A lower hydraulic conductivity of 1×10^{-4} cm/s was used for the bottom layer because the additional overburden pressure will cause additional consolidation to this layer that will likely lower the hydraulic conductivity. The moisture content, field capacity, and porosity values were selected as discussed previously.

Intermediate Cover

The intermediate cover consists of a 12-inch-thick layer of soil placed over the waste. Default soil characteristics from the HELP Version 3.07 table were selected to represent the available on-site soils.

Final Cover System

The final cover consists of a 12-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer (to be conservative this layer is not considered in HELP Model), a 40-mil LLDPE geomembrane liner, and an infiltration layer. The geomembrane liner was modeled for good installation quality, 4 construction defects per acre, and a pinhole density of 4 holes/acre. The infiltration layer consists of 18-inch-thick compacted soil with a hydraulic conductivity of 1×10^{-5} cm/s.

Help Output

The HELP summaries and output files are presented starting on page IIIB-B-6.

Prep By: BPY
Date: 2/22/2022

Chkd By: NT
Date: 2/22/2022

TURKEY CREEK LANDFILL
0771-368-11-123
HELP SUMMARY SHEET
POINT OF COMPLIANCE DEMONSTRATION

		ACTIVE (10 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (170 FT WASTE)	CLOSED (170 FT WASTE)
GENERAL	Case No.	1	2	3	4
INFORMATION	No. of Years	1	10	10	30
	Ground Cover	BARE	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	81.7
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	0	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	12
EROSION	Thickness (in)				12
LAYER	Porosity (vol/vol)				0.3980
(Texture = 10)	Field Capacity (vol/vol)				0.2440
	Wilting Point (vol/vol)				0.1360
	Init. Moisture Content (vol/vol)				0.2440
	Hyd. Conductivity (cm/s)				1.2E-04
FLEXIBLE	Thickness (in)				0.04
MEMBRANE	Hyd. Conductivity (cm/s)				4.0E-13
LINER	Pinhole Density (holes/acre)				4
(Texture = 36)	Install. Defects (holes/acre)				4
	Placement Quality				GOOD
INFILTRATION	Thickness (in)				18
LAYER	Porosity (vol/vol)				0.4270
(Texture = 0)	Field Capacity (vol/vol)				0.4180
	Wilting Point (vol/vol)				0.3670
	Init. Moisture Content (vol/vol)				0.4270
	Hyd. Conductivity (cm/s)				1.0E-05
INTERMEDIATE	Thickness (in)		12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6649	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			540	540
(Texture = 0)	Porosity (vol/vol)			0.5472	0.5472
	Field Capacity (vol/vol)			0.4927	0.4927
	Wilting Point (vol/vol)			0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.300	0.272	0.244	0.242
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	22.32	10.43	4.01	2.53
	Slope[1] (%)	0.10	0.10	0.10	0.10
	Slope Length (ft)	300	300	300	300
FLEXIBLE	Thickness (in)	0.04	0.04	0.04	0.04
MEMBRANE	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13
LINER	Pinhole Density (holes/acre)	4	4	4	4
(Texture = 36)	Install. Defects (holes/acre)	4	4	4	4
	Placement Quality	GOOD	GOOD	GOOD	GOOD
GEOSYNTETIC CLAY	Thickness (in)	0.25	0.25	0.25	0.25
LINER	Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500
(Texture = 17)	Field Capacity (vol/vol)	0.7470	0.7470	0.7470	0.7470
	Wilting Point (vol/vol)	0.4000	0.4000	0.4000	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	3.0E-08	3.0E-08	3.0E-08	3.0E-08
INTERMEDIATE COVER	Thickness (in)	12	12	12	12
LAYER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05
PRE-SUBTITLE D WASTE[2]	Thickness (in)	1800	1800	1800	1800
(Texture = 0)	Porosity[2] (vol/vol)	0.5988	0.4876	0.4812	0.4812
	Field Capacity (vol/vol)	0.5074	0.4863	0.4665	0.4665
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
PRE-SUBTITLE D SOIL	Thickness (in)	36	36	36	36
LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270
(Texture = 11)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.07	3.07	7.34
EVAPOTRANSPIRATION	Average Annual (in)	34.13	28.22	28.22	30.51
HEAD ON	Average Annual (in)	0.005	0.105	0.253	0.518
OVERLINER	Peak Daily (in)	0.235	0.618	2.749	5.277
HEAD ON PRE-SUBTITLE D	Average Annual (in)	0.000	0.000	0.000	0.000
LINER	Peak Daily (in)	0.000	0.000	0.000	0.000
PERCOLATION THROUGH	Average Annual (cf/Y)	0.011	0.097	0.239	0.553
OVERLINER	Average Annual (m/yr)	7.697E-08	6.787E-07	1.672E-06	3.869E-06
PERCOLATION THROUGH	Average Annual (cf/Y)	0.000	0.000	0.000	0.000
PRE-SUBTITLE D LINER	Average Annual (m/yr)	0.000E+00	0.000E+00	0.000E+00	0.000E+00

[1] The overliner slope was set to 0.1% to maximize potential head on the overliner and percolation through the overliner. This assumption was made to conservatively measure the percolation rate and does not reflect likely settlement conditions. See Appendix IIIM for overliner settlement anaysis.

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

HELP MODEL OUTPUT

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:     C:\TC\B\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\B\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\B\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\B\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\B\AC\DATA10.D10
OUTPUT DATA FILE:            C:\TC\B\AC\OUTPUT1.OUT


TIME:  31:41     DATE:  11/10/2021


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

     TITLE:  TURKEY CREEK - OVERLINER POC - ACTIVE 10 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                   =    120.00   INCHES
```

```
POROSITY                       =      0.6649 VOL/VOL
FIELD CAPACITY                 =      0.5262 VOL/VOL
WILTING POINT                  =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                         LAYER  2
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  10
THICKNESS                      =     24.00    INCHES
POROSITY                       =      0.3980 VOL/VOL
FIELD CAPACITY                 =      0.2440 VOL/VOL
WILTING POINT                  =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT     =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.119999997000E-03 CM/SEC


                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                      =      0.30    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.      =   22.3199997000      CM/SEC
SLOPE                          =      0.10    PERCENT
DRAINAGE LENGTH                =    300.0     FEET


                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
THICKNESS                      =      0.04    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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
                        --------

             TYPE 3 - BARRIER SOIL LINER
             MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC


                        LAYER  6
                        --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  11
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4640 VOL/VOL
FIELD CAPACITY              =      0.3100 VOL/VOL
WILTING POINT               =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC


                        LAYER  7
                        --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1800.00   INCHES
POROSITY                    =      0.5988 VOL/VOL
FIELD CAPACITY              =      0.5074 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	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 #11 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	94.60	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.500	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.649	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.770	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	739.138	INCHES
TOTAL INITIAL WATER	=	739.138	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                     =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

```
*******************************************************************************

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS     9 THROUGH     9
-------------------------------------------------------------------------------
```

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.73	3.33	4.41	4.44	6.41	2.61
	6.99	0.00	5.71	2.68	8.44	3.81
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
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	2.693	2.929	4.028	2.202	4.482	3.589
	2.823	0.374	3.618	2.332	3.040	2.080
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
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0456	0.0691	0.0540	0.1389	0.1854	0.3205
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 5						
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	0.0000	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	0.0000	0.0000
	0.0035	0.0053	0.0043	0.0106	0.0147	0.0245
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 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

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.56 (0.000)	183532.8	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.190 (0.0000)	124111.41	67.624
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.81355 (0.00000)	2953.172	1.60907
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.011	0.00001
AVERAGE HEAD ON TOP OF LAYER 4	0.005 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000 (0.00000)	0.000	0.00000

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
CHANGE IN WATER STORAGE	15.556 (	0.0000)	56468.17	30.767

****

****

PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.26	11833.800
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01285	46.63947
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00009
AVERAGE HEAD ON TOP OF LAYER 4	0.030	
MAXIMUM HEAD ON TOP OF LAYER 4	0.235	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
SNOW WATER	1.35	4901.6436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4452
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0770

*** 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 9

LAYER	(INCHES)	(VOL/VOL)
1	45.1350	0.3761
2	6.2589	0.2608
3	0.0211	0.0702
4	0.0000	0.0000
5	0.1875	0.7500
6	3.7200	0.3100
7	684.0000	0.3800
8	15.3720	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:     C:\TC\B\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\B\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\B\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\B\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\B\I100\DATA10.D10
OUTPUT DATA FILE:            C:\TC\B\I100\OUTPUT1.OUT


TIME:  31:45     DATE:  11/10/2021


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

     TITLE:  TURKEY CREEK - OVERLINER POC - INTERIM 100 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
          THICKNESS                       =     12.00   INCHES
```

```
POROSITY                      =      0.4640 VOL/VOL
FIELD CAPACITY                =      0.3100 VOL/VOL
WILTING POINT                 =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
       FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                     =    1200.00   INCHES
POROSITY                      =      0.6277 VOL/VOL
FIELD CAPACITY                =      0.5156 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.3980 VOL/VOL
FIELD CAPACITY                =      0.2440 VOL/VOL
WILTING POINT                 =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC


                          LAYER  4
                          --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.27   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.   =   10.4300003000     CM/SEC
SLOPE                       =      0.10   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  11
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4640 VOL/VOL
FIELD CAPACITY              =      0.3100 VOL/VOL
WILTING POINT               =      0.1870 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =       0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC


                   LAYER  8
                   --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =   1800.00   INCHES
POROSITY                    =       0.4876 VOL/VOL
FIELD CAPACITY              =       0.4863 VOL/VOL
WILTING POINT               =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                   LAYER  9
                   --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                   =     36.00   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 #11 WITH A
          FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
          AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     87.10
FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
```

UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1168.858	INCHES
TOTAL INITIAL WATER	=	1168.858	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.6226	0.5924	0.6441	0.6185	0.6415	0.5927
	0.6256	0.6632	0.6143	0.6555	0.6208	0.6398
STD. DEVIATIONS	0.1581	0.0888	0.0964	0.1203	0.0636	0.0633
	0.0772	0.0919	0.0777	0.1000	0.1052	0.0799

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

PERCOLATION/LEAKAGE THROUGH LAYER 9

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 5

AVERAGES	0.1019	0.1066	0.1054	0.1046	0.1050	0.1002
	0.1024	0.1085	0.1039	0.1073	0.1050	0.1047
STD. DEVIATIONS	0.0259	0.0159	0.0158	0.0203	0.0104	0.0107
	0.0126	0.0150	0.0131	0.0164	0.0178	0.0131

DAILY AVERAGE HEAD ON TOP OF LAYER 9

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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00

RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.53094	(0.92768)	27337.311	18.26568
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00003	(0.00000)	0.097	0.00006
AVERAGE HEAD ON TOP OF LAYER 5	0.105	(0.013)		
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	(0.000)		
CHANGE IN WATER STORAGE	2.414	(3.1853)	8764.55	5.856

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE COLLECTED FROM LAYER 4	0.03969	144.06526
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00050
AVERAGE HEAD ON TOP OF LAYER 5	0.201	
MAXIMUM HEAD ON TOP OF LAYER 5	0.618	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00000

AVERAGE HEAD ON TOP OF LAYER 9	0.000	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	480.3534	0.4003
3	6.6298	0.2762
4	0.1419	0.5217
5	0.0000	0.0000
6	0.1875	0.7500
7	3.7200	0.3100
8	684.0002	0.3800
9	15.3720	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:     C:\TC\B\I170\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\B\I170\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\B\I170\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\B\I170\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\B\I170\DATA10.D10
OUTPUT DATA FILE:            C:\TC\B\I170\OUTPUT1.OUT


TIME:  31:46     DATE:  11/10/2021


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     TITLE:  TURKEY CREEK - OVERLINER POC - INTERIM 170 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =     12.00   INCHES
```

```
   POROSITY                        =      0.4640 VOL/VOL
   FIELD CAPACITY                  =      0.3100 VOL/VOL
   WILTING POINT                   =      0.1870 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       = 0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =    1500.00   INCHES
   POROSITY                        =      0.6174 VOL/VOL
   FIELD CAPACITY                  =      0.5127 VOL/VOL
   WILTING POINT                   =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       = 0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =     540.00   INCHES
   POROSITY                        =      0.5472 VOL/VOL
   FIELD CAPACITY                  =      0.4927 VOL/VOL
   WILTING POINT                   =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       = 0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
   THICKNESS                       =      24.00   INCHES
   POROSITY                        =      0.3980 VOL/VOL
   FIELD CAPACITY                  =      0.2440 VOL/VOL
   WILTING POINT                   =      0.1360 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   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.   =   4.09999990000     CM/SEC
SLOPE                       =      0.10   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                        LAYER  6
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC
```

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 11

```
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4640 VOL/VOL
FIELD CAPACITY              =      0.3100 VOL/VOL
WILTING POINT               =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.639999998000E-04 CM/SEC
```

LAYER 9

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

```
THICKNESS                   =   1800.00   INCHES
POROSITY                    =      0.4812 VOL/VOL
FIELD CAPACITY              =      0.4665 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

LAYER 10

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 16

```
THICKNESS                   =     36.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1488.058	INCHES
TOTAL INITIAL WATER	=	1488.058	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	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	10.0	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

2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

```
 EVAPOTRANSPIRATION
 ------------------
   TOTALS                1.899    1.877    2.445    2.983    2.984    2.462
                         3.333    1.827    3.048    2.255    1.305    1.801

   STD. DEVIATIONS       0.278    0.703    0.634    1.203    1.092    1.614
                         1.476    1.228    1.207    1.319    0.687    0.561

 LATERAL DRAINAGE COLLECTED FROM LAYER  5
 ----------------------------------------
   TOTALS                0.4670   0.4699   0.5198   0.4987   0.5167   0.4973
                         0.5097   0.5072   0.4944   0.5116   0.4945   0.5102

   STD. DEVIATIONS       0.1221   0.0353   0.0528   0.0538   0.0550   0.0481
                         0.0486   0.0453   0.0371   0.0360   0.0395   0.0381

 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

 PERCOLATION/LEAKAGE THROUGH LAYER 10
 ------------------------------------
   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  6
 -------------------------------------
   AVERAGES              0.1962   0.2586   0.2859   0.2891   0.2836   0.2721
                         0.2591   0.2525   0.2360   0.2331   0.2393   0.2292

   STD. DEVIATIONS       0.0526   0.1474   0.2116   0.2411   0.2100   0.2000
                         0.1461   0.1396   0.0795   0.0473   0.0785   0.0538

 DAILY AVERAGE HEAD ON TOP OF LAYER 10
 -------------------------------------
   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

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.99719	(0.42053)	21769.797	14.54569
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00007	(0.00003)	0.239	0.00016
AVERAGE HEAD ON TOP OF LAYER 6	0.253	(0.115)		
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 10	0.000	(0.000)		
CHANGE IN WATER STORAGE	3.948	(2.9994)	14332.12	9.576

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900

RUNOFF	2.308	8376.4365
DRAINAGE COLLECTED FROM LAYER 5	0.02359	85.62767
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000002	0.00665
AVERAGE HEAD ON TOP OF LAYER 6	2.227	
MAXIMUM HEAD ON TOP OF LAYER 6	2.749	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	151.6 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 10	0.000	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	616.1878	0.4108
3	198.7843	0.3681

4	6.4971	0.2707
5	0.1927	0.7896
6	0.0000	0.0000
7	0.1875	0.7500
8	3.7200	0.3100
9	684.0007	0.3800
10	15.3720	0.4270
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:     C:\TC\B\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\B\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\B\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\B\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\B\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\B\CL\OUTPUT1.OUT


TIME:  31:43     DATE:  11/10/2021


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

     TITLE:  TURKEY CREEK - OVERLINER POC - CLOSED 170 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
           THICKNESS                  =     12.00   INCHES
```

```
   POROSITY                         =      0.3980 VOL/VOL
   FIELD CAPACITY                   =      0.2440 VOL/VOL
   WILTING POINT                    =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT       =      0.2440 VOL/VOL
   EFFECTIVE SAT. HYD. COND.        =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
   THICKNESS                        =      0.04   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.        =  0.399999993000E-12 CM/SEC
   FML PINHOLE DENSITY              =      4.00   HOLES/ACRE
   FML INSTALLATION DEFECTS         =      4.00   HOLES/ACRE
   FML PLACEMENT QUALITY            =  3 - GOOD


                              LAYER  3
                              --------

                    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  4
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  11
   THICKNESS                        =     12.00   INCHES
```

```
POROSITY                        =      0.4640 VOL/VOL
FIELD CAPACITY                  =      0.3100 VOL/VOL
WILTING POINT                   =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC


                        LAYER  5
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                       =   1500.00   INCHES
POROSITY                        =      0.6174 VOL/VOL
FIELD CAPACITY                  =      0.5127 VOL/VOL
WILTING POINT                   =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC


                        LAYER  6
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                       =    540.00   INCHES
POROSITY                        =      0.5472 VOL/VOL
FIELD CAPACITY                  =      0.4927 VOL/VOL
WILTING POINT                   =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC


                        LAYER  7
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  10
THICKNESS                       =     24.00   INCHES
POROSITY                        =      0.3980 VOL/VOL
FIELD CAPACITY                  =      0.2440 VOL/VOL
WILTING POINT                   =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC
```

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.24	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.	=	2.52999997000	CM/SEC
SLOPE	=	0.10	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

```
                    LAYER 11
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  11
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4640 VOL/VOL
FIELD CAPACITY               =      0.3100 VOL/VOL
WILTING POINT                =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                    LAYER 12
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =   1800.00   INCHES
POROSITY                     =      0.4812 VOL/VOL
FIELD CAPACITY               =      0.4665 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                    LAYER 13
                    --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     36.00   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 5.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1498.672	INCHES
TOTAL INITIAL WATER	=	1498.672	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34

2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.576	0.391	0.753	0.263	0.284	0.212
	0.444	0.033	0.238	1.802	0.950	1.393
STD. DEVIATIONS	0.831	0.645	1.331	0.611	0.656	0.402
	0.936	0.073	0.324	2.672	1.582	1.838
EVAPOTRANSPIRATION						

TOTALS	1.760	1.863	2.886	3.893	3.829	3.288
	3.161	2.071	3.047	2.032	1.156	1.524
STD. DEVIATIONS	0.366	0.557	0.980	1.126	1.493	1.860
	1.981	1.588	1.548	0.886	0.397	0.409

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0007	0.0007	0.0007	0.0004	0.0001	0.0001
	0.0001	0.0000	0.0001	0.0005	0.0006	0.0008
STD. DEVIATIONS	0.0003	0.0002	0.0002	0.0002	0.0001	0.0001
	0.0001	0.0001	0.0002	0.0004	0.0005	0.0004

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.2902	0.2753	0.3033	0.2939	0.3029	0.2922
	0.3003	0.3005	0.2903	0.2986	0.2876	0.2952
STD. DEVIATIONS	0.0861	0.0770	0.0883	0.0871	0.0914	0.0884
	0.0908	0.0896	0.0844	0.0861	0.0819	0.0814

PERCOLATION/LEAKAGE THROUGH LAYER 10

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 13

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 2

AVERAGES	6.8793	6.7324	6.1524	3.3186	0.9596	1.0018
	0.7566	0.2676	1.0289	4.4329	6.1555	7.4774
STD. DEVIATIONS	3.0178	2.5973	2.2726	1.9220	1.3863	1.1511

1.2070	0.5696	1.4740	3.8561	4.5482	3.6461

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.4555	0.5414	0.5532	0.5607	0.5512	0.5387
	0.5315	0.5259	0.5070	0.5046	0.4861	0.4619
STD. DEVIATIONS	0.8386	0.9310	0.9926	1.0282	1.0355	1.0312
	1.0232	0.9968	0.9700	0.9413	0.9102	0.8601

DAILY AVERAGE HEAD ON TOP OF LAYER 13

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

****

****

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85 (7.081)	137390.7	100.00
RUNOFF	7.338 (4.2143)	26637.55	19.388
EVAPOTRANSPIRATION	30.508 (4.1964)	110744.53	80.606
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00474 (0.00142)	17.222	0.01254
AVERAGE HEAD ON TOP OF LAYER 2	3.764 (1.142)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	3.53051 (0.98626)	12815.770	9.32798
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00015 (0.00030)	0.553	0.00040
AVERAGE HEAD ON TOP OF LAYER 9	0.518 (0.932)		
PERCOLATION/LEAKAGE THROUGH	0.00000 (0.00000)	0.000	0.00000

LAYER 13

AVERAGE HEAD ON TOP OF LAYER 13	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-3.528 (	1.5238)	-12807.21	-9.322

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.70	20691.000
RUNOFF	3.968	14404.7227
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000040	0.14690
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.01966	71.34798
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000004	0.01574
AVERAGE HEAD ON TOP OF LAYER 9	4.663	
MAXIMUM HEAD ON TOP OF LAYER 9	5.277	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	200.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 13	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 13	0.000	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8564	0.2380
2	0.0000	0.0000
3	7.6860	0.4270
4	3.7200	0.3100
5	505.1465	0.3368
6	163.9178	0.3036
7	6.0976	0.2541
8	0.1187	0.4906
9	0.0000	0.0000
10	0.1875	0.7500
11	3.7200	0.3100
12	684.0046	0.3800
13	15.3720	0.4270
SNOW WATER	0.000	

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APPENDIX IIIB-C

MULTIMED MODEL ANALYSIS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIB-C-1 through IIIB-C-9

CONTENTS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02-22-22

MULTIMED CHEMICAL-SPECIFIC DATA

Variable Name	Units	Value	Comments
Solid phase decay coefficient	1/yr	0	decay not used
Dissolved phase decay coefficient	1/yr	0	decay not used
Chemical decay coefficient	1/yr	0	decay not used
Acid catalyst hydrolysis constant	l/m-yr	0	hydrolysis not used
Neutral hydrolysis rate constant	1/yr	0	hydrolysis not used
Base catalyst hydrolysis constant	l/m-yr	0	hydrolysis not used
Reference temperature	degrees C	20	not used in model since decay not used
Normalized distribution coefficient	ml/g	0	0 because simulation is steady state, with no chemical decay
Distribution coefficient	ml/g		derived by MULTIMED from normalized distribution coefficient
Biodegradation coefficient	1/yr	0	biodegradation not allowed by TCEQ

MULTIMED SOURCE-SPECIFIC DATA

Variable Name	Units	Value	Comments
Infiltration rate	m/yr	3.869×10^{-6}	From HELP Model (page IIIB-B-6)
Area of waste disposal unit	m^2	62,700	15.5 acres
Spread of contaminant source	m		Derived by MULTIMED
Recharge rate	m/yr	0.105	5% of average annual precipitation
Initial concentration at landfill (C_o)	mg/l	1.0	Set at 1.0 to find DAF
Length scale of facility	m		Derived by MULTIMED
Width scale of facility	m		Derived by MULTIMED

MULTIMED UNSATURATED ZONE DATA

The unsaturated zone was not modeled as part of this alternative overliner design demonstration. The attenuating effects of the unsaturated zone were conservatively disregarded.

MULTIMED AQUIFER-SPECIFIC DATA

Variable Name	Unit	Value	Comments
Particle diameter	cm	------	Not used as input when user specifies porosity.
Aquifer porosity	unitless	0.1	Average porosity calculated form geotechnical testing data using dry unit weight and an assumed specific gravity of 2.65.
Bulk density	g/cc	1.55	From geotechnical testing data using average moist unit weight.
Aquifer thickness	m	5.2	Depth from top of highest measured groundwater to top of the bounding shale unit.
Mixing zone depth	m		Derived by MULTIMED.
Hydraulic conductivity	m/yr	315.6	This is the maximum measured hydraulic conductivity ($1.0x10^{-3}$ cm/s) reported for the uppermost groundwater zone.
Hydraulic gradient	unitless	0.016	Estimated hydraulic gradient between the limits of waste and point of compliance.[1]
Groundwater seepage velocity	m/yr		Derived by MULTIMED.
Retardation coefficient	unitless		Derived by MULTIMED.
Longitudinal dispersivity	m		Derived by MULTIMED.
Transversal dispersivity	m		Derived by MULTIMED.
Vertical dispersivity	m		Derived by MULTIMED.
Organic carbon content	%	$1x10^{-6}$	Conservative assumption. (see Table 4-1 on page IIIB-8 for discussion)
Receptor distance from well	m	14.7	Distance from limits of waste to MW #21, 38.5 feet.
Z-distance from water table	m	0	Assume water table at bottom of liner.

[1] This hydraulic gradient is established using Figure IIIG-D-1, Groundwater Potentiometric Surface Contour Map. Refer to Table 4-1 (pages IIIB-7 and IIIB-8) for a detailed discussion.

CALCULATIONS OF THE DILUTION ATTENUATION FACTOR

Case 1

Result from MULTIMED model:

chemical concentration at the point of compliance = 0.8289×10^{-4} mg/1
(see MULTIMED model output)

to find the resulting DAF, take the reciprocal:

$$DAF = \frac{1}{0.8289 \times 10^{-4}\ mg/l}$$

DAF = 12,064

LEACHATE DATA

An initial concentration (C_o) equal to 1.0 mg/L was used for MULTIMED modeling, as detailed in the TCEQ's *Alternate Liner Design Handbook,* Input Leachate Requirements (page 23).

MULTIMED MODEL OUTPUT

MULTIMED model outputs for the four cases follow.

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1
Run options
--- -------

TURKEY CREEK LANDFILL

CASE - CLOSED
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated zone model
Run was	DETERMIN

Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS		LIMITS	
			MEAN	STD DEV	MIN	MAX
Solid phase decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Reference temperature	C	CONSTANT	20.0	-999.	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Distribution coefficient	--	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	-999.	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Molecular weight	g/M	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	0.000E+00	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000E+00	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.387E-05	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.627E+05	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	-999.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.105	-999.	0.000E+00	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000E+00	0.000E+00	1.00

1

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200E-03	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.100	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.55	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	5.20	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	316.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.160E-01	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	-999.	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Transverse dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Vertical dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Temperature of aquifer	C	CONSTANT	20.0	-999.	0.000E+00	100.
pH	--	CONSTANT	7.50	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.100E-05	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	14.7	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.8289E-04

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIC
LEACHATE AND CONTAMINATED WATER MANAGEMENT PLAN

Prepared for

Texas Regional Landfill Company, LP

February 2022

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

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WCG Project No. 0771-368-11-123

This document is intended for permitting purposes only.

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STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
02/22/22

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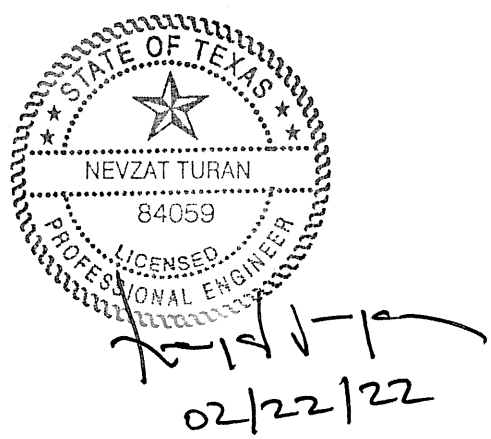

TABLES

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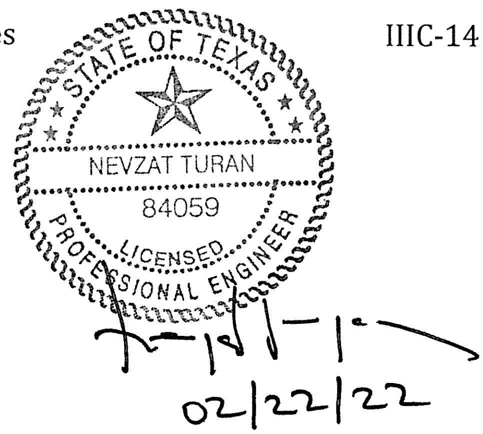

1 PURPOSE AND SCOPE

This appendix addresses §§330.305(g), 330.177, 330.207 and 330.333.

This Leachate and Contaminated Water Management Plan for the Turkey Creek Landfill was prepared consistent with Title 30 Texas Administrative Code (TAC) §§330.305(g), 330.177, 330.207, and 330.333. This plan provides the details of the collection, storage, treatment and disposal of contaminated water, and leachate generated during the active and postclosure periods of the landfill. The design details for the liner, overliner, and final cover systems are included in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The excavation plan and final contour plan are also included in Part III, Appendix IIIA-A. Additionally, Figure 3-1 includes the excavation plan showing the leachate collection system layout including the leachate collection system forcemain and leachate storage tanks.

2 LEACHATE AND CONTAMINATED WATER GENERATION

2.1 Generation Process

Leachate is generated when water percolates through the layers of solid waste as moisture is released from high moisture content waste. The capacity of solid waste to absorb moisture is known as field capacity. When the field capacity is exceeded, leachate is generated. However, leachate may also flow within the landfill through preferential pathways; therefore, some downward flow of leachate will occur before the field capacity of waste is reached. The quantity of leachate produced will depend upon the climate, site topography, type of cover, construction and landfilling procedures, and waste characteristics.

Contaminated water is defined in Title 30 TAC §330.3(36) as "leachate, gas condensate, or water that has come into contact with waste." Contaminated water is therefore generated when stormwater runoff has come into contact with solid waste at the working face of the landfill or any other area at the site where water contacts solid waste, leachate, or gas condensate.

2.2 Leachate Generation and Contaminated Stormwater Modeling

The Hydrologic Evaluation of Landfill Performance (HELP) model, Version 3.07, was used to estimate the amount of leachate that will be generated at the Turkey Creek Landfill. The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model 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, recirculation, evapotranspiration, and lateral drainage.

Leachate generation was evaluated for both active and closed landfill conditions. An explanation of the assumed conditions, methodologies, models and printouts of the results are included as Appendix IIIC-A.

The Rational Method was used to estimate the volume of contaminated water that must be contained around the working face. The design calculations and the size of the diversion and containment berms required around the working face for a 25-year, 24-hour storm event are provided in Appendix IIIC-C.

2.3 Stormwater Management

The Turkey Creek Landfill will manage surface water throughout the active life of the landfill to minimize the amount of stormwater that will come in contact with waste or leachate. Uncontaminated surface water will be controlled through the use of diversion berms, stormwater diversion ditches, and sumps. To promote runoff and prevent ponding, the operational cover will be graded and maintained. The use of drainage swales, diversion berms, and the containment berm is illustrated in Parts I/II, Appendix I/IIA, Drawings I/IIA.4 through I/IIA.7 – Sector Development Plans.

Stormwater that comes into contact with waste will be considered contaminated water and handled consistent with Title 30 TAC §330.207. Contaminated water will be contained by the containment berm at the working face as shown in Appendix IIIC-C. At no time will contaminated water be allowed to discharge into waters of the United States. Storage of contaminated water and its disposal are discussed in Section 4 and Section 5 of this appendix, respectively.

The final cover has been designed to minimize rain water infiltration and promote runoff. Uncontaminated surface water will be managed throughout the active life of the landfill to minimize infiltration into the filled areas and to minimize contact with solid waste. Also, daily and intermediate cover will be graded and maintained to promote runoff and prevent ponding as described in Part IV – Site Operating Plan (SOP).

Procedures for verifying the adequacy of daily cover placement to cover all waste material is discussed in Part IV – SOP, Section 4.18.2. Runoff generated from fill areas covered with a minimum 6 inches of earthen daily cover having no exposed waste or 12 inches of intermediate cover will be considered as uncontaminated and allowed to drain to the perimeter drainage system. In the event that the 6 inches of daily cover does not prevent stormwater from contacting solid waste or leachate, this stormwater will be collected and managed as contaminated and disposed of in an authorized manner. Uncontaminated surface water runoff will be diverted around the working face as shown in Appendix IIIC-C.

3 LEACHATE COLLECTION SYSTEM

3.1 System Layout and Design Criteria

3.1.1 Introduction

The leachate collection system (LCS) for the Subtitle D area will consist of: (1) a collection layer placed over the liner system, (2) the leachate collection piping, and (3) the leachate collection sumps and pumps. An overliner leachate collection system will be placed above the overliner system geomembrane liner within the pre-Subtitle D area to collect leachate generated from the waste placed in the vertical expansion area. The plan for the overliner LCS piping and grading is shown in Part III, Appendix IIIA-A, Drawing A.1 – Excavation Plan and Figure 3-1. LCS details are provided in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The existing leachate collection system has been analyzed to show that the proposed change in site configuration will not adversely impact the existing leachate collection system.

3.1.2 Design Criteria

The leachate management system is designed and operated to collect and remove leachate from each sector, maintain leachate levels below 12 inches (or 30 cm) above the liner systems, channel leachate to designated collection sumps, and effectively manage leachate through storage and disposal. The system is designed to eliminate potential migration of landfill leachate into the environment and to meet the requirements of Title 30 TAC §330.333, namely:

- constructed of materials that are chemically resistant to the leachate expected to be generated;
- of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by equipment used at the facility; and
- designed to function through the scheduled closure and post-closure period of the facility.

The LCS is designed to maintain the maximum leachate depth on the liner to less than 12 inches, in accordance with 30 TAC §330.331(a)(2) by the monitoring of head levels and timely recovery of leachate. This is accomplished by setting the control level for the automatic sump pumps above the lip of the sump. The drainage geocomposite leachate collection layer is designed to convey the estimated peak leachate flow rate without the leachate level within the geocomposite exceeding the thickness of the geocomposite. The operation of the leachate sump and the conveyance capacity of the geocomposite leachate collection layer work in tandem to maintain compliance with the design standard listed in Title 30 TAC §330.331(a)(2). The leachate collection system piping network is designed to convey collected leachate to the leachate collection sumps. The LCS piping is designed for post-settlement slopes and to meet each of the three criteria listed within the bullets on the previous page.

In addition, the leachate collection system for the Subtitle D areas is designed to manage leachate that will be recirculated at the working face. Section 5.2 includes a leachate recirculation plan. Also, Appendix IIIC-A (pages IIIC-A-4 and 5) provides a discussion regarding how the estimated additional leachate load due to recirculation was determined.

The geotextiles used for the geocomposite drainage layer utilize 100% continuous-filament polyester or polypropylene. Extensive testing, including EPA 9090 for chemical resistance, has demonstrated that polyester and polypropylene are resistant to a wide range of chemical classes encountered in soil and to typical Class 1 and MSW leachate. The LCS piping and the geonet portion of the geocomposite are constructed of high density polyethylene. Polyethylene is an industry standard material and is resistant to a wide range of chemical constituents, including those typically found in leachate (both Class 1 and MSW).

3.1.3 Leachate Collection System Layout

3.1.3.1 Subtitle D Areas

The leachate collection system layout is shown on Figure 3-1. Sectors 1 through 11A have been constructed to date. For Sectors 2A, 3A, 4A, 4B, and 6A, the leachate collection layer consists of 1 foot of tire chips placed over 1 foot of general fill to collect and transfer the leachate to the leachate collection pipes and sumps. For the Subtitle D Sectors 1, 2B, 3B, 4C, 5, 6B, and 7-11A, the leachate collection layer includes geocomposite placed over the liner system to collect and transfer leachate to the leachate collection pipes and sumps. The currently constructed leachate collection system has been evaluated considering the leachate collection layer and leachate collection header pipe grades under the proposed landfill expansion conditions (i.e., after landfill foundation settlement – refer to Appendix IIIE). Leachate collection layer slopes and slope lengths have been estimated for the proposed closed landfill conditions. Table 3-1 provides a design summary for the developed Subtitle D Sectors. As shown in each case, the maximum depth of leachate that occurs in the liner system is less than 12 inches and the flow depth is less than the thickness of the drainage geocomposite.

Table 3-1
Subtitle D Leachate Collection System Design Summary
Maximum Depth of Leachate on Liner

Sectors[3]	Location	Initial Slope	Post-Settlement Slope/Slope Used for Design[4]	Maximum Depth of Leachate on Liner Using Peak Flow Rate Generated by HELP[1]	Flow Depth Less than Thickness of Drainage Geocomposite
Sectors 1-8 (Developed MSW Sectors)	Slope between cell ridgeline and leachate collection pipe	2.15%	1.8%	0.117 inches	Yes
	Slope of leachate collection pipe	0.8%	0.22%	Peak flow less than the capacity of the collection pipe[2]	
Sectors 13-14 (Undeveloped MSW Sectors)	Slope between cell ridgeline and leachate collection pipe	2.5%	1.8%	0.067 inches	Yes
	Slope of leachate collection pipe	1.5%	0.22%	Peak flow less than the capacity of the collection pipe[2]	
Sectors 9, 10, and 11A (Developed Class 1 Sectors)	Slope between cell ridgeline and leachate collection pipe	2.15%	2.05%	0.134 inches	Yes
	Slope of leachate collection pipe	0.8%	0.22%	Peak flow less than the capacity of the collection pipe[2]	
Sectors 11B and 12 (Undeveloped Class 1 Sector)	Slope between cell ridgeline and leachate collection pipe	2.15%	2.05%	0.107 inches	Yes
	Slope of leachate collection pipe	0.8%	0.22%	Peak flow less than the capacity of the collection pipe[2]	

1 Maximum depth of leachate on liner was determined using the design slope. Refer to Appendices IIIC-A and IIIC-B for additional information.
2 The leachate collection pipe is a 6-inch-diameter pipe.
3 The leachate collection layer is as follows: Sectors 1, 2B, 3B, 4C, 5, 6B, 7, 8-13, and 14 – 200-mil-thick single-sided geocomposite; Sectors 9, 10, 11, and 12 – 220-mil-thick single-sided geocomposite; and Sectors 2A, 3A, 4A, 4B, and 6A – one foot of tire chips above one foot of general fill.
4 Refer to Appendix IIIE-B for settlement analysis.

For the undeveloped sector (Sectors 11B and 12) the leachate collection layer will also be placed directly over the liner system. The undeveloped sectors have been designed for the estimated overburden pressure that will be created by the proposed expansion. Material specifications are included in Appendix IIID – Liner Quality Control Plan (LQCP). Foundation settlement at the site is discussed in Section 6.3 of Appendix IIIE – Geotechnical Report. A leachate flow path slope of 1.8 percent was conservatively selected for the MSW Subtitle D sectors and 2.05 percent for the Class 1 Subtitle D sectors to use in the HELP analysis included in Appendix IIIC-A. Table 3-1 presents a summary of the initial and post-settlement/design slope for the Subtitle D sectors.

3.1.3.2 Overliner Area

As shown on Figure 3-1, the overliner system will be installed in the pre-Subtitle D area. The grades of the overliner will match the permitted bottom of final cover grades. The leachate will drain to collection pipes and be conveyed to the Sector 14 sump.

The post-settlement slopes of the overliner were used to demonstrate that the overliner leachate collection system will maintain less than 12 inches of leachate above the liner. The settlement analysis is discussed in detail in Appendix IIIE-B. The overliner has a minimum post-settlement slope of 3.4 percent. To provide for a conservative analysis, a slope of 1.0 percent was used for the overliner in the HELP model included in Appendix IIIC-A. Table 3-2 presents a summary of the initial and post-settlement slopes for the overliner and the maximum depth of leachate on the overliner system.

3.2 Leachate Collection Layer

3.2.1 Subtitle D Areas

The leachate collection layer for the undeveloped MSW and Class 1 sectors will be placed directly over the liner system to collect and transfer leachate to the leachate collection system pipes and sumps. The leachate collection layer placed over the floor grades for the MSW sectors consists of a 200-mil-thick HDPE geonet with a 6 oz/sy non-woven geotextile heat bonded to the top side of the HDPE geonet. The leachate collection layer placed over the sideslopes will consist of a 200-mil-thick HDPE geonet with a geotextile heat bonded to both sides. Calculations indicating the required properties of the geocomposite drainage layer (after accounting for losses due to clogging) are presented in Appendix IIIC-A.

Table 3-2
Overliner Leachate Collection System Design Summary
Maximum Depth of Leachate on Liner

Item	Location	Typical Initial Slope	Post-Settlement Slope	Slope Used for Design	Maximum Depth of Leachate on Liner Using Peak Flow Rate Generated by HELP[1]	Flow Depth Less than Thickness of Drainage Geocomposite
Overliner	Slope of overliner	5.3 – 25%	3.35% (minimum)	1.0%	0.040 inches	Yes
	Slope of leachate collection pipe	1.0% (minimum)	0.60%	0.5%	Peak flow less than capacity of the collection pipe[2]	

1 Maximum depth of leachate on liner was determined using the design slope. Refer to Appendix IIIC-A for additional information.
2 The leachate collection pipe is a 6-inch-diameter HDPE pipe.

A HELP model of the Class 1 sectors is also included in Appendix IIIC-A. The Class 1 sectors were modeled with a 220-mil-thick geonet heat-bonded to an overlying 8 oz/sy non-woven geotextile. Sectors 2A, 3A, 4A, 4B, and 6A were constructed with a leachate collection layer consisting of 1 foot of tire chips placed over 1 foot of general fill. The calculations included in Appendix IIIC-B address the maximum head on the liner in these sectors.

3.2.2 Overliner Areas

In addition to the leachate collection layer for the Subtitle D area, an overliner leachate collection system will be placed above the overliner system geomembrane liner in the pre-Subtitle D area to collect and transfer leachate to the leachate collection system drainage pipes.

The leachate collection layer placed in the overliner area will consist of a 300-mil-thick HDPE geonet with a 6 oz/sy non-woven geotextile heat bonded to both sides of the HDPE geonet. Calculations indicating the required properties of the geocomposite drainage layer are presented in Appendix IIIC-A. The overliner drainage geocomposite will comply with the specifications included in Appendix IIID – LQCP. Estimated percolation rates used to demonstrate that the overliner design meets the requirements presented in Title 30 TAC §330.331(a)(1) are included in Appendix IIIB.

3.2.3 Chimney Drains

The chimney drains will be installed above the LCS pipes and the top of the chimney drain gravel will extend to the top of protective cover grades as shown in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details. The chimney drains will be constructed with drainage stone material (gravel) having a hydraulic conductivity of 1.0 cm/s or greater and will be covered by a geotextile to restrict migration of the protective cover soil into the LCS. The chimney drains will allow leachate to flow into the LCS without a buildup of head above the protective cover layer. Calculations showing the adequacy of the chimney drain are provided in Appendix IIIC-B.

3.3 Leachate Collection Piping

3.3.1 Subtitle D Areas

The liner and overlying leachate collection layer will slope to drain toward the LCS trenches, which will each contain a perforated leachate collection pipe surrounded by drainage stone and separated from the adjacent protective cover and waste layers by a geotextile fabric. The leachate collection pipes will direct the leachate to the landfill sumps. The existing leachate collection pipes are perforated 6-inch ADS N-12 HDPE smooth wall pipes in Sectors 1 through 8 and HDPE SDR 17 smooth wall pipes in Sectors 9 and 10. The proposed leachate collection pipe will be a perforated SDR 17 HDPE smooth wall pipe. As shown in Table 3-1, the LCS pipes are analyzed for slopes that are equal to or less than the estimated post-settlement slope.

The geotextile fabric and pipe perforations are designed to prevent clogging of the fabric or pipe. The leachate collection system is designed with cleanout risers to allow cleaning. Leachate collection pipe design calculations are provided in Appendix IIIC-B. These calculations demonstrate the adequacy of the pipes to convey leachate to the sumps, the structural stability of the pipes, and the satisfaction of the perforation requirements. Details of the LCS layer and pipe trench are shown in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

3.3.2 Overliner Areas

The overliner leachate collection pipes will direct the leachate to the landfill sump located in the overliner area and will consist of perforated SDR 17 HDPE smooth wall pipes. The overliner leachate collection pipe design calculations are provided in Appendix IIIC-B. These calculations demonstrate the adequacy of the pipes to convey leachate to the sumps, the structural stability of the pipes, and the satisfaction of the perforation requirements. As shown in Table 3-2, the LCS pipes are designed for slopes that are equal to or less than the estimated post-settlement slope. Details of the overliner LCS layer and pipe trench are shown in Part III, Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

3.4 Leachate Sumps and Pumps

The leachate collection sumps and pumps have been sized to comply with the regulatory design standard listed in §330.331(a)(2). The leachate collection sumps and pumps have been designed to maintain less than 30 cm (12 inches) depth of leachate over the liner. Analysis of all leachate sumps is included in Appendix IIIC-B.

The leachate sump in Sectors 11, 12, 13, and 14 have been sized based on the amount of leachate generation. The minimum sump size for these sectors will be 3 feet deep (and 2 feet, 4 inches below the pipe invert) with minimum dimensions of approximately 45 by 45 feet at the landfill floor and 27 by 27 feet at the sump base and will store a minimum of 3,969 cubic feet of leachate. The size and capacity of the sumps are presented in Appendix IIIC-B. The sump will be backfilled with drainage stone meeting the gradation in accordance with ASTM D 448, size number 467 (nominal aggregate size is 2 inches to 3/16 inches).

Each sump will be emptied by a submersible pump located in an 18-inch nominal diameter sidewall riser pipe which extends into the bottom of the sump and is perforated in the sump. Pumps will be operated either manually or automatically by pressure transducers. Control levels for an automatic pump will be set to maintain sump liquid levels between the lip of the sump and pump intake. The objective of the pump operation is to ensure that a free-flowing condition is maintained in the LCS. If the pump malfunctions, the pump will be removed, repaired, and replaced, or a new pump will be used.

The specified pump will have the capacity to pump leachate at a rate of 15 gpm or 21,600 gpd. The maximum estimated flow to be pumped from the largest sector is approximately 11,854 gpd. If the specified leachate sump pumps are not able to empty the sump and maintain less than 12 inches of head on the liner at reasonable cycle times, then a pump with more capacity will be used (refer to Section 4.1 for more information).

The leachate depth monitoring procedure and leachate removal will be the same for all disposal areas. The depth of leachate in the sump will be monitored by the pressure transducer which will be calibrated to provide direct read-out of the leachate level in the sump (e.g., typically the leachate level is shown on a continuous digital display at the sump as the pressure transducers provide a constant determination of the leachate levels in the sump). As noted in Part IV – SOP, Section 4.24, the leachate levels for each sump will be recorded in the Site Operating Record once per week. If the pressure transducers are not functioning, the pumps will be operated manually until the automatic system is repaired. Details of the leachate sump are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

3.5 Drainage Stone (Coarse Aggregate)

Granular drainage material around the leachate collection pipes and in the LCS sumps in the overliner and Subtitle D areas will consist of typical (e.g., unit weight of 90 to 110 pcf) or lightweight (e.g., unit weight less than 70 pcf) materials that comply with the following criteria. The aggregate will have a loss of mass due to calcium carbonate of less than 15 percent (in accordance with JLT-S-105-89 or ASTM D3042 method modified to use a solution of hydrochloric acid having a pH of 5). The drainage stone will meet the following gradation in accordance with ASTM D448, size number 467.

Sieve Size Square Opening	Percent Passing
2 inches	100
1½ inches	95 - 100
¾ inch	35 - 70
3/8 inch	10 - 30
No. 4 (3/16 inch)	0 - 5

Drainage materials not complying with the above gradations may also be approved by the POR if demonstrated to have a hydraulic conductivity of at least 1.0 cm/s and meet the gradation requirements of the filter and leachate collection pipe (in no case will the maximum rock size be greater than 2 inches). At a minimum, the drainage stone will meet the following criteria:

For circular holes:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter}} > 1.7$$

For slots:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Slot Width}} > 2.0$$

The drainage stone will be covered by a geotextile to maintain separation of drainage stone from the overlying layers. The geotextile will be resistant to commonly encountered chemicals, hydrocarbons and mildew, and will be rot resistant. Geotextile design calculations are presented in Appendix IIIC-B.

0 200 400
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- LIMIT OF CLASS 1 WASTE DISPOSAL AREA
- 750 EXISTING CONTOUR
- N 6816000 STATE PLANE COORDINATE
- 32° 21' 20" GEODETIC COORDINATE
- EASEMENT
- RELOCATED EASEMENT
- SECTOR BOUNDARY
- 800 OVERLINER CONTOUR
- 670 PERMITTED/EXISTING TOP OF LINER CONTOUR
- 662 PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
- PERMITTED/UNDEVELOPED LEACHATE LINE
- LEACHATE COLLECTION SUMP
- MW-7 EXISTING GROUNDWATER MONITORING WELL
- GMP-12 EXISTING GAS MONITORING PROBE
- MW-7 PROPOSED GROUNDWATER MONITORING WELL
- GMP-17 PROPOSED GAS MONITORING PROBE
- PRE SUBTITLE D AREA

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 648 FT-MSL.
5. SUBTITLE D AREA LCS PIPES SLOPE WITH A MINIMUM OF 0.8% TO SUMPS. OVERLINER LCS PIPES SLOPE WITH A MINIMUM 1.0% TO SUMPS.
6. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.5 THROUGH I/IIA.7.
7. CLASS 1 NON HAZARDOUS INDUSTRIAL WASTE (NOT CLASSIFIED AS SUCH DUE TO ASBESTOS CONTENT) WILL BE DISPOSED OF ONLY IN SECTORS 9A, 9B, 10A, 10B, 11, 11A, 11B, AND 12.
8. THIS LEACHATE STORAGE TANK WILL BE RELOCATED FROM AROUND SECTOR 8A RISER AREA TO THE LOCATION SHOWN ON THIS DRAWING FOR THE DEVELOPMENT OF SECTOR 12 AND/OR PERIMETER DRAINAGE STRUCTURES.

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED PROFESSIONAL ENGINEER

02/22/22

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- [ ] ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: 3-1 LEACHATE PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE COLLECTION SYSTEM PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE 3-1

O:\0771\368\EXPANSION 2021\PART III\IIIC\3-1-LEACHATE PLAN.dwg, rarrington, 1:2

4 LEACHATE AND CONTAMINATED WATER STORAGE

4.1 Leachate Storage

Temporary leachate storage will be provided in the leachate collection sumps. The leachate collection sumps have been sized based on the amount of leachate generated. Leachate from the MSW and Class 1 waste disposal areas will be comingled in the leachate collection system piping, sumps, and storage tanks. The undeveloped sectors will have sumps which will provide at least 3,969 cubic feet of storage capacity. The existing sumps provided a minimum of 2,781 cubic feet of storage capacity. Additional storage will be provided in the onsite above-ground storage tanks as discussed in Section 4.3. Table 4-1 summarizes the estimated leachate flow into the sump and the daily pump operating time provided by representative sectors/areas. The estimated leachate generation rate is based on the average leachate generation produced by the HELP model analysis. Sump volume calculations are provided in Appendix IIIC-B. Details of the leachate sumps are provided in Appendix IIIA-A – Liner, Overliner, and Final Cover System Details.

Leachate levels in the sumps will be measured and recorded to evaluate leachate production and fluctuations. A form to record leachate measurements will be kept in the Site Operating Record and will be used to evaluate the effectiveness of leachate monitoring and control facilities. The sumps will be emptied by submersible pumps located within the sump section of the sidewall riser pipes. Disposal of leachate is discussed in Section 5. Leachate will be pumped to the leachate storage tank(s) through the forcemain and/or recirculated at the working face. The operation of the onsite storage tanks is discussed in Section 4.3. The locations of the leachate storage tanks are shown on Figure 4-1; however, locations may vary but will be located within the permit boundary. The storage tank calculations are presented in Appendix IIIC-D.

The forcemain that connects the sumps to the leachate storage tank will consist of a 2-inch minimum diameter pipe encased in a 4-inch minimum diameter carrier pipe. The carrier pipe will provide leak detection and containment. The forcemain will be extended to serve each sector as landfill development progresses. The location of the leachate forcemain is shown on Figure 4-1. Details of the connection between the 18-inch riser and forcemain are presented on Figure 4-2, and the forcemain capacity calculations are presented in Appendix IIIC-D.

Table 4-1
Sump Flow and Pump Operating Times

Condition	Sump Storage Summary					
	Sump for Sector 4 (Developed Area)[1]			Sump for Sector 14 (Undeveloped Area)[1]		
	Average Flow[2] (gpd)	Pump Operating Time (hours/day)	Pump Capacity (gpm)	Average Flow[2] (gpd)	Pump Operating Time (hours/day)	Pump Capacity (gpm)
Active	8,938.1	9.9	15	8,010.2	8.9	15
Interim	11,858.8	13.2	15	10,051.3	11.2	15
Closed	8,702.8	9.7	15	8,725.8	9.1	15

[1] Sumps for the largest drainage areas are shown. Refer to Appendix IIIC-B, Sheet IIIC-B-62 – Sump Drainage Areas for sector layout and sump drainage areas.
[2] Refer to Appendix IIIC-B, pages IIIC-B-56 through IIIC-B-62 for sump calculations for the developed and undeveloped areas.

4.2 Contaminated Water Management

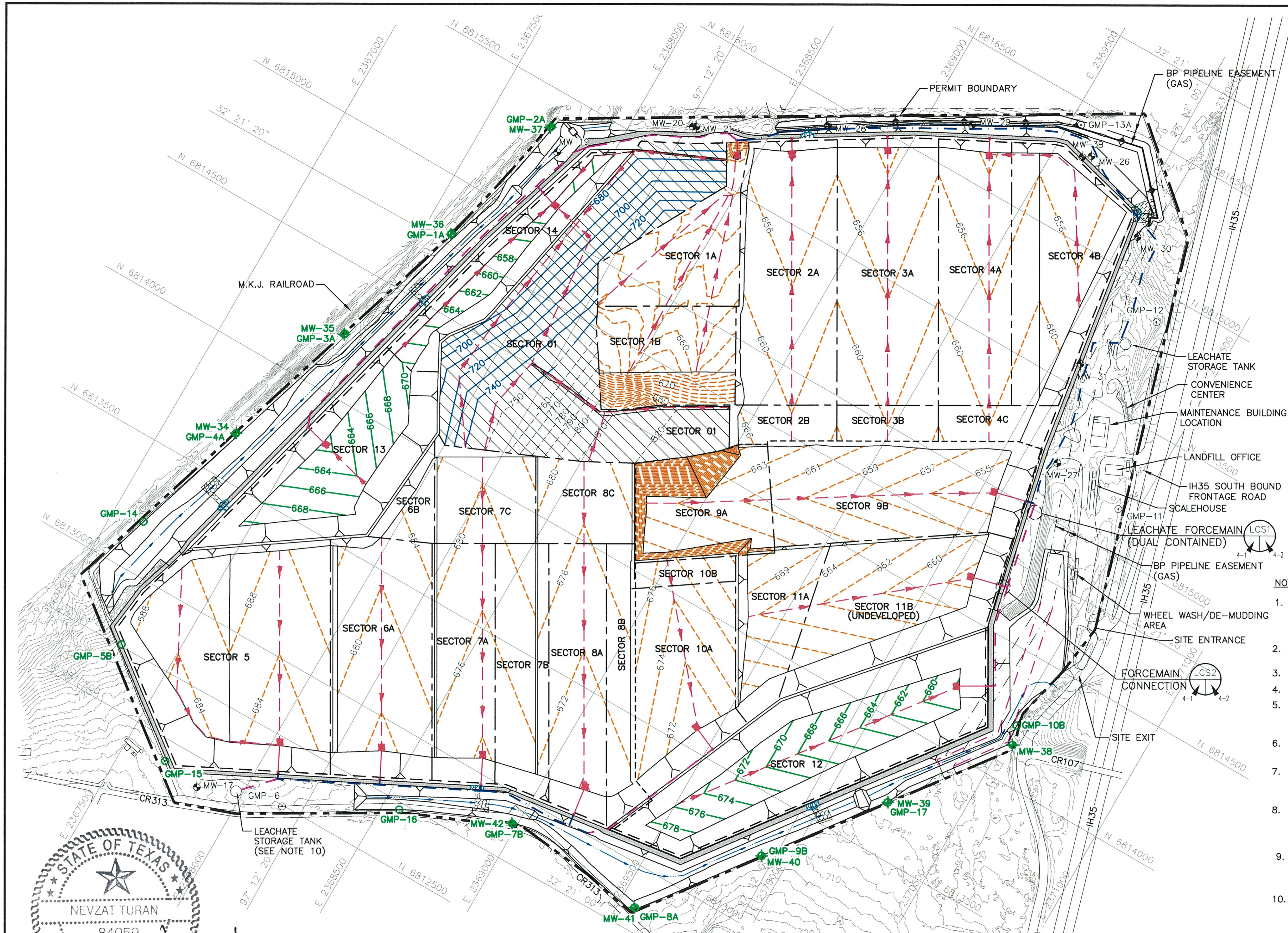
Contaminated water will be contained at the working face as shown in Appendix IIIC-C. A vacuum truck or similar vehicle will remove contaminated water from this area. Contaminated water will then be transported via tanker trucks to a properly permitted privately owned offsite wastewater treatment facility or publicly owned treatment works (POTW), as discussed in Section 5. As an alternative, contaminated water may be taken to the onsite solidification facility to solidify and dispose of at the site.

4.3 Onsite Storage Tanks

There will be two on-site storage tanks located at the site. Each tank will provide a minimum of 100,000 gallons of storage capacity. The number and locations of tanks may vary; however, the minimum required capacity will be 200,000 gallons combined. The storage tanks will operated as discussed in Section 5.1.

Each tank is equipped with a liquid-level sensor and a high-level alarm to prevent overfill. When the high level alarm is triggered, a light on the tank will start flashing, which will alert site personnel of the high level in the tank. Additionally, the alarm will activate an electronic signal that will be sent to the leachate sump pumps to shut them down until the issue is resolved. Site personnel will then take appropriate actions to reduce the leachate level in the tank. The storage tanks will be emptied consistent with the leachate storage system operation plan detailed in Section 5.

The tanks consist of a double-walled leachate tank made of steel containment that contains an inner double-walled tank ("storage vessel") consisting of a geomembrane liner. The steel containment will be placed over a foundation to provide stability for the tank. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner. Any leachate that migrates through the primary liner drains to a collection sump which is equipped with a witness riser pipe. The witness riser pipe extends under the tank and through the concrete foundation. Leachate in the observed inspection port indicates a leak of the primary HDPE geomembrane liner. If this occurs, the tank will be evaluated and repaired if necessary.



LEGEND

	PERMIT BOUNDARY
	LIMITS OF WASTE
	LIMIT OF CLASS 1 WASTE DISPOSAL AREA
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
	EASEMENT
	RELOCATED EASEMENT
	SECTOR BOUNDARY
800	OVERLINER CONTOUR
670	PERMITTED/EXISTING TOP OF LINER CONTOUR
662	PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
	PERMITTED/UNDEVELOPED LEACHATE LINE
	LEACHATE COLLECTION SUMP
MW-7	EXISTING GROUNDWATER MONITORING WELL
GMP-12	EXISTING GAS MONITORING PROBE
MW-7	PROPOSED GROUNDWATER MONITORING WELL
GMP-17	PROPOSED GAS MONITORING PROBE
	PRE SUBTITLE D AREA
	EXISTING LEACHATE FORCEMAIN
	PROPOSED LEACHATE FORCEMAIN

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 648 FT-MSL.
5. SUBTITLE D AREA LCS PIPES SLOPE WITH A MINIMUM OF 0.8% TO SUMPS. OVERLINER LCS PIPES SLOPE WITH A MINIMUM 1.0% TO SUMPS.
6. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.5 THROUGH I/IIA.7.
7. CLASS 1 NON HAZARDOUS INDUSTRIAL WASTE (NOT CLASSIFIED AS SUCH DUE TO ASBESTOS CONTENT) WILL BE DISPOSED OF ONLY IN SECTORS 9A, 9B, 10A, 10B, 11, 11A, 11B, AND 12.
8. THE LEACHATE COLLECTED IN THE OVERLINER SUMP WILL BE CONVEYED TO THE SUMP IN SECTOR 1. ALTERNATIVELY THE SITE MAY OPT TO INSTALL A BOOSTER PUMP WHERE THE PROPOSED FORCEMAIN TIES TO THE EXISTING FORCEMAIN.
9. A FORCEMAIN BETWEEN THE OVERLINER AREA SUMP AND SECTOR 1A SUMP AREA MAY BE LOCATED INSIDE THE EXISTING WASTE. A FORCEMAIN INSTALLED WITHIN THE WASTE FILL AREA WILL BE SINGLE WALLED.
10. THIS LEACHATE STORAGE TANK WILL BE RELOCATED FROM AROUND SECTOR 8A RISER AREA TO THE LOCATION SHOWN ON THIS DRAWING FOR THE DEVELOPMENT OF SECTOR 12 AND/OR PERIMETER DRAINAGE STRUCTURES.

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
02/22/22

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DATE: 02/2022
FILE: 0771-368-11
CAD: 4-1 FORCEMAIN PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT FORCEMAIN AND STORAGE TANK PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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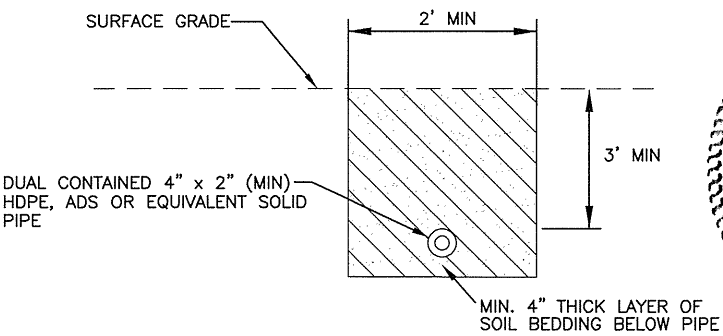
FIGURE 4-1



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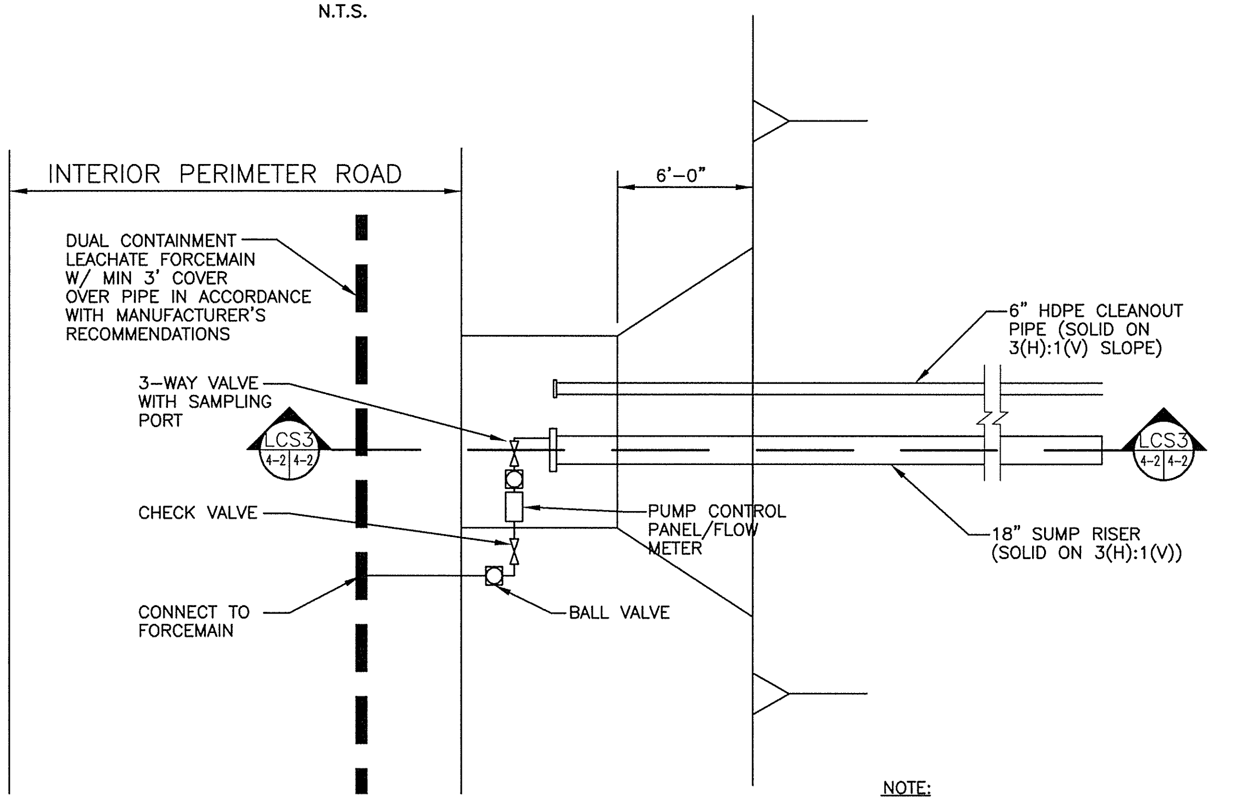
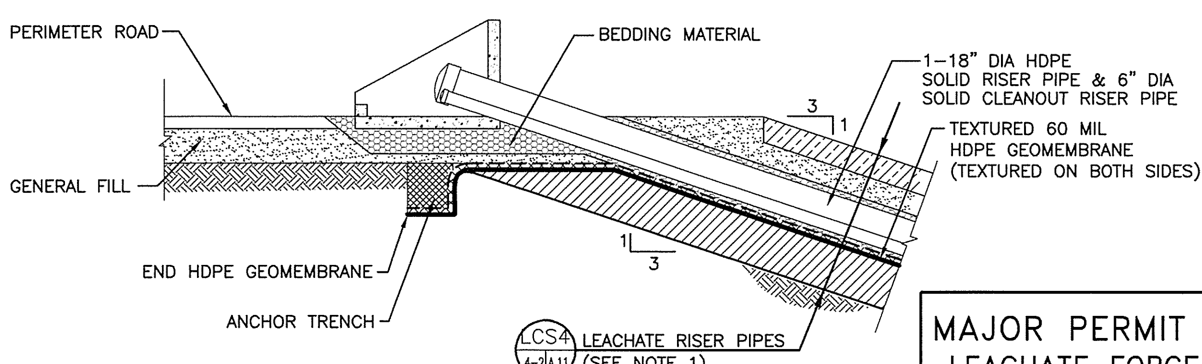
LEACHATE FORCEMAIN (DUAL CONTAINED) LCS1 4-1 4-2
N.T.S.



NOTE:

1. REFER TO APPENDIX IIIA-A-LINER, OVERLINER, AND FINAL COVER SYSTEM DETAILS FOR LINER INFORMATION.

FORCEMAIN CONNECTION LCS2 4-1 4-2
N.T.S.



LEACHATE RISER/CLEANOUT LCS3 4-2 4-2

0 4 8
SCALE IN FEET

MAJOR PERMIT AMENDMENT
LEACHATE FORCEMAIN DETAILS

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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DRAWN BY: JDW	DATE: 02/2022	FILE: 0771-368-11
REVIEWED BY: NT	CAD: 4-2 FORCEMAIN DTLS.DWG	FIGURE 4-2

O:\0771\368\EXPANSION 2021\PART III\IIIC\4-2 FORCEMAIN DETAILS.dwg, jwilson, 1:1

5 LEACHATE AND CONTAMINATED WATER DISPOSAL

5.1 Leachate Storage System Operation and Disposal

Leachate that is generated at the site will be conveyed to the leachate collection sumps. Leachate levels in the sumps are measured to evaluate leachate production and fluctuations. The depth of leachate in the sump will be monitored by the pressure transducer to provide direct read-out of the leachate level in the sump (e.g., typically the leachate level is shown on a continuous digital display at the sump, as the pressure transducers provide a constant determination of the leachate levels in the sump). Leachate will be pumped from the leachate sumps and transferred to the leachate storage tank via the forcemain (see Figure 4-1 for location).

The collected leachate will be either recirculated (refer to Section 5.2) or transferred from the leachate storage tank into a tanker truck for transportation directly to the liquid waste bulking facility, a properly permitted privately-owned off-site facility, or a POTW for treatment. For leachate that is transported off-site, sampling and analysis will be limited to the disposal facility's requirements.

5.2 Leachate Recirculation Plan

The main purpose of recirculating leachate at this facility is to enhance the ability to manage and control leachate. Additionally, in an effort to promote an increase in waste compaction, leachate recirculation will provide the opportunity to create a uniform moisture content throughout the waste at the working face. The additional moisture will help stabilize the waste mass, thus providing for an increased compaction of the waste. The leachate will be better managed because the recirculation of leachate through the waste mass allows for treatment of the leachate to occur through physical, biological, and chemical interactions with the organic and some inorganic portions of the waste. This increases the rate of waste decomposition and stabilization, as well as increasing the rate of landfill gas recovery. Recirculation of leachate also facilitates dust control at the working face.

Consistent with Title 30 TAC §330.177, recirculation of leachate will only occur over areas underlain by a Subtitle D liner system. Leachate will be recirculated by surface spraying at the working face. Leachate will be distributed from a tanker truck or other comparable equipment using a spray bar or hose to distribute leachate back to the working face (i.e., within the active waste fill area that is contained by the containment berm).

The following performance standards will govern the application rate of leachate recirculation.

- The rate of leachate recirculation will not exceed the moisture holding capacity of the landfill. For example, the application rate will be applied so that no seeps or ponding occur from recirculation activities.
- Leachate recirculation will not occur immediately before, during, or immediately after rainfall events, or during freezing temperatures that could affect the holding capacity of the waste.
- Leachate recirculation will not occur during high wind events.
- Refer to Part IV – SOP, Section 4.10 for additional information regarding the plan to be followed if odors due to leachate recirculation become an issue.

Sampling and analytical testing are not required for the recirculated leachate. Contaminated stormwater will not be recirculated into the waste.

The leachate generated from the landfill will be recirculated to the landfill working face or solidified, and excess quantities of leachate will be directed to the leachate storage facilities.

5.3 Contaminated Water Disposal

Contaminated water that collects behind the containment berm will be pumped into tanker trucks and transported to the solidification facility, leachate tanks, a properly permitted privately-owned treatment facility, or a POTW for treatment. Contaminated water will be removed as soon as practicable from the area behind the contaminated water containment berm (refer to Section 4.24 of the SOP for additional information and record keeping requirements). Contaminated water may also be transported to the leachate storage tank. When contaminated water is stored in the leachate storage tank, no leachate recirculation will occur, and a sign will be posted on the tank stating "No Recirculation." When the tank containing the contaminated water is emptied, the sign will be removed. Also, a record will be placed in the Site Operating Record noting that contaminated water is being stored in the leachate storage tank. Contaminated water (generally small quantities) may be taken to the solidification facility to solidify and be disposed of at the site.

5.4 Landfill Gas Condensate

Consistent with 30 TAC §330.177 and §330.207(e), landfill gas condensate will be pumped to the permanent on-site leachate storage tanks. It will then be recirculated per Section 5.2 or transported via tanker trucks to a properly permitted, privately-owned offsite waste water treatment facility or POTW. Condensate (generally small quantities) may be taken to the solidification facility to solidify and be disposed of at the site.

APPENDIX IIIC-A

LEACHATE GENERATION MODEL

STATE OF TEXAS
NEVZAT TURAN
84059
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02/22/22

Includes pages IIIC-A-1 through IIIC-A-286

LEACHATE GENERATION MODEL

HELP Model

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to estimate quantity of leachate that will be generated during the active life and postclosure period of the Turkey Creek Landfill. The HELP Model is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of the landfill. The model 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.

Model Setup

The site was modeled as a 1-acre unit area for the following stages of landfill development in developed MSW Subtitle D areas (Sectors 1A through 8C):

- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 300 feet of waste with intermediate cover
- 320 feet of waste with intermediate cover
- 320 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of Landfill development in undeveloped MSW Subtitle D areas (Sectors 13 and 14):

- Working face within 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 140 feet of waste with intermediate cover
- 140 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in developed Class 1 Subtitle D areas(Sectors 9A through 10B):

- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 300 feet of waste with intermediate cover
- 330 feet of waste with intermediate cover
- 330 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in the undeveloped Class 1 Subtitle D area (Sectors 11A through 12):

- Working face with 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 200 feet of waste with intermediate cover
- 270 feet of waste with intermediate cover
- 270 feet of waste with final cover

The site was modeled as a 1-acre unit area for the following stages of landfill development in the undeveloped overliner area:

- Working face with 10 feet of waste
- 50 feet of waste with intermediate cover
- 100 feet of waste with intermediate cover
- 170 feet of waste with intermediate cover
- 170 feet of waste with final cover

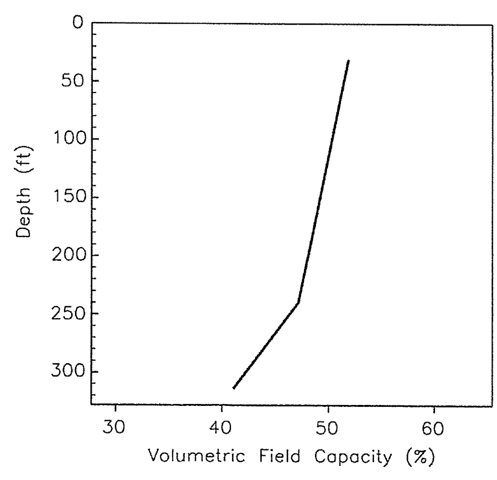
The active stage was modeled for one year with initial moisture contents initialized at 25 percent. The interim stages with intermediate cover were modeled for 10 years. The closed landfill condition was modeled for 30 years. The evaporative zone depth was selected to be 10 inches for the active and interim cases and 12 inches for the closed case. The leaf area index was selected to be 0 for the active case, 2 for the interim cases and 4.5 for the closed case based on the selected ground area. The Soil Conservation Service (SCS) runoff curve numbers were calculated by HELP based on soil data and expected ground cover, surface slope, and slope length. The active case models a curve number of 94.6 and percent runoff area of zero, which is representative given that this condition assumes complete infiltration (minus evapotranspiration). The interim cases utilize the default curve number assigned by the HELP model which is 87.1 and corresponds to "fair" ground cover. The percent runoff area used was 80. This is representative of the intermediate cover, which will be 12 inches of compacted soil with 60 percent or more vegetation coverage. The final case models a curve number of 80.3 and percent runoff area of 100, which corresponds to "good" ground cover. This is representative of the final cover, which will have a minimum 90 percent vegetation coverage.

Moisture Content and Field Capacity

For a conservative analysis, the initial moisture content was set at field capacity for all profile layers except the compacted clay barrier layer and the waste layer. HELP automatically sets the initial moisture content for a compacted clay barrier layer at porosity (i.e., fully saturated). The initial moisture content for the waste layer was selected to be 25 percent for the 10-foot-thick and 50-foot-thick waste column cases. A moisture content of 25 percent is typical for recently placed waste. For the remaining cases, the initial moisture content for the waste layer was selected to be 38 percent to account for the fact that the waste will be in place for a longer period of time and the moisture content could increase.

Default values for the field capacity of each profile layer, other than the waste layer, were used. The field capacity values for the waste layer were obtained from "Retention of Free Liquids in Landfills Undergoing Vertical Expansion" (Zornberg, Jorge G., et al., 1999) and varies based on average waste column thickness. The relationship used is shown in the following graph.

VOLUMETRIC FIELD CAPACITY AS A
FUNCTION OF
WASTE DEPTH



The above curve is used for both Class 1 and MSW waste disposal areas for the analysis included in Appendix IIIC-A. In addition, a demonstration has been included in Appendix IIIC-A.3 to show how leachate generation is affected if the field capacity of the Class 1 waste is lower than what is represented by the above graph (which could be the case given that the soil content of Class 1 waste is typically higher than non-Class 1 waste). The demonstration updates the parameters of the Class 1 areas to represent a soil-like waste material. The moisture content of the Class 1 waste was assumed to be at field capacity. Additionally, a heavier density of 100 pcf was assigned to Class 1 waste for a conservative analysis. The effect on the LCS has been addressed in Appendix IIIC-A.1. As shown in this appendix, the LCS will still function as designed even with the soil-like characteristics and heavier density assigned to the Class 1 waste.

Climate Data Input

Precipitation data was synthetically generated by the HELP model program using normal mean monthly precipitation data from the NOAA for Alvarado, Texas weather station. The average annual precipitation over the modeled 30-year period was 37.85 inches. Temperature and solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas.

Landfill Profile

The landfill profiles for various stages of the landfill development are presented in the attached HELP Model summary sheets. The profile presented below includes a composite liner with a standard Subtitle D final cover system, as well as the overliner.

Liner Systems

The Subtitle D composite liner designed for developed and undeveloped cells consists of a 60-mil high-density polyethylene (HDPE) geomembrane placed over a 24-inch-thick compacted clay liner for the MSW areas and a 36-inch-thick compacted clay liner for the Class 1 areas with a hydraulic conductivity of 1×10^{-7} cm/s. The geomembrane liner was modeled for good installation quality, with no defects or pinholes to produce the largest leachate flow rate (which is a conservative assumption because it will produce a conservative leachate head value). Default characteristics from the HELP model were selected for the HDPE geomembrane hydraulic conductivity. Default soil characteristics from the HELP model also were selected for the compacted clay liner.

The pre-Subtitle D overliner consists of a 40-mil LLDPE geomembrane overlain a geosynthetic clay liner. The geomembrane liner was modeled for good installation quality, with no defects or pinholes to produce the greatest head on the liner. Default soil characteristics from the HELP model were selected for the HDPE geomembrane hydraulic conductivity.

Leachate Collection System

Developed Subtitle D Sectors 1, 2B, 3B, 4C, 5, 6B, 7 and 8 were constructed with a 200-mil-thick geonet heat-bonded to an overlying 8 oz/sy non-woven geotextile. Sectors 9 and 10 were constructed with a 220-mil-thick geonet heat bonded to an overlying 8 oz/sy non-woven geotextile. Undeveloped Subtitle D Sectors 13 and 14 will be constructed with an LCS that includes a 200-mil-thick, single-sided geocomposite (floor grades). Undeveloped Subtitle D Sector 11 and 12 will be constructed with an LCS that includes a 220-mil-thick single-sided geocomposite (floor grades). The calculations for determining the hydraulic conductivity of the geocomposite are shown on pages IIIC-A-7 through IIIC-A-26. The double-sided geocomposite used on sideslopes is analyzed in Appendix IIIC-A.2.

In the HELP model demonstrations 10 percent recirculation is used. This is a conservative assumption since that recirculation will only occur at the working face, which will move on a daily basis. For example, the HELP Model analysis is based on a 1-acre "unit" area. As discussed in Section 5.2, recirculation will only occur at the working face. Therefore, the area that receives additional leachate due to recirculation is limited to the working face area which constantly moves within the area defined by the waste fill footprint. As a result, the majority of the time most of the waste footprint area does not experience any recirculation, and for the purpose of this analysis it is assumed that the "unit" acre will experience recirculation 10 percent of the time (this is a conservative assumption given that the site currently recirculates almost all the leachate that is produced). In addition to the above, a second demonstration is included in Appendix IIIC-A.1 that shows the additional leachate generation that would result from leachate being recirculated at a working face that is "parked" over a 1-acre area for 50 percent of the site's life. This analysis is included to show that the leachate collection system will continue to meet the regulatory requirements, even with this extreme leachate loading scenario. Refer to Appendix IIIC, Section 5.2 for specific guidance regarding leachate recirculation. Consistent with Subtitle D regulations, leachate will only be recirculated over areas underlain by a Subtitle D compliant liner system that is consistent with 30 TAC §330.331(b).

The pre-Subtitle D overliner LCS includes a drainage geocomposite collection layer consisting of a 300-mil geonet heat bonded on both sides with a 6 oz/sy non-woven geotextile. The calculations for determining the hydraulic conductivity of the geocomposite are shown on pages IIIC-A-27 through IIIC-A-29.

Waste Layers

Various waste thicknesses were modeled to represent the various stages of landfill development in the Subtitle D and pre-subtitle D areas. A default wilting point was selected from HELP to represent municipal solid waste. The waste column was split into two layers. The top 125-foot layer was modeled with a hydraulic conductivity of $1x10^{-3}$ cm/s. A lower hydraulic conductivity of $1x10^{-4}$ cm/s was used for the bottom layer because the additional overburden pressure will cause additional consolidation to this layer that will likely lower the hydraulic conductivity. The moisture content, field capacity, and porosity values were selected as discussed previously.

Intermediate Cover

The intermediate cover consists of a 12-inch-thick layer of soil placed over the waste. Default soil characteristics were selected from HELP to represent the available onsite soils with a hydraulic conductivity of 6.4×10^{-5} cm/s.

Final Cover

The final cover over the Subtitle D and pre-Subtitle D areas consists of a 12-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer (to be conservative this layer is not considered in HELP modeling), a 40-mil LLDPE geomembrane liner, and an 18-inch infiltration layer. The geomembrane liner was modeled for good installation quality, 4 construction defects per acre, and a pinhole density of 1 hole per acre. The infiltration layer consists of compacted soil with a hydraulic conductivity of 1×10^{-5} cm/s. In Class 1 sectors (Sectors 9 through 11), the infiltration layer consists of a 48-inch-thick compacted soil with a hydraulic conductivity of 1×10^{-7} cm/s.

HELP Model Output

The HELP summary tables and output files for the various stages of the landfill development are presented beginning on page IIIC-A-30.

TURKEY CREEK LANDFILL
0771-368-11
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
MSW DEVELOPED SUBTITLE D AREAS

Required:

Estimate the properties of the 200-mil-thick geocomposite leachate collection layer for the developed Subtitle D sectors.

Note: Sectors 1, 2B, 3B, 4C, 5, 6B, 7, and 8 were constructed with a 200-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

   Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)=	0.20	in
Unit Weight of Soil =	120	pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,110	0.189	0.005
Interim - 100'	100	3	57	6,060	0.179	0.005
Interim - 200'	200	3	71	14,560	0.155	0.004
Interim - 300'	300	3	78	23,760	0.131	0.003
Interim - 320'	320	3	78	25,320	0.127	0.003
Closed - 320'	320	5.5	78	25,620	0.127	0.003

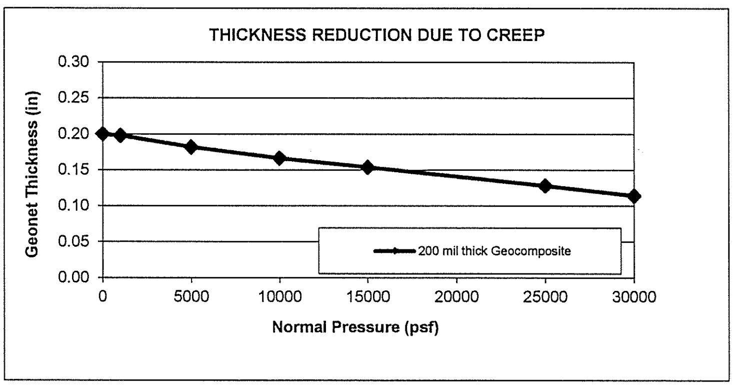
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (320' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.43	1.98	2.11	2.38	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.86	3.96	4.22	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 200-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-27. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,110	0.189	1.10E-03	2.86	3.85E-04	8.02
Interim - 100'	100	6,060	0.179	8.23E-04	3.96	2.08E-04	4.57
Interim - 200'	200	14,560	0.155	5.62E-04	4.22	1.33E-04	3.38
Interim - 300'	300	23,760	0.131	4.34E-04	4.75	9.14E-05	2.74
Interim - 320'	320	25,320	0.127	4.17E-04	5.02	8.32E-05	2.57
Closed - 320'	320	25,620	0.127	4.15E-04	5.72	7.25E-05	2.24

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-27.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

Required:

Estimate the properties of the 200-mil-thick geocomposite leachate collection layer for the undeveloped Subtitle D sectors.

Note: Sectors 13 and 14 are currenty undeveloped.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.
5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

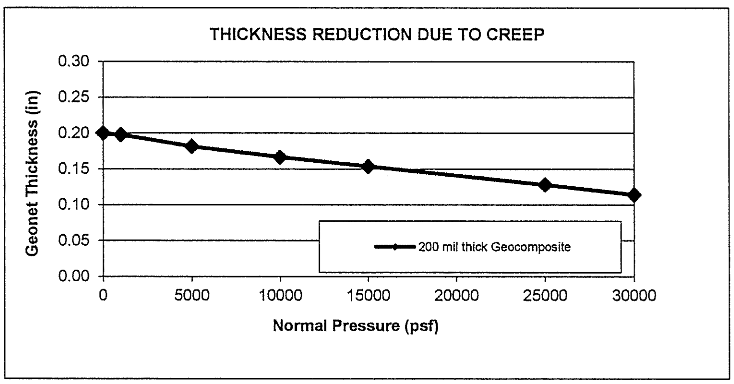
Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)=	0.20	in
Unit Weight of Soil =	120	pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	3	55	910	0.198	0.005
Interim - 50'	50	3	55	3,110	0.189	0.005
Interim - 100'	100	3	57	6,060	0.179	0.005
Interim - 140'	140	3	63	9,180	0.169	0.004
Closed - 140'	140	5.5	63	9,480	0.168	0.004

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.
[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.
[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.
[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.
[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition				
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (140' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	2.0
RF_{BC}	Biological Clogging	1.0	1.0	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.43	1.98	2.11	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	2.86	3.96	4.22	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 200-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-27. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	910	0.198	1.47E-03	2.20	6.67E-04	13.25
Interim - 50'	50	3,110	0.189	1.10E-03	2.86	3.85E-04	8.00
Interim - 100'	100	6,060	0.179	8.23E-04	3.96	2.08E-04	4.58
Interim - 140'	140	9,180	0.169	7.24E-04	4.22	1.71E-04	3.99
Closed - 140'	140	9,480	0.168	7.15E-04	5.72	1.25E-04	2.93

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-27.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A-7 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

For the undeveloped sectors the drainage geocomposite required transmissivity values will be measured at a gradient of 0.018 under normal pressures of 1,000, 5,000 and 9480 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seat time of 100 hours and will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of single-sided geocomposite placement area, one additional liner transmissivity test will be run under the maximum normal stress (i.e., 9,480 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 7.15 x10^{-4} m^2/s.

TURKEY CREEK LANDFILL
0771-368-11
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
CLASS 1 DEVELOPED SUBTITLE D AREAS

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 9 and 10 were constructed with a 220-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

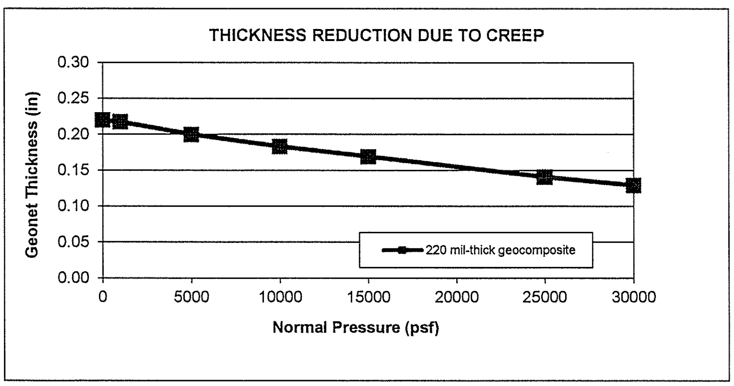
Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)= 0.22 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thicknes

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,110	0.208	0.005
Interim - 100'	100	3	57	6,060	0.196	0.005
Interim - 200'	200	3	71	14,560	0.170	0.004
Interim - 300'	300	3	78	23,760	0.145	0.004
Interim - 330'	330	3	78	26,100	0.138	0.004
Closed - 330'	330	8	78	26,700	0.137	0.003

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.
[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.
[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.
[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.
[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (330' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.57	1.98	2.11	2.38	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		3.15	3.96	4.22	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-28. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,110	0.208	1.67E-03	3.15	5.30E-04	10.00
Interim - 100'	100	6,060	0.196	1.08E-03	3.96	2.72E-04	5.46
Interim - 200'	200	14,560	0.170	6.19E-04	4.22	1.46E-04	3.38
Interim - 300'	300	23,760	0.145	5.02E-04	4.75	1.06E-04	2.88
Interim - 330'	330	26,100	0.138	4.74E-04	5.02	9.44E-05	2.68
Closed - 330'	330	26,700	0.137	4.65E-04	5.72	8.13E-05	2.33

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-28.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 11 and 12 are currently undeveloped.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)= 0.22 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	3	55	910	0.218	0.006
Interim - 50'	50	3	55	3,110	0.208	0.005
Interim - 100'	100	3	57	6,060	0.196	0.005
Interim - 200'	200	3	71	14,560	0.170	0.004
Interim - 270'	270	3	78	21,420	0.151	0.004
Closed - 270'	270	8	78	22,020	0.148	0.004

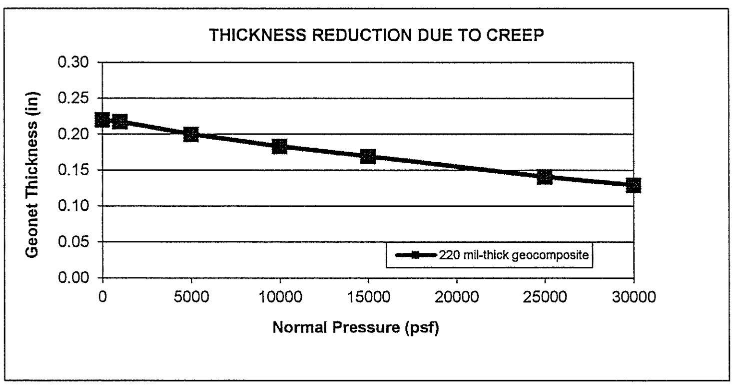
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (270' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.11	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	3.15	3.96	4.22	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-28. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	910	0.218	2.56E-03	2.20	1.17E-03	21.05
Interim - 50'	50	3,110	0.208	1.67E-03	3.15	5.30E-04	10.00
Interim - 100'	100	6,060	0.196	1.08E-03	3.96	2.72E-04	5.46
Interim - 200'	200	14,560	0.170	6.19E-04	4.22	1.46E-04	3.38
Interim - 270'	270	21,420	0.151	5.27E-04	5.02	1.05E-04	2.74
Closed - 270'	270	22,020	0.148	5.37E-04	5.72	9.39E-05	2.50

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-28.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

As shown on the HELP model summary sheets, a geocomposite with characteristics similar to the graph shown on Sheet IIIC-A-28 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

For the undeveloped sectors the drainage geocomposite required transmissivity values will be measured at a gradient of 0.0205 under normal pressures of 1,000, 5,000 and 22,020 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seat time of 100 hours and will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of single-sided geocomposite placement area, one additional liner transmissivity test will be run under the maximum normal stress (i.e., 33,020 psf) with all the same assumptions as the first three tests. The minimum transmissivity will be 5.37×10^{-4} m^2/s.

OVERLINER GEOCOMPOSITE
LEACHATE COLLECTION LAYER PROPERTIES

Required: Determine the minimum requirements of the 300-mil-thick geocomposite overliner leachate collection layer.

Method:

1. Determine the 300-mil geocomposite overliner leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum required transmissivity for the 300-mil-thick double-sided geocomposite overliner leachate collection layer.
4. Compute the design transmissivity of the 300-mil geocomposite overliner leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.
5. Specify the geocomposite properties for the overliner leachate collection layer.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, Second Edition, June 2007.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Overliner Geocomposite Leachate Collection Layer Thickness:

Assume the overliner geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness = 0.30 in
Unit Weight of Soil = 120 pcf

Table 1 - Overliner Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (psf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	2	55	790	0.300	0.008
Interim - 50'	50	3	55	3,110	0.291	0.007
Interim - 100'	100	3	57	6,060	0.278	0.007
Interim - 170'	170	3	66	11,580	0.255	0.006
Closed - 170'	170	5.5	66	11,880	0.253	0.006

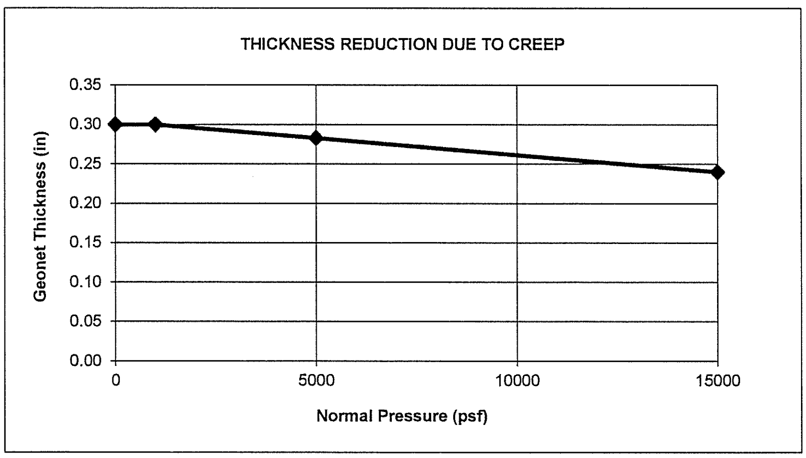
[1] d_W is the depth of waste and daily cover soil above the overliner geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, or final cover) above the overliner geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the overliner geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the overliner geocomposite leachate collection layer after being subjected to compression based on the following chart adapted from Reference 4.



2. Reduction Factors and Factor of Safety for Strength and Environmental Conditions

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition				
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (170' Waste)	Closed (170' Waste)
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	2.0
RF_{BC}	Biological Clogging	1.0	1.0	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.43	1.98	2.11	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	2.86	3.96	4.22	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Minimum Required Transmissivity Data

The minimum required transmissivity for the 300-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-29. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the Design Transmissivity (T) of the Overliner Geocomposite Leachate Collection Layer:

Table 3 - Required Transmissivity for Overliner

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	790	0.300	6.81E-03	2.20	3.10E-03	40.63
Interim - 50'	50	3,110	0.291	6.07E-03	2.86	2.12E-03	27.83
Interim - 100'	100	6,060	0.278	5.24E-03	3.96	1.32E-03	18.69
Interim - 170'	170	11,580	0.255	3.57E-03	4.22	8.44E-04	13.05
Closed - 170'	170	11,880	0.253	3.44E-03	5.72	6.02E-04	9.35

[1] d_W is the depth of waste above the overliner geocomposite leachate collection layer.

[2] P is the pressure on the overliner geocomposite leachate collection layer due to the weight of the waste and soil from Table 1 for a 300-mil drainage geocomposite.

[3] t is the calculated overliner geocomposite leachate collection layer thickness from Table 1 for a 300-mil drainage geocomposite.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer (6 oz/sy polypropylene geotextiles with 300-mil-thick geonet) as shown on Sheet IIIC-A-29.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

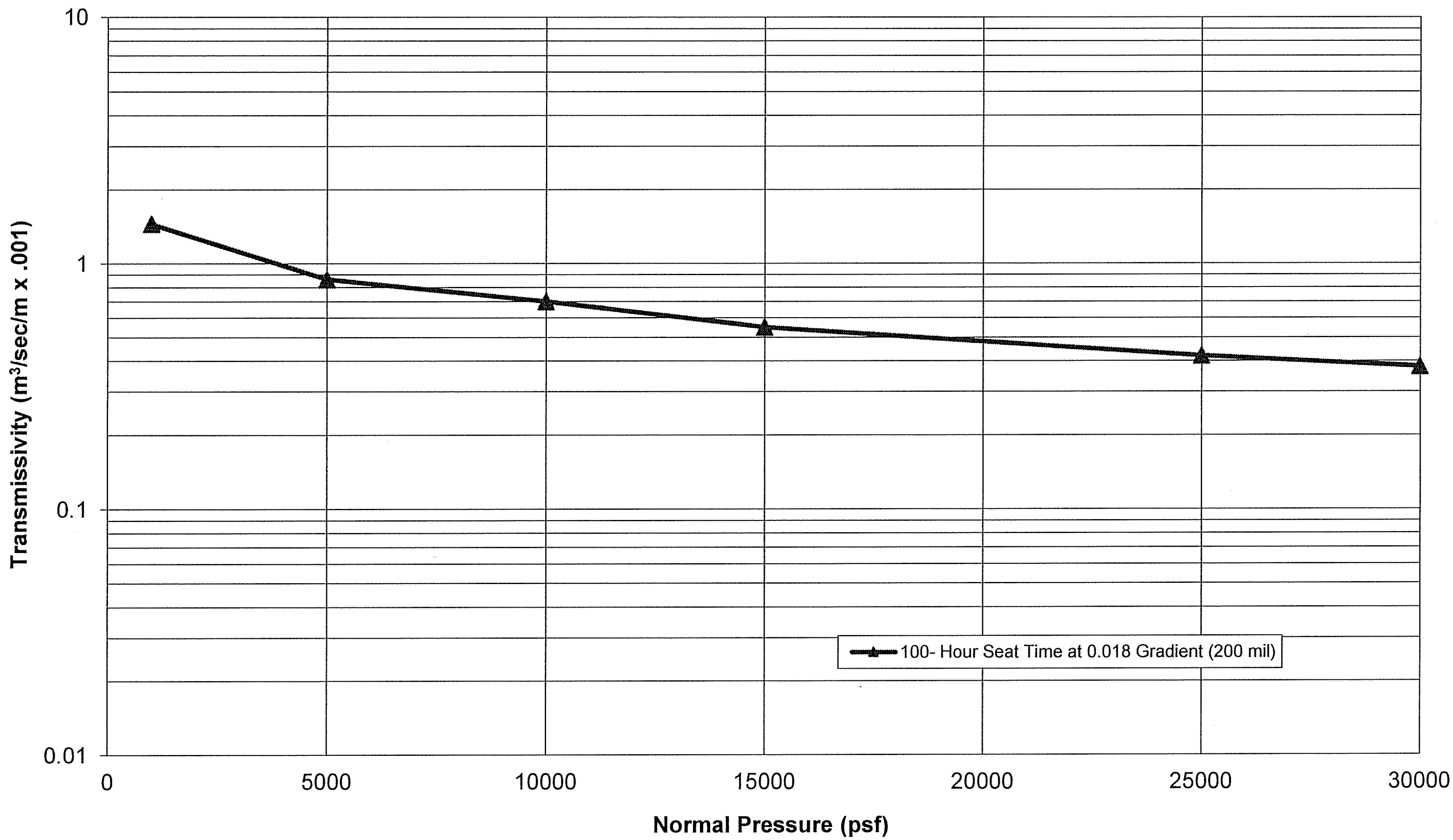
$$k = T_{DES}/t$$

5. Specify the geocomposite properties for the overliner leachate collection layer.

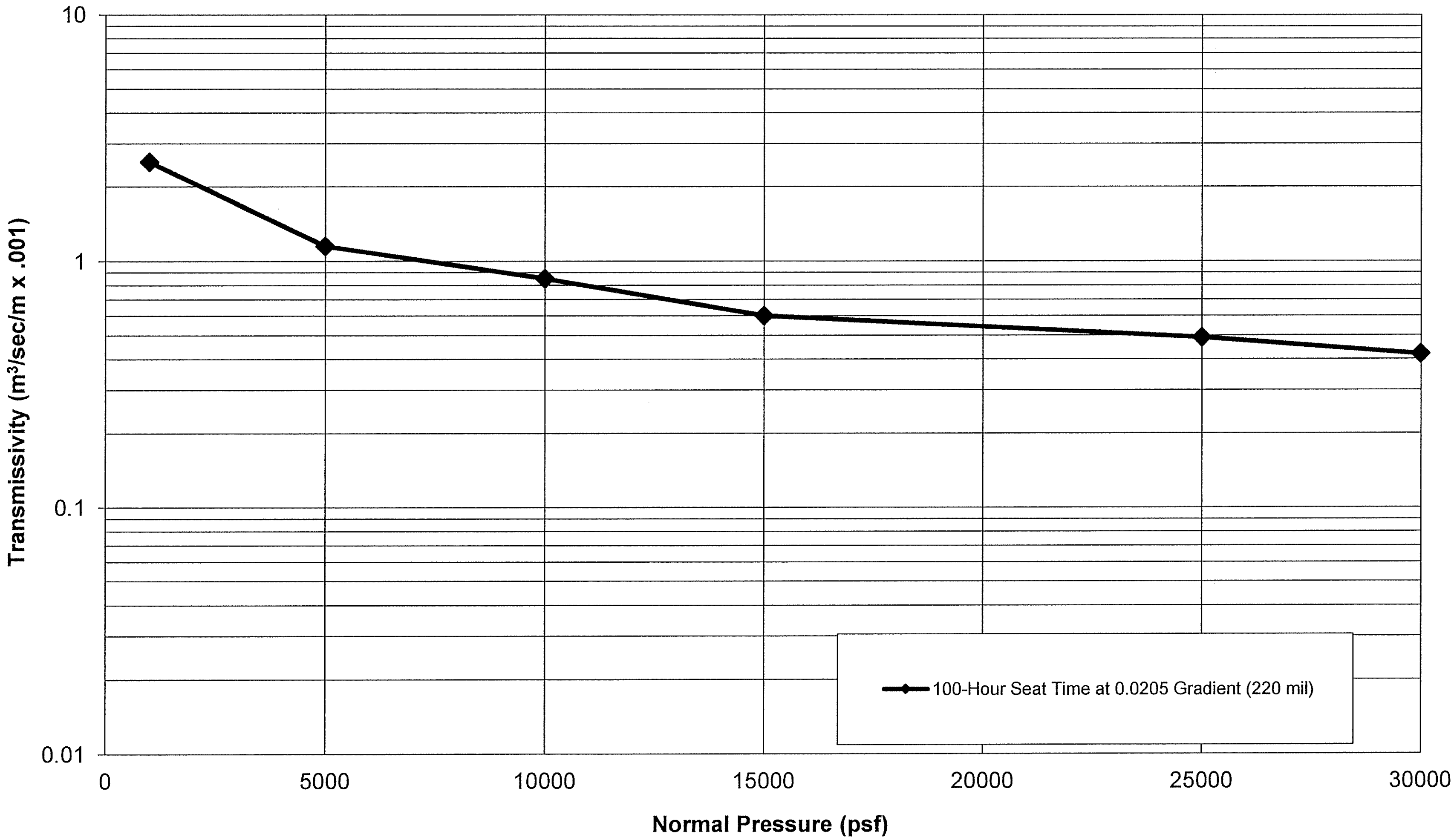
As shown on the HELP model summary sheet, a geocomposite with characteristics similar to the graphs shown on IIIC-A-29 will provide a drainage layer that will maintain less than twelve inches of head on the liner system.

The transmissivity of the overliner geocomposite will be measured at a minimum gradient of 0.03 under a minimum normal pressure of 1,000, 3,000 and 11,8830 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours. The minimum transmissivity will be 2.53×10^{-3} m^2/s. For each additional 100,000 square feet of liner geocomposite placement area, one additional transmissivity test will be run under the minimum normal stress (i.e., 11,880 psf) with all the same assumptions as the first three tests.

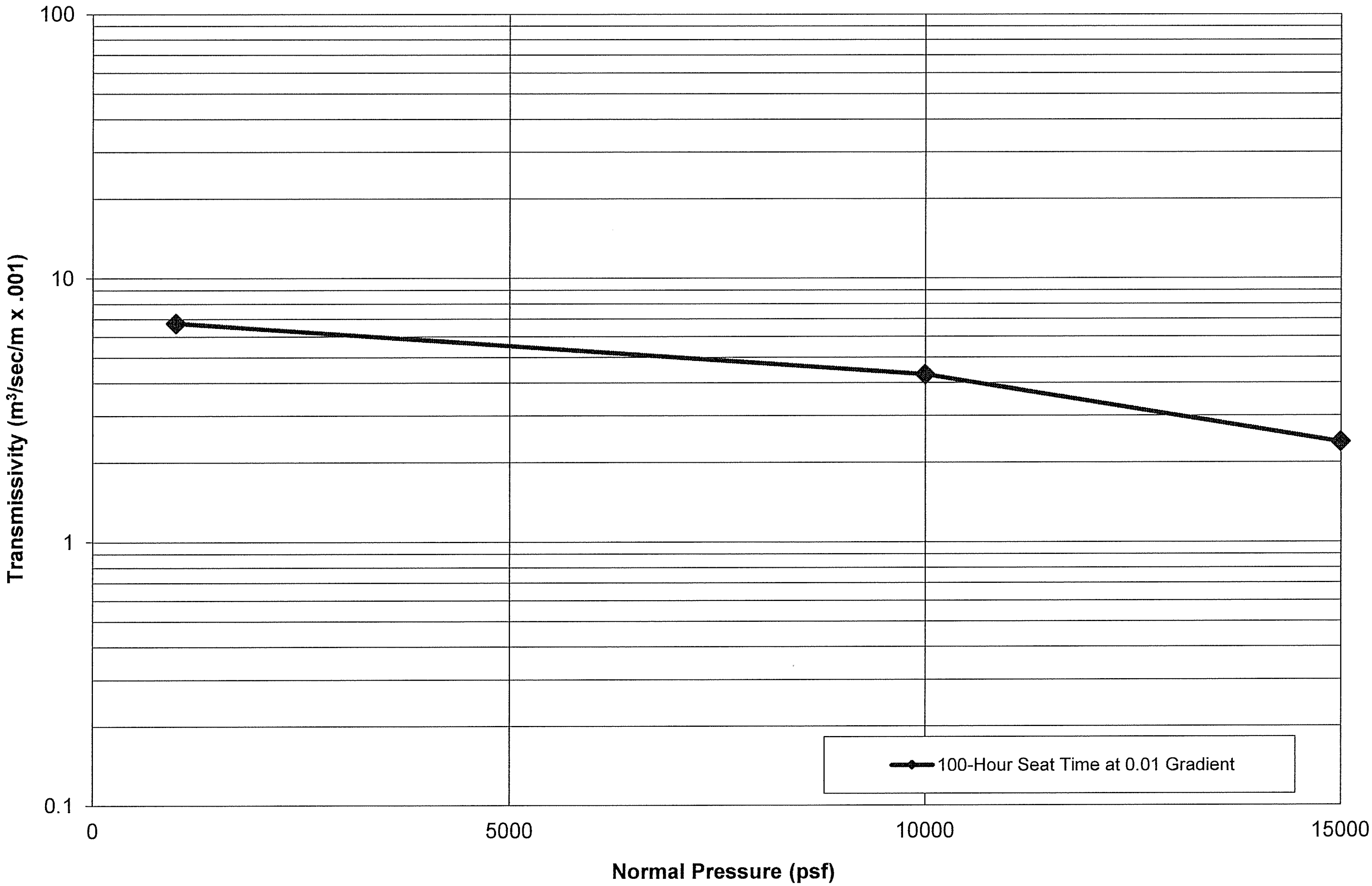
TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
8 oz/sy Polypropylene Geotextile with 200 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextile with 220 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextile with 300-mil Drainage Net
(Soil/Geocomposite/Geomembrane)



		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (320 FT WASTE)	CLOSED (320 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5	6
	No. of Years	10	10	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	80	80	80	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION LAYER (Texture = 10)	Thickness (in)						12
	Porosity (vol/vol)						0.3980
	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)						0.04
	Hyd. Conductivity (cm/s)						4.0E-13
	Pinhole Density (holes/acre)						1
	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)						18
	Porosity (vol/vol)						0.4270
	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500	1500	1500	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			900	2100	2340	2340
	Porosity (vol/vol)			0.5348	0.4935	0.4852	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.189	0.179	0.155	0.131	0.127	0.127
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	8.02	4.57	3.38	2.74	2.57	2.13
	Slope (%)	1.8	1.8	1.8	1.8	1.8	1.8
	Slope Length (ft)	230	230	230	230	230	230
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	3.10	3.07	3.07	3.07	3.07	7.21
EVAPOTRANSPIRATION	Average Annual (in)	28.57	28.22	28.22	28.22	28.22	30.55
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	6,315.2	28,609.8	24,311.4	35,284.7	38,381.5	24,784.4
	Peak Daily (cf/day)	84.7	209.1	118.4	190.2	220.4	213.2
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	631.5	2,861.0	2,431.1	3,528.5	3,838.1	
	Peak Daily (cf/day)	8.5	20.9	11.8	19.0	22.0	
HEAD ON LINER	Average Annual (in)	0.001	0.011	0.012	0.022	0.025	0.019
	Peak Daily (in)	0.014	0.057	0.043	0.085	0.105	0.117

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		Active (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (140 FT WASTE)	CLOSED (140 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	6
	No. of Years	1	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	12
EROSION LAYER (Texture = 10)	Thickness (in)					12
	Porosity (vol/vol)					0.3980
	Field Capacity (vol/vol)					0.2440
	Wilting Point (vol/vol)					0.1360
	Init. Moisture Content (vol/vol)					0.2440
	Hyd. Conductivity (cm/s)					1.2E-04
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					0.04
	Hyd. Conductivity (cm/s)					4.0E-13
	Pinhole Density (holes/acre)					1
	Install. Defects (holes/acre)					4
	Placement Quality					GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)					48
	Porosity (vol/vol)					0.4270
	Field Capacity (vol/vol)					0.4180
	Wilting Point (vol/vol)					0.3670
	Init. Moisture Content (vol/vol)					0.4270
	Hyd. Conductivity (cm/s)					1.0E-07
INTERMEDIATE COVER (Texture = 11)	Thickness (in)		12	12	12	12
	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	120	600	1200	1500	1500
	Porosity (vol/vol)	0.6649	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5215	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)				180	180
	Porosity (vol/vol)				0.5596	0.5596
	Field Capacity (vol/vol)				0.4963	0.4963
	Wilting Point (vol/vol)				0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.189	0.189	0.179	0.169	0.168
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	13.25	8.00	4.58	3.99	2.93
	Slope (%)	1.8	1.8	1.8	1.8	1.8
	Slope Length (ft)	285	285	285	285	285
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.06	3.07	3.07	7.21
EVAPOTRANSPIRATION	Average Annual (in)	34.31	28.23	28.22	28.22	30.55
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	2,490.6	7,396.0	28,510.1	21,553.2	11,384.7
	Peak Daily (cf/day)	43.8	105.1	200.6	102.6	74.9
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)		739.6	2,851.0	2,155.3	
	Peak Daily (cf/day)		10.5	20.1	10.3	
HEAD ON LINER	Average Annual (in)	0.000	0.002	0.013	0.011	0.008
	Peak Daily (in)	0.005	0.020	0.067	0.039	0.039

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (330 FT WASTE)	CLOSED (330 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	10	15	10	5	5	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	86.8	86.8	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	70	80	80	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						48
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	2100	2340	2340
(Texture = 0)	Porosity (vol/vol)			0.5348	0.4935	0.4852	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.208	0.196	0.170	0.145	0.138	0.137
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	10.00	5.46	3.38	2.88	2.68	2.33
	Slope (%)	2.05	2.05	2.05	2.05	2.05	2.05
	Slope Length (ft)	305	305	305	305	305	305
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	3.10	3.07	3.07	3.07	3.07	7.20
EVAPOTRANSPIRATION	Average Annual (in)	28.57	28.22	28.22	28.22	28.22	30.55
LATERAL	Average Annual (cf/year)	6,266.9	28,617.0	24,192.0	35,210.4	40,226.3	25,894.3
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	84.7	216.3	114.9	189.0	220.8	218.4
LATERAL	Average Annual (cf/year)	626.7	2,861.7	2,419.6	3,521.0	4,022.6	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	8.5	21.6	11.5	18.9	22.1	
HEAD ON LINER	Average Annual (in)	0.001	0.010	0.014	0.024	0.030	0.022
	Peak Daily (in)	0.009	0.058	0.049	0.094	0.118	0.134

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

Prep By: BPY
Date: 10/5/2021

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
CLASS 1 UNDEVELOPED SUBTITLE D AREAS

Chkd By: NT
Date: 10/5/2021

		Active (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (270 FT WASTE)	CLOSED (270 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5	6
	No. of Years	1	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION LAYER (Texture = 10)	Thickness (in)						12
	Porosity (vol/vol)						0.3980
	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)						0.04
	Hyd. Conductivity (cm/s)						4.0E-13
	Pinhole Density (holes/acre)						1
	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)						48
	Porosity (vol/vol)						0.4270
	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE COVER (Texture = 11)	Thickness (in)		12	12	12	12	12
	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	120	600	1200	1500	1500	1500
	Porosity (vol/vol)	0.6649	0.6483	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5215	0.5156	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)				1740	1740	1470
	Porosity (vol/vol)				0.5348	0.5596	0.5596
	Field Capacity (vol/vol)				0.4892	0.4963	0.4963
	Wilting Point (vol/vol)				0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.218	0.208	0.196	0.170	0.151	0.148
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	20.05	10.00	5.46	3.38	2.74	2.50
	Slope (%)	2.05	2.05	2.05	2.05	2.05	2.05
	Slope Length (ft)	355	355	355	355	355	355
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.06	3.07	3.07	3.07	6.99
EVAPOTRANSPIRATION	Average Annual (in)	34.27	28.23	28.22	28.22	28.22	30.50
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	3,004.4	7,453.0	28,508.0	24,280.7	31,099.8	19,871.0
	Peak Daily (cf/day)	37.7	106.5	202.9	111.7	161.2	159.6
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)		745.3	2,850.8	2,428.1	3,110.0	
	Peak Daily (cf/day)		10.6	20.3	11.2	16.1	
HEAD ON LINER	Average Annual (in)	0.000	0.002	0.012	0.017	0.026	0.018
	Peak Daily (in)	0.007	0.018	0.062	0.056	0.099	0.107

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

Prep By: BPY
Date: 2/21/2022

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
OVERLINER AREA

Chkd By: NT
Date: 2/21/2022

		ACTIVE (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (170 FT WASTE)	CLOSED (170 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5
	No. of Years	1	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	12
EROSION LAYER (Texture = 10)	Thickness (in)					12
	Porosity (vol/vol)					0.3980
	Field Capacity (vol/vol)					0.2440
	Wilting Point (vol/vol)					0.1360
	Init. Moisture Content (vol/vol)					0.2440
	Hyd. Conductivity (cm/s)					1.2E-04
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					0.04
	Hyd. Conductivity (cm/s)					4.0E-13
	Pinhole Density (holes/acre)					1
	Install. Defects (holes/acre)					4
	Placement Quality					GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)					18
	Porosity (vol/vol)					0.4270
	Field Capacity (vol/vol)					0.4180
	Wilting Point (vol/vol)					0.3670
	Init. Moisture Content (vol/vol)					0.4270
	Hyd. Conductivity (cm/s)					1.0E-05
INTERMEDIATE COVER (Texture = 11)	Thickness (in)		12	12	12	12
	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	120	600	1200	1500	1500
	Porosity (vol/vol)	0.6649	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5215	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)				540	540
	Porosity (vol/vol)				0.5472	0.5472
	Field Capacity (vol/vol)				0.4927	0.4927
	Wilting Point (vol/vol)				0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.300	0.291	0.278	0.255	0.253
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	40.63	27.83	18.69	13.05	9.35
	Slope[1] (%)	1.0	1.0	1.0	1.0	1.0
	Slope Length (ft)	300	300	300	300	300
FLEXIBLE MEMBRANE LINER[3] (Texture = 36)	Thickness (in)	0.04	0.04	0.04	0.04	0.04
	Hyd. Conductivity (cm/s)	4.0E-13	4.0E-13	4.0E-13	4.0E-13	4.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
GEOSYNTETIC CLAY LINER (Texture = 17)	Thickness (in)	0.25	0.25	0.25	0.25	0.25
	Porosity (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500
	Field Capacity (vol/vol)	0.7470	0.7470	0.7470	0.7470	0.7470
	Wilting Point (vol/vol)	0.4000	0.4000	0.4000	0.4000	0.4000
	Init. Moisture Content (vol/vol)	0.7500	0.7500	0.7500	0.7500	0.7500
	Hyd. Conductivity (cm/s)	3.0E-09	3.0E-09	3.0E-09	3.0E-09	3.0E-09
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.14	3.10	3.07	7.34
EVAPOTRANSPIRATION	Average Annual (in)	34.02	28.68	28.53	28.22	30.58
LATERAL DRAINAGE COLLECTED	Average Annual (cf/year)	3,049.5	5,813.2	24,696.4	21,837.4	12,826.6
	Peak Daily (cf/day)	39.8	67.9	150.4	112.6	104.8
HEAD ON LINER	Average Annual (in)	0.000	0.001	0.005	0.007	0.005
	Peak Daily (in)	0.003	0.006	0.023	0.025	0.033

[1] A slope of 1.0% was used to be conservative. Refer to Appendix IIIE-B for settlement calculations.
[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

HELP MODEL OUTPUT

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******************************************************************************
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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:     C:\TC\C\MSWDEV\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWDEV\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWDEV\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWDEV\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWDEV\I50\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWDEV\I50\OUTPUT1.OUT


TIME:  14:28     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - INTERIM 50 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =     12.00   INCHES
```

```
   POROSITY                        =      0.4640 VOL/VOL
   FIELD CAPACITY                  =      0.3100 VOL/VOL
   WILTING POINT                   =      0.1870 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =    600.00   INCHES
   POROSITY                        =      0.6483 VOL/VOL
   FIELD CAPACITY                  =      0.5215 VOL/VOL
   WILTING POINT                   =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.2500 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
   THICKNESS                       =     24.00   INCHES
   POROSITY                        =      0.3980 VOL/VOL
   FIELD CAPACITY                  =      0.2440 VOL/VOL
   WILTING POINT                   =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC


                           LAYER  4
                           --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =      0.19   INCHES
   POROSITY                        =      0.8500 VOL/VOL
```

```
  FIELD CAPACITY               =      0.0100 VOL/VOL
  WILTING POINT                =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =   8.02000046000     CM/SEC
  SLOPE                        =      1.80   PERCENT
  DRAINAGE LENGTH              =    230.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                          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          =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =      0.00   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 #11 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.826	INCHES
TOTAL INITIAL WATER	=	169.826	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.104	0.121	0.100	0.092	0.171	0.343
	0.629	0.123	0.438	0.612	0.090	0.278
STD. DEVIATIONS	0.099	0.225	0.115	0.117	0.172	0.388
	0.861	0.188	0.361	1.252	0.148	0.324
EVAPOTRANSPIRATION						
TOTALS	1.914	1.905	2.497	3.022	2.960	2.482
	3.405	1.872	3.102	2.302	1.329	1.777
STD. DEVIATIONS	0.269	0.685	0.660	1.223	1.061	1.612

	1.572	1.275	1.241	1.329	0.666	0.544

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0132	0.0124	0.0134	0.0139	0.0151	0.0141
	0.0143	0.0138	0.0152	0.0150	0.0164	0.0171
STD. DEVIATIONS	0.0151	0.0142	0.0152	0.0162	0.0182	0.0157
	0.0167	0.0166	0.0166	0.0155	0.0168	0.0176

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1186	0.1119	0.1209	0.1251	0.1360	0.1265
	0.1291	0.1242	0.1365	0.1349	0.1478	0.1543
STD. DEVIATIONS	0.1356	0.1277	0.1371	0.1454	0.1638	0.1409
	0.1502	0.1496	0.1492	0.1395	0.1516	0.1585

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0132	0.0124	0.0134	0.0139	0.0151	0.0141
	0.0143	0.0138	0.0152	0.0150	0.0164	0.0171
STD. DEVIATIONS	0.0151	0.0142	0.0152	0.0162	0.0182	0.0157
	0.0167	0.0166	0.0166	0.0155	0.0168	0.0176

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 5

AVERAGES	0.0012	0.0012	0.0012	0.0013	0.0014	0.0013
	0.0013	0.0013	0.0014	0.0014	0.0015	0.0016
STD. DEVIATIONS	0.0014	0.0014	0.0014	0.0015	0.0017	0.0015
	0.0015	0.0015	0.0016	0.0014	0.0016	0.0016

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.101	(1.2584)	11257.11	7.522
EVAPOTRANSPIRATION	28.567	(2.9991)	103699.25	69.288
DRAINAGE RECIRCULATED INTO LAYER 2	0.17397	(0.19230)	631.518	0.42195
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.56575	(1.73072)	5683.658	3.79759
DRAINAGE RECIRCULATED FROM LAYER 4	0.17397	(0.19230)	631.518	0.42195
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	7.996	(3.4265)	29024.34	19.393

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.166	7862.5942
DRAINAGE RECIRCULATED INTO LAYER 2	0.00233	8.47047
DRAINAGE COLLECTED FROM LAYER 4	0.02100	76.23422

DRAINAGE RECIRCULATED FROM LAYER 4	0.00233	8.47047
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.007	
MAXIMUM HEAD ON TOP OF LAYER 5	0.014	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4513

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.6481	0.2207
2	230.5312	0.3842
3	6.3504	0.2646
4	0.0050	0.0263
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:     C:\TC\C\MSWDEV\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWDEV\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWDEV\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWDEV\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWDEV\I100\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWDEV\I100\OUTPUT1.OUT


TIME:  11:17     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - INTERIM 100 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
          THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1200.00   INCHES
  POROSITY                        =      0.6277 VOL/VOL
  FIELD CAPACITY                  =      0.5156 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
  FIELD CAPACITY                  =      0.2440 VOL/VOL
  WILTING POINT                   =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC


                           LAYER  4
                           --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =      0.18   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.   =   4.57000017000     CM/SEC
   SLOPE                       =      1.80    PERCENT
   DRAINAGE LENGTH             =    230.0     FEET
 NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                              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         =      0.00    HOLES/ACRE
   FML INSTALLATION DEFECTS    =      0.00    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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	475.826	INCHES
TOTAL INITIAL WATER	=	475.826	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614

1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0662	0.0569	0.0682	0.0661	0.0624	0.0660
	0.0654	0.0685	0.0665	0.0688	0.0662	0.0669
STD. DEVIATIONS	0.0169	0.0073	0.0132	0.0065	0.0079	0.0100
	0.0103	0.0149	0.0109	0.0123	0.0117	0.0105

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5962	0.5117	0.6140	0.5951	0.5612	0.5943
	0.5888	0.6163	0.5987	0.6192	0.5957	0.6021
STD. DEVIATIONS	0.1524	0.0655	0.1186	0.0582	0.0714	0.0896
	0.0923	0.1344	0.0983	0.1104	0.1050	0.0943

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0662	0.0569	0.0682	0.0661	0.0624	0.0660
	0.0654	0.0685	0.0665	0.0688	0.0662	0.0669
STD. DEVIATIONS	0.0169	0.0073	0.0132	0.0065	0.0079	0.0100
	0.0103	0.0149	0.0109	0.0123	0.0117	0.0105

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 5

AVERAGES	0.0105	0.0099	0.0109	0.0109	0.0099	0.0109
	0.0104	0.0109	0.0109	0.0109	0.0109	0.0106
STD. DEVIATIONS	0.0027	0.0012	0.0021	0.0011	0.0013	0.0016
	0.0016	0.0024	0.0018	0.0020	0.0019	0.0017

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.78815	(0.10569)	2860.977	1.91159
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.09333	(0.95120)	25748.783	17.20429
DRAINAGE RECIRCULATED FROM LAYER 4	0.78815	(0.10569)	2860.977	1.91159
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.011	(0.001)		
CHANGE IN WATER STORAGE	2.852	(3.1772)	10351.79	6.917

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00576	20.91004
DRAINAGE COLLECTED FROM LAYER 4	0.05184	188.19040

DRAINAGE RECIRCULATED FROM LAYER 4	0.00576	20.91004
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.028	
MAXIMUM HEAD ON TOP OF LAYER 5	0.057	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	1.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	484.7086	0.4039
3	6.7676	0.2820
4	0.0208	0.1161
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:    C:\TC\C\MSWDEV\I200\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\MSWDEV\I200\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\MSWDEV\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\MSWDEV\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\MSWDEV\I200\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\MSWDEV\I200\OUTPUT1.OUT


TIME:  11:19     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - INTERIM 200 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =    12.00   INCHES
```

```
    POROSITY                        =      0.4640 VOL/VOL
    FIELD CAPACITY                  =      0.3100 VOL/VOL
    WILTING POINT                   =      0.1870 VOL/VOL
    INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
    EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
    THICKNESS                       =   1500.00   INCHES
    POROSITY                        =      0.6174 VOL/VOL
    FIELD CAPACITY                  =      0.5174 VOL/VOL
    WILTING POINT                   =      0.0770 VOL/VOL
    INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
    EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
    THICKNESS                       =    900.00   INCHES
    POROSITY                        =      0.5348 VOL/VOL
    FIELD CAPACITY                  =      0.4892 VOL/VOL
    WILTING POINT                   =      0.0770 VOL/VOL
    INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
    EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
    THICKNESS                       =     24.00   INCHES
    POROSITY                        =      0.3980 VOL/VOL
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FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   = 0.119999997000E-03 CM/SEC
```

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                       LAYER  5
                       --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.16   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.   =   3.38000011000     CM/SEC
SLOPE                       =      1.80   PERCENT
DRAINAGE LENGTH             =    230.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

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                       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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       = 3 - GOOD
```

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                       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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	931.826	INCHES
TOTAL INITIAL WATER	=	931.826	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0536	0.0522	0.0584	0.0558	0.0573	0.0551
	0.0569	0.0566	0.0551	0.0574	0.0555	0.0557
STD. DEVIATIONS	0.0095	0.0062	0.0070	0.0068	0.0070	0.0053
	0.0056	0.0054	0.0060	0.0056	0.0048	0.0046

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4824	0.4696	0.5260	0.5026	0.5161	0.4961
	0.5125	0.5090	0.4955	0.5170	0.4994	0.5014
STD. DEVIATIONS	0.0856	0.0562	0.0628	0.0608	0.0634	0.0473
	0.0501	0.0485	0.0538	0.0506	0.0435	0.0418

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0536	0.0522	0.0584	0.0558	0.0573	0.0551
	0.0569	0.0566	0.0551	0.0574	0.0555	0.0557
STD. DEVIATIONS	0.0095	0.0062	0.0070	0.0068	0.0070	0.0053
	0.0056	0.0054	0.0060	0.0056	0.0048	0.0046

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 6

AVERAGES	0.0115	0.0124	0.0126	0.0124	0.0123	0.0123
	0.0123	0.0122	0.0122	0.0124	0.0123	0.0120
STD. DEVIATIONS	0.0020	0.0015	0.0015	0.0015	0.0015	0.0012
	0.0012	0.0012	0.0013	0.0012	0.0011	0.0010

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.66973	(0.05781)	2431.138	1.62439
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.02762	(0.52033)	21880.242	14.61949
DRAINAGE RECIRCULATED FROM LAYER 5	0.66973	(0.05781)	2431.138	1.62439
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.012	(0.001)		
CHANGE IN WATER STORAGE	3.918	(3.0744)	14221.74	9.502

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00326	11.84059
DRAINAGE COLLECTED FROM LAYER 5	0.02936	106.56532
DRAINAGE RECIRCULATED FROM LAYER 5	0.00326	11.84059
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.022	
MAXIMUM HEAD ON TOP OF LAYER 6	0.043	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.7 FEET	
SNOW WATER	1.31	4756.4434
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870	

*** 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	2.5981	0.2165
2	623.0415	0.4154
3	328.5835	0.3651
4	6.5224	0.2718
5	0.0103	0.0663
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:     C:\TC\C\MSWDEV\I300\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWDEV\I300\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWDEV\I300\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWDEV\I300\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWDEV\I300\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWDEV\I300\OUTPUT1.OUT


TIME:  11:21     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - INTERIM 300 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  11
          THICKNESS                          =     12.00   INCHES
```

```
  POROSITY                          =      0.4640 VOL/VOL
  FIELD CAPACITY                    =      0.3100 VOL/VOL
  WILTING POINT                     =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =   1500.00   INCHES
  POROSITY                          =      0.6174 VOL/VOL
  FIELD CAPACITY                    =      0.5174 VOL/VOL
  WILTING POINT                     =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =   2100.00   INCHES
  POROSITY                          =      0.4935 VOL/VOL
  FIELD CAPACITY                    =      0.4775 VOL/VOL
  WILTING POINT                     =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                         =     24.00   INCHES
  POROSITY                          =      0.3980 VOL/VOL
```

```
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   = 0.119999997000E-03 CM/SEC
```

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                   =      0.13   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.   =   2.74000001000     CM/SEC
SLOPE                       =      1.80   PERCENT
DRAINAGE LENGTH             =    230.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
        LAYER IS RECIRCULATED INTO LAYER #  2.
```

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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1387.825	INCHES
TOTAL INITIAL WATER	=	1387.825	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0801	0.0778	0.0843	0.0817	0.0819	0.0798
	0.0824	0.0825	0.0803	0.0816	0.0788	0.0810
STD. DEVIATIONS	0.0140	0.0139	0.0178	0.0143	0.0141	0.0143
	0.0154	0.0136	0.0141	0.0138	0.0141	0.0148

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7205	0.7005	0.7583	0.7350	0.7373	0.7183
	0.7413	0.7426	0.7224	0.7344	0.7089	0.7288
STD. DEVIATIONS	0.1259	0.1247	0.1601	0.1283	0.1269	0.1288
	0.1383	0.1224	0.1268	0.1238	0.1266	0.1330

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0801	0.0778	0.0843	0.0817	0.0819	0.0798
	0.0824	0.0825	0.0803	0.0816	0.0788	0.0810
STD. DEVIATIONS	0.0140	0.0139	0.0178	0.0143	0.0141	0.0143
	0.0154	0.0136	0.0141	0.0138	0.0141	0.0148

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 6

AVERAGES	0.0212	0.0227	0.0224	0.0224	0.0217	0.0219
	0.0219	0.0219	0.0220	0.0217	0.0216	0.0215
STD. DEVIATIONS	0.0037	0.0041	0.0047	0.0039	0.0037	0.0039
	0.0041	0.0036	0.0039	0.0037	0.0039	0.0039

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.97203	(0.16387)	3528.467	2.35758
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.74827	(1.47478)	31756.209	21.21821
DRAINAGE RECIRCULATED FROM LAYER 5	0.97203	(0.16387)	3528.467	2.35758
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.022	(0.004)		
CHANGE IN WATER STORAGE	1.197	(3.4314)	4346.12	2.904

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00524	19.01520
DRAINAGE COLLECTED FROM LAYER 5	0.04715	171.13683
DRAINAGE RECIRCULATED FROM LAYER 5	0.00524	19.01520
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.043	
MAXIMUM HEAD ON TOP OF LAYER 6	0.085	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.4 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	644.9196	0.4299
3	735.4087	0.3502
4	6.6072	0.2753
5	0.0165	0.1261
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:    C:\TC\C\MSWDEV\I320\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\MSWDEV\I320\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\MSWDEV\I320\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\MSWDEV\I320\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\MSWDEV\I320\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\MSWDEV\I320\OUTPUT1.OUT


TIME:  11:23     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - INTERIM 320 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  11
           THICKNESS                         =     12.00   INCHES
```

```
  POROSITY                         =      0.4640 VOL/VOL
  FIELD CAPACITY                   =      0.3100 VOL/VOL
  WILTING POINT                    =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =   1500.00   INCHES
  POROSITY                         =      0.6174 VOL/VOL
  FIELD CAPACITY                   =      0.5174 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =   2340.00   INCHES
  POROSITY                         =      0.4852 VOL/VOL
  FIELD CAPACITY                   =      0.4751 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                        =     24.00   INCHES
  POROSITY                         =      0.3980 VOL/VOL
```

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FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                      LAYER  5
                      --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.13   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.   =   2.56999993000     CM/SEC
SLOPE                       =      1.80   PERCENT
DRAINAGE LENGTH             =    230.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                      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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   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 #11 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     87.10
FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =   1479.025  INCHES
TOTAL INITIAL WATER                  =   1479.025  INCHES
TOTAL SUBSURFACE INFLOW              =      0.00   INCHES/YEAR
```

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          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         DALLAS                 TEXAS

     STATION LATITUDE                         =  32.85 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   2.00
     START OF GROWING SEASON (JULIAN DATE)    =     63
     END OF GROWING SEASON (JULIAN DATE)      =    329
     EVAPORATIVE ZONE DEPTH                   =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

```
RUNOFF
------
  TOTALS                  0.098    0.117    0.104    0.091    0.177    0.332
                          0.637    0.124    0.429    0.623    0.086    0.248

  STD. DEVIATIONS         0.100    0.218    0.125    0.113    0.186    0.379
                          0.881    0.189    0.369    1.286    0.146    0.312

EVAPOTRANSPIRATION
------------------
  TOTALS                  1.899    1.877    2.445    2.983    2.984    2.462
                          3.333    1.827    3.048    2.255    1.305    1.801

  STD. DEVIATIONS         0.278    0.703    0.634    1.203    1.092    1.614
                          1.476    1.228    1.207    1.319    0.687    0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                  0.0878   0.0829   0.0916   0.0900   0.0896   0.0904
                          0.0907   0.0886   0.0850   0.0882   0.0850   0.0875

  STD. DEVIATIONS         0.0149   0.0175   0.0195   0.0187   0.0166   0.0197
                          0.0185   0.0181   0.0158   0.0167   0.0163   0.0154

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                  0.7905   0.7461   0.8240   0.8097   0.8063   0.8138
                          0.8163   0.7977   0.7651   0.7941   0.7646   0.7879

  STD. DEVIATIONS         0.1344   0.1573   0.1754   0.1686   0.1494   0.1770
                          0.1661   0.1627   0.1419   0.1504   0.1464   0.1382

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                  0.0878   0.0829   0.0916   0.0900   0.0896   0.0904
                          0.0907   0.0886   0.0850   0.0882   0.0850   0.0875

  STD. DEVIATIONS         0.0149   0.0175   0.0195   0.0187   0.0166   0.0197
                          0.0185   0.0181   0.0158   0.0167   0.0163   0.0154

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 6

AVERAGES	0.0249	0.0258	0.0259	0.0263	0.0254	0.0264
	0.0257	0.0251	0.0249	0.0250	0.0248	0.0248
STD. DEVIATIONS	0.0042	0.0055	0.0055	0.0055	0.0047	0.0058
	0.0052	0.0051	0.0046	0.0047	0.0048	0.0043

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	1.05734	(0.19672)	3838.149	2.56449
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.51607	(1.77052)	34543.336	23.08045
DRAINAGE RECIRCULATED FROM LAYER 5	1.05734	(0.19672)	3838.149	2.56449
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.025	(0.005)		
CHANGE IN WATER STORAGE	0.430	(3.5944)	1559.23	1.042

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00607	22.03963
DRAINAGE COLLECTED FROM LAYER 5	0.05464	198.35661
DRAINAGE RECIRCULATED FROM LAYER 5	0.00607	22.03963
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.053	
MAXIMUM HEAD ON TOP OF LAYER 6	0.105	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.4 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	650.5212	0.4337
3	813.3199	0.3476
4	6.6115	0.2755
5	0.0218	0.1716
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:    C:\TC\C\MSWDEV\CL\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\MSWDEV\CL\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\MSWDEV\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\MSWDEV\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\MSWDEV\CL\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\MSWDEV\CL\OUTPUT1.OUT


TIME:  11: 9     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - MSW DEVELOPED AREA - CLOSED 320 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                      =     12.00   INCHES
```

```
    POROSITY                        =       0.3980 VOL/VOL
    FIELD CAPACITY                  =       0.2440 VOL/VOL
    WILTING POINT                   =       0.1360 VOL/VOL
    INITIAL SOIL WATER CONTENT      =       0.2440 VOL/VOL
    EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC
  NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                             LAYER  2
                             --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
    THICKNESS                       =       0.04   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.       =  0.399999993000E-12 CM/SEC
    FML PINHOLE DENSITY             =       1.00   HOLES/ACRE
    FML INSTALLATION DEFECTS        =       4.00   HOLES/ACRE
    FML PLACEMENT QUALITY           =  3 - GOOD


                             LAYER  3
                             --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
    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.       =  0.999999975000E-05 CM/SEC


                             LAYER  4
                             --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  11
    THICKNESS                       =      12.00   INCHES
```

```
POROSITY                      =      0.4640 VOL/VOL
FIELD CAPACITY                =      0.3100 VOL/VOL
WILTING POINT                 =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC


                        LAYER  5
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   1500.00   INCHES
POROSITY                      =      0.6174 VOL/VOL
FIELD CAPACITY                =      0.5174 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                        LAYER  6
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   2340.00   INCHES
POROSITY                      =      0.4852 VOL/VOL
FIELD CAPACITY                =      0.4751 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                        LAYER  7
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.3980 VOL/VOL
FIELD CAPACITY                =      0.2440 VOL/VOL
WILTING POINT                 =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
```

```
                        LAYER  8
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.13   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.   =   2.24000001000     CM/SEC
SLOPE                       =      1.80   PERCENT
DRAINAGE LENGTH             =    230.0    FEET


                        LAYER  9
                        --------

            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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER 10
                        --------

              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 6.% AND A SLOPE LENGTH OF 530. FEET.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1489.639	INCHES
TOTAL INITIAL WATER	=	1489.639	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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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	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.570	0.378	0.739	0.252	0.272	0.196
	0.427	0.024	0.223	1.798	0.944	1.383

STD. DEVIATIONS	0.824	0.638	1.325	0.605	0.656	0.399
	0.931	0.058	0.324	2.678	1.581	1.830

EVAPOTRANSPIRATION

TOTALS	1.761	1.864	2.881	3.885	3.834	3.304
	3.180	2.078	3.055	2.033	1.155	1.522
STD. DEVIATIONS	0.368	0.553	0.983	1.124	1.495	1.859
	2.005	1.595	1.552	0.886	0.397	0.408

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0144	0.0128	0.0130	0.0069	0.0021	0.0022
	0.0017	0.0006	0.0022	0.0094	0.0124	0.0156
STD. DEVIATIONS	0.0062	0.0048	0.0047	0.0039	0.0029	0.0024
	0.0026	0.0013	0.0031	0.0080	0.0091	0.0075

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.5752	0.5374	0.5854	0.5727	0.5812	0.5735
	0.5860	0.5772	0.5519	0.5701	0.5523	0.5646
STD. DEVIATIONS	0.2346	0.2370	0.2588	0.2586	0.2475	0.2619
	0.2551	0.2468	0.2326	0.2440	0.2314	0.2350

PERCOLATION/LEAKAGE THROUGH LAYER 10

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 2

AVERAGES	6.8380	6.6649	6.0987	3.2919	0.9696	1.0374
	0.7826	0.2757	1.0614	4.4554	6.1447	7.4559
STD. DEVIATIONS	3.0252	2.6147	2.2749	1.9147	1.3865	1.1817
	1.2404	0.5843	1.4904	3.8493	4.5419	3.6391

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0187	0.0192	0.0190	0.0192	0.0189	0.0192
	0.0190	0.0187	0.0185	0.0185	0.0185	0.0183
STD. DEVIATIONS	0.0076	0.0085	0.0084	0.0087	0.0080	0.0088
	0.0083	0.0080	0.0078	0.0079	0.0078	0.0076

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.85	(7.081)	137390.7	100.00
RUNOFF	7.205	(4.1955)	26154.34	19.036
EVAPOTRANSPIRATION	30.553	(4.2137)	110906.27	80.723
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.09328	(0.02794)	338.622	0.24647
AVERAGE HEAD ON TOP OF LAYER 2	3.756	(1.144)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	6.82767	(2.91641)	24784.443	18.03939
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.019	(0.008)		
CHANGE IN WATER STORAGE	-6.737	(3.0894)	-24454.38	-17.799

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

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PRECIPITATION	5.70	20691.000
RUNOFF	4.030	14630.1230
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000797	2.89305
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.05874	213.21231
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 9	0.059	
MAXIMUM HEAD ON TOP OF LAYER 9	0.117	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	2.8 FEET	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8573	0.2381

2	0.0000	0.0000
3	7.6860	0.4270
4	3.7200	0.3100
5	555.5975	0.3704
6	701.1168	0.2996
7	6.2989	0.2625
8	0.0125	0.0981
9	0.0000	0.0000
10	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:    C:\TC\C\MSWUNDEV\AC\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\MSWUNDEV\AC\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\MSWUNDEV\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\MSWUNDEV\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\MSWUNDEV\AC\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\MSWUNDEV\AC\OUTPUT1.OUT


TIME:   8:15     DATE:  10/ 5/2021


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     TITLE:  TURKEY CREEK - MSW UNDEVELOPED AREA - ACTIVE 10 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                        =    120.00   INCHES
```

```
POROSITY                    =      0.6649 VOL/VOL
FIELD CAPACITY              =      0.5262 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.19   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.   =   13.2500000000     CM/SEC
SLOPE                       =      1.80   PERCENT
DRAINAGE LENGTH             =    285.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
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                        LAYER  5
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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
```

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #11 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
          A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER            =     94.60
FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
EVAPORATIVE ZONE DEPTH             =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      6.649  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.770  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     46.106  INCHES
TOTAL INITIAL WATER                =     46.106  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

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             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	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.73	3.33	4.41	4.44	6.41	2.61
	6.99	0.00	5.71	2.68	8.44	3.81
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
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	2.704	2.929	4.052	2.278	4.593	3.626
	2.819	0.215	3.627	2.346	3.038	2.083
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
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0547	0.0000	0.0588	0.1386	0.1487	0.2853
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 5						
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	0.0000	0.0000
	0.0004	0.0000	0.0004	0.0009	0.0010	0.0019
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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.56 (0.000)	183532.8	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.310 (0.0000)	124544.37	67.859
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.68611 (0.00000)	2490.594	1.35703
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.006	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)		
CHANGE IN WATER STORAGE	15.564 (0.0000)	56497.77	30.783

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PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.26	11833.800

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01207	43.80876
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.003	
MAXIMUM HEAD ON TOP OF LAYER 4	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.35	4901.6436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4291
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0770

*** 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 9

LAYER	(INCHES)	(VOL/VOL)
1	45.1600	0.3763
2	6.2567	0.2607
3	0.0053	0.0279
4	0.0000	0.0000

5	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:    C:\TC\C\MSWUNDEV\I50\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\MSWUNDEV\I50\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\MSWUNDEV\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\MSWUNDEV\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\MSWUNDEV\I50\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\MSWUNDEV\I50\OUTPUT1.OUT


TIME:  14:25     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - MSW UNDEVELOPED AREA - INTERIM 50 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                    =     12.00   INCHES
```

```
  POROSITY                        =       0.4640 VOL/VOL
  FIELD CAPACITY                  =       0.3100 VOL/VOL
  WILTING POINT                   =       0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =     600.00   INCHES
  POROSITY                        =       0.6483 VOL/VOL
  FIELD CAPACITY                  =       0.5215 VOL/VOL
  WILTING POINT                   =       0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.2500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =      24.00   INCHES
  POROSITY                        =       0.3980 VOL/VOL
  FIELD CAPACITY                  =       0.2440 VOL/VOL
  WILTING POINT                   =       0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC


                           LAYER  4
                           --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =       0.19   INCHES
  POROSITY                        =       0.8500 VOL/VOL
```

```
  FIELD CAPACITY                =      0.0100 VOL/VOL
  WILTING POINT                 =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT    =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =   8.00000000000     CM/SEC
  SLOPE                         =      1.80   PERCENT
  DRAINAGE LENGTH               =    285.0    FEET
NOTE:    10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

```
                              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           =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS      =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY         =  3 - GOOD
```

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                              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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	169.826	INCHES
TOTAL INITIAL WATER	=	169.826	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.178	0.331
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.378
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.898	1.877	2.455	2.985	2.987	2.459
	3.334	1.820	3.046	2.252	1.314	1.799
STD. DEVIATIONS	0.280	0.710	0.634	1.201	1.085	1.608

	1.477	1.229	1.205	1.315	0.687	0.560

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0150	0.0146	0.0169	0.0153	0.0179	0.0157
	0.0175	0.0174	0.0177	0.0187	0.0181	0.0189
STD. DEVIATIONS	0.0173	0.0174	0.0203	0.0169	0.0186	0.0152
	0.0179	0.0178	0.0184	0.0194	0.0180	0.0189

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1354	0.1311	0.1520	0.1377	0.1613	0.1414
	0.1579	0.1570	0.1589	0.1681	0.1625	0.1704
STD. DEVIATIONS	0.1556	0.1565	0.1830	0.1525	0.1677	0.1372
	0.1611	0.1600	0.1658	0.1746	0.1617	0.1701

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0150	0.0146	0.0169	0.0153	0.0179	0.0157
	0.0175	0.0174	0.0177	0.0187	0.0181	0.0189
STD. DEVIATIONS	0.0173	0.0174	0.0203	0.0169	0.0186	0.0152
	0.0179	0.0178	0.0184	0.0194	0.0180	0.0189

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 5

AVERAGES	0.0017	0.0018	0.0019	0.0018	0.0020	0.0018
	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021
STD. DEVIATIONS	0.0019	0.0022	0.0023	0.0020	0.0021	0.0018
	0.0020	0.0020	0.0021	0.0022	0.0021	0.0021

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.064	(1.2957)	11122.62	7.432
EVAPOTRANSPIRATION	28.227	(2.9143)	102462.45	68.461
DRAINAGE RECIRCULATED INTO LAYER 2	0.20375	(0.21319)	739.603	0.49417
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.83373	(1.91875)	6656.431	4.44756
DRAINAGE RECIRCULATED FROM LAYER 4	0.20375	(0.21319)	739.603	0.49417
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.002)		
CHANGE IN WATER STORAGE	8.105	(3.6087)	29422.61	19.659

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8379.5771
DRAINAGE RECIRCULATED INTO LAYER 2	0.00290	10.51177
DRAINAGE COLLECTED FROM LAYER 4	0.02606	94.60591

DRAINAGE RECIRCULATED FROM LAYER 4	0.00290	10.51177
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.010	
MAXIMUM HEAD ON TOP OF LAYER 5	0.020	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5985	0.2165
2	231.5444	0.3859
3	6.4804	0.2700
4	0.0085	0.0451
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              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\TC\C\MSWUNDEV\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWUNDEV\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWUNDEV\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWUNDEV\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWUNDEV\I100\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWUNDEV\I100\OUTPUT1.OUT


TIME:  31:30     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - MSW UNDEVELOPED AREA - INTERIM 100 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                  =     12.00   INCHES
```

```
  POROSITY                          =      0.4640 VOL/VOL
  FIELD CAPACITY                    =      0.3100 VOL/VOL
  WILTING POINT                     =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =   1200.00   INCHES
  POROSITY                          =      0.6277 VOL/VOL
  FIELD CAPACITY                    =      0.5156 VOL/VOL
  WILTING POINT                     =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                              LAYER  3
                              --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
  THICKNESS                         =     24.00   INCHES
  POROSITY                          =      0.3980 VOL/VOL
  FIELD CAPACITY                    =      0.2440 VOL/VOL
  WILTING POINT                     =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.119999997000E-03 CM/SEC


                              LAYER  4
                              --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =      0.18   INCHES
  POROSITY                          =      0.8500 VOL/VOL
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```
  FIELD CAPACITY                   =      0.0100 VOL/VOL
  WILTING POINT                    =      0.0050 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =   4.57999992000     CM/SEC
  SLOPE                            =      1.80   PERCENT
  DRAINAGE LENGTH                  =    285.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                          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              =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS         =      0.00   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 #11 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	475.826	INCHES
TOTAL INITIAL WATER	=	475.826	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614

	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0640	0.0636	0.0662	0.0636	0.0679	0.0663
	0.0644	0.0672	0.0624	0.0634	0.0663	0.0702
STD. DEVIATIONS	0.0160	0.0113	0.0081	0.0101	0.0134	0.0118
	0.0088	0.0147	0.0092	0.0116	0.0115	0.0103

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5760	0.5721	0.5955	0.5724	0.6110	0.5966
	0.5792	0.6048	0.5615	0.5704	0.5970	0.6320
STD. DEVIATIONS	0.1442	0.1020	0.0732	0.0911	0.1205	0.1058
	0.0792	0.1320	0.0829	0.1046	0.1032	0.0931

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0640	0.0636	0.0662	0.0636	0.0679	0.0663
	0.0644	0.0672	0.0624	0.0634	0.0663	0.0702
STD. DEVIATIONS	0.0160	0.0113	0.0081	0.0101	0.0134	0.0118
	0.0088	0.0147	0.0092	0.0116	0.0115	0.0103

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 5

AVERAGES	0.0126	0.0137	0.0130	0.0129	0.0134	0.0135
	0.0127	0.0132	0.0127	0.0125	0.0135	0.0138
STD. DEVIATIONS	0.0032	0.0024	0.0016	0.0021	0.0026	0.0024
	0.0017	0.0029	0.0019	0.0023	0.0023	0.0020

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.78540	(0.10525)	2851.005	1.90493
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.06861	(0.94730)	25659.049	17.14433
DRAINAGE RECIRCULATED FROM LAYER 4	0.78540	(0.10525)	2851.005	1.90493
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.013	(0.002)		
CHANGE IN WATER STORAGE	2.877	(3.1836)	10442.58	6.977

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00553	20.06417
DRAINAGE COLLECTED FROM LAYER 4	0.04975	180.57748

DRAINAGE RECIRCULATED FROM LAYER 4	0.00553	20.06417
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.034	
MAXIMUM HEAD ON TOP OF LAYER 5	0.067	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	1.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	485.1913	0.4043
3	6.5437	0.2727
4	0.0120	0.0670
5	0.0000	0.0000
6	10.2480	0.4270

SNOW WATER 0.000

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:     C:\TC\C\MSWUNDEV\I140\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWUNDEV\I140\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWUNDEV\I140\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWUNDEV\I140\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWUNDEV\I140\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWUNDEV\I140\OUTPUT1.OUT


TIME:  31:32     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - MSW UNDEVELOPED AREA - INTERIM 140 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
          THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1500.00   INCHES
  POROSITY                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5174 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =    180.00   INCHES
  POROSITY                        =      0.5348 VOL/VOL
  FIELD CAPACITY                  =      0.4892 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC


                           LAYER  4
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
```

```
  FIELD CAPACITY                 =      0.2440 VOL/VOL
  WILTING POINT                  =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT     =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.      =  0.119999997000E-03 CM/SEC


                         LAYER  5
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
  THICKNESS                      =      0.17   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.      =   3.99000001000     CM/SEC
  SLOPE                          =      1.80   PERCENT
  DRAINAGE LENGTH                =    285.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                         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            =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS       =      0.00   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 #11 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     87.10
FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    658.226  INCHES
TOTAL INITIAL WATER                  =    658.226  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                    =   2.00
     START OF GROWING SEASON (JULIAN DATE)      =     63
     END OF GROWING SEASON (JULIAN DATE)        =    329
     EVAPORATIVE ZONE DEPTH                     =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0465	0.0478	0.0516	0.0495	0.0509	0.0488
	0.0507	0.0509	0.0484	0.0500	0.0480	0.0507
STD. DEVIATIONS	0.0081	0.0064	0.0077	0.0069	0.0061	0.0050
	0.0045	0.0049	0.0042	0.0060	0.0052	0.0058

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4187	0.4300	0.4640	0.4457	0.4581	0.4388
	0.4566	0.4577	0.4357	0.4499	0.4323	0.4563
STD. DEVIATIONS	0.0728	0.0576	0.0690	0.0620	0.0550	0.0453
	0.0404	0.0441	0.0381	0.0543	0.0468	0.0518

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0465	0.0478	0.0516	0.0495	0.0509	0.0488
	0.0507	0.0509	0.0484	0.0500	0.0480	0.0507
STD. DEVIATIONS	0.0081	0.0064	0.0077	0.0069	0.0061	0.0050
	0.0045	0.0049	0.0042	0.0060	0.0052	0.0058

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 6

AVERAGES	0.0105	0.0119	0.0116	0.0116	0.0115	0.0114
	0.0115	0.0115	0.0113	0.0113	0.0112	0.0115
STD. DEVIATIONS	0.0018	0.0016	0.0017	0.0016	0.0014	0.0012
	0.0010	0.0011	0.0010	0.0014	0.0012	0.0013

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.066 (1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219 (2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.59375 (0.05909)	2155.317	1.44010
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.34376 (0.53178)	19397.859	12.96086
DRAINAGE RECIRCULATED FROM LAYER 5	0.59375 (0.05909)	2155.317	1.44010
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.011 (0.001)		
CHANGE IN WATER STORAGE	4.602 (3.0301)	16703.85	11.161

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00283	10.26236
DRAINAGE COLLECTED FROM LAYER 5	0.02544	92.36122
DRAINAGE RECIRCULATED FROM LAYER 5	0.00283	10.26236
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.020	
MAXIMUM HEAD ON TOP OF LAYER 6	0.039	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	4.5 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	618.7481	0.4125
3	66.0906	0.3672
4	6.5388	0.2724
5	0.0182	0.1078
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:     C:\TC\C\MSWUNDEV\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\MSWUNDEV\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\MSWUNDEV\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\MSWUNDEV\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\MSWUNDEV\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\MSWUNDEV\CL\OUTPUT1.OUT


TIME:  12:42     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - MSW UNDEVELOPED AREA - CLOSED 140 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
           THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                          =      0.3980 VOL/VOL
  FIELD CAPACITY                    =      0.2440 VOL/VOL
  WILTING POINT                     =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                            LAYER  2
                            --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  36
  THICKNESS                         =      0.04   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.         =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY               =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS          =      4.00   HOLES/ACRE
  FML PLACEMENT QUALITY             =  3 - GOOD


                            LAYER  3
                            --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER   0
  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.         =  0.999999975000E-05 CM/SEC


                            LAYER  4
                            --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  11
  THICKNESS                         =     12.00   INCHES
```

```
POROSITY                   =     0.4640 VOL/VOL
FIELD CAPACITY             =     0.3100 VOL/VOL
WILTING POINT              =     0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.639999998000E-04 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =   1500.00   INCHES
POROSITY                   =     0.6174 VOL/VOL
FIELD CAPACITY             =     0.5174 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =    180.00   INCHES
POROSITY                   =     0.5596 VOL/VOL
FIELD CAPACITY             =     0.4963 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.999999975000E-04 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                  =     24.00   INCHES
POROSITY                   =     0.3980 VOL/VOL
FIELD CAPACITY             =     0.2440 VOL/VOL
WILTING POINT              =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =     0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.119999997000E-03 CM/SEC
```

```
                         LAYER  8
                         --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
THICKNESS                    =       0.17   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.    =    2.93000007000     CM/SEC
SLOPE                        =       1.80   PERCENT
DRAINAGE LENGTH              =     285.0    FEET


                         LAYER  9
                         --------

               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          =       0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =       0.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER 10
                         --------

                 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 6.% AND A SLOPE LENGTH OF 530. FEET.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	668.840	INCHES
TOTAL INITIAL WATER	=	668.840	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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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	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.570	0.378	0.739	0.252	0.272	0.196
	0.427	0.024	0.223	1.798	0.944	1.383

```
  STD. DEVIATIONS        0.824    0.638    1.325    0.605    0.656    0.399
                         0.931    0.058    0.324    2.678    1.581    1.830

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.761    1.864    2.881    3.885    3.834    3.304
                         3.180    2.078    3.055    2.033    1.155    1.522

  STD. DEVIATIONS        0.368    0.553    0.983    1.124    1.495    1.859
                         2.005    1.595    1.552    0.886    0.397    0.408

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------
  TOTALS                 0.0144   0.0128   0.0130   0.0069   0.0021   0.0022
                         0.0017   0.0006   0.0022   0.0094   0.0124   0.0156

  STD. DEVIATIONS        0.0062   0.0048   0.0047   0.0039   0.0029   0.0024
                         0.0026   0.0013   0.0031   0.0080   0.0091   0.0075

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.2613   0.2499   0.2705   0.2617   0.2676   0.2598
                         0.2636   0.2646   0.2561   0.2646   0.2544   0.2621

  STD. DEVIATIONS        0.0584   0.0699   0.0745   0.0712   0.0708   0.0680
                         0.0662   0.0667   0.0629   0.0638   0.0616   0.0607

PERCOLATION/LEAKAGE THROUGH LAYER 10
------------------------------------
  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  2
-------------------------------------
  AVERAGES               6.8380   6.6649   6.0987   3.2919   0.9696   1.0374
                         0.7826   0.2757   1.0614   4.4554   6.1447   7.4559

  STD. DEVIATIONS        3.0252   2.6147   2.2749   1.9147   1.3865   1.1817
                         1.2404   0.5843   1.4904   3.8493   4.5419   3.6391

DAILY AVERAGE HEAD ON TOP OF LAYER  9
```

AVERAGES	0.0080	0.0084	0.0083	0.0083	0.0082	0.0083
	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081
STD. DEVIATIONS	0.0018	0.0024	0.0023	0.0023	0.0022	0.0022
	0.0020	0.0021	0.0020	0.0020	0.0020	0.0019

****

****

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85 (7.081)	137390.7	100.00
RUNOFF	7.205 (4.1955)	26154.34	19.036
EVAPOTRANSPIRATION	30.553 (4.2137)	110906.27	80.723
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.09328 (0.02794)	338.622	0.24647
AVERAGE HEAD ON TOP OF LAYER 2	3.756 (1.144)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	3.13628 (0.77441)	11384.695	8.28637
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.008 (0.002)		
CHANGE IN WATER STORAGE	-3.045 (1.4094)	-11054.62	-8.046

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

	----------	-------------
PRECIPITATION	5.70	20691.000
RUNOFF	4.030	14630.1230
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000797	2.89305
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.02075	75.31369
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.020	
MAXIMUM HEAD ON TOP OF LAYER 9	0.039	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	1.2 FEET	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8573	0.2381

2	0.0000	0.0000
3	7.6860	0.4270
4	3.7200	0.3100
5	492.4286	0.3283
6	54.4710	0.3026
7	6.0620	0.2526
8	0.0061	0.0365
9	0.0000	0.0000
10	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:     C:\TC\C\CS1DEV\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1DEV\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1DEV\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1DEV\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1DEV\I50\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1DEV\I50\OUTPUT1.OUT


TIME:  31:43     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - INTERIM 50 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                    LAYER  1
                                    --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER  11
           THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                     =      0.4640 VOL/VOL
  FIELD CAPACITY               =      0.3100 VOL/VOL
  WILTING POINT                =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =    600.00   INCHES
  POROSITY                     =      0.6483 VOL/VOL
  FIELD CAPACITY               =      0.5215 VOL/VOL
  WILTING POINT                =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.


                           LAYER  3
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.3980 VOL/VOL
  FIELD CAPACITY               =      0.2440 VOL/VOL
  WILTING POINT                =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                           LAYER  4
                           --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =      0.21   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                         =      2.05   PERCENT
  DRAINAGE LENGTH               =    305.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                          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           =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS      =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY         =  3 - GOOD


                          LAYER  6
                          --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
  THICKNESS                     =     36.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	174.950	INCHES
TOTAL INITIAL WATER	=	174.950	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.104	0.121	0.100	0.092	0.171	0.343
	0.629	0.123	0.438	0.612	0.090	0.278
STD. DEVIATIONS	0.099	0.225	0.115	0.117	0.172	0.388
	0.861	0.188	0.361	1.252	0.148	0.324
EVAPOTRANSPIRATION						
TOTALS	1.914	1.905	2.497	3.022	2.960	2.482
	3.405	1.872	3.102	2.302	1.329	1.777
STD. DEVIATIONS	0.269	0.685	0.660	1.223	1.061	1.612

	1.572	1.275	1.241	1.329	0.666	0.544

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0125	0.0129	0.0139	0.0131	0.0151	0.0136
	0.0152	0.0139	0.0140	0.0160	0.0159	0.0166
STD. DEVIATIONS	0.0144	0.0150	0.0158	0.0154	0.0177	0.0153
	0.0177	0.0164	0.0148	0.0164	0.0155	0.0164

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1127	0.1162	0.1247	0.1175	0.1361	0.1226
	0.1367	0.1247	0.1263	0.1438	0.1435	0.1490
STD. DEVIATIONS	0.1300	0.1348	0.1426	0.1383	0.1589	0.1377
	0.1591	0.1473	0.1330	0.1474	0.1399	0.1474

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0125	0.0129	0.0139	0.0131	0.0151	0.0136
	0.0152	0.0139	0.0140	0.0160	0.0159	0.0166
STD. DEVIATIONS	0.0144	0.0150	0.0158	0.0154	0.0177	0.0153
	0.0177	0.0164	0.0148	0.0164	0.0155	0.0164

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 5

AVERAGES	0.0011	0.0012	0.0012	0.0011	0.0013	0.0012
	0.0013	0.0012	0.0012	0.0014	0.0014	0.0014
STD. DEVIATIONS	0.0012	0.0014	0.0013	0.0013	0.0015	0.0013
	0.0015	0.0014	0.0013	0.0014	0.0014	0.0014

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.101 (1.2584)	11257.11	7.522
EVAPOTRANSPIRATION	28.567 (2.9991)	103699.25	69.288
DRAINAGE RECIRCULATED INTO LAYER 2	0.17264 (0.18888)	626.693	0.41873
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.55378 (1.69990)	5640.235	3.76858
DRAINAGE RECIRCULATED FROM LAYER 4	0.17264 (0.18888)	626.693	0.41873
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.001 (0.001)		
CHANGE IN WATER STORAGE	8.008 (3.3944)	29067.74	19.422

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.166	7862.5942
DRAINAGE RECIRCULATED INTO LAYER 2	0.00233	8.47184
DRAINAGE COLLECTED FROM LAYER 4	0.02100	76.24660

DRAINAGE RECIRCULATED FROM LAYER 4	0.00233	8.47184
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.006	
MAXIMUM HEAD ON TOP OF LAYER 5	0.009	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	85.4 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4513
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.6481	0.2207
2	230.6373	0.3844
3	6.3641	0.2652
4	0.0049	0.0235
5	0.0000	0.0000
6	15.3720	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:    C:\TC\C\CS1DEV\I100\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\CS1DEV\I100\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\CS1DEV\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\CS1DEV\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\CS1DEV\I100\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\CS1DEV\I100\OUTPUT1.OUT


TIME:  31:43     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - INTERIM 100 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  11
           THICKNESS                   =     12.00   INCHES
```

```
  POROSITY                        =       0.4640 VOL/VOL
  FIELD CAPACITY                  =       0.3100 VOL/VOL
  WILTING POINT                   =       0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                            LAYER  2
                            --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =    1200.00   INCHES
  POROSITY                        =       0.6277 VOL/VOL
  FIELD CAPACITY                  =       0.5156 VOL/VOL
  WILTING POINT                   =       0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
         IS RECIRCULATED INTO THIS LAYER.



                            LAYER  3
                            --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =       0.3980 VOL/VOL
  FIELD CAPACITY                  =       0.2440 VOL/VOL
  WILTING POINT                   =       0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =       0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC



                            LAYER  4
                            --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
  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.     =   5.46000004000     CM/SEC
  SLOPE                         =      2.05   PERCENT
  DRAINAGE LENGTH               =    305.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

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           =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS      =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY         =  3 - GOOD
```

LAYER 6

```
               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
  THICKNESS                     =     36.00   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 #11 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	480.950	INCHES
TOTAL INITIAL WATER	=	480.950	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	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	10.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614

	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0656	0.0590	0.0703	0.0634	0.0646	0.0656
	0.0664	0.0664	0.0631	0.0665	0.0678	0.0697
STD. DEVIATIONS	0.0161	0.0094	0.0167	0.0098	0.0088	0.0116
	0.0092	0.0110	0.0125	0.0105	0.0126	0.0136

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5906	0.5314	0.6324	0.5704	0.5810	0.5903
	0.5975	0.5974	0.5681	0.5988	0.6104	0.6270
STD. DEVIATIONS	0.1448	0.0842	0.1501	0.0879	0.0793	0.1042
	0.0828	0.0994	0.1127	0.0941	0.1130	0.1228

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0656	0.0590	0.0703	0.0634	0.0646	0.0656
	0.0664	0.0664	0.0631	0.0665	0.0678	0.0697
STD. DEVIATIONS	0.0161	0.0094	0.0167	0.0098	0.0088	0.0116
	0.0092	0.0110	0.0125	0.0105	0.0126	0.0136

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 5

AVERAGES	0.0102	0.0101	0.0109	0.0102	0.0100	0.0105
	0.0103	0.0103	0.0101	0.0103	0.0109	0.0108
STD. DEVIATIONS	0.0025	0.0015	0.0026	0.0016	0.0014	0.0019
	0.0014	0.0017	0.0020	0.0016	0.0020	0.0021

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.78835	(0.11212)	2861.699	1.91207
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.09512	(1.00909)	25755.289	17.20864
DRAINAGE RECIRCULATED FROM LAYER 4	0.78835	(0.11212)	2861.699	1.91207
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.010	(0.001)		
CHANGE IN WATER STORAGE	2.850	(3.2468)	10346.21	6.913

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00596	21.62949
DRAINAGE COLLECTED FROM LAYER 4	0.05363	194.66544

DRAINAGE RECIRCULATED FROM LAYER 4	0.00596	21.62949
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.029	
MAXIMUM HEAD ON TOP OF LAYER 5	0.058	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	484.9459	0.4041
3	6.5244	0.2718
4	0.0115	0.0589
5	0.0000	0.0000
6	15.3720	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:     C:\TC\C\CS1DEV\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1DEV\I200\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1DEV\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1DEV\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1DEV\I200\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1DEV\I200\OUTPUT1.OUT


TIME:  31:44     DATE:  10/ 4/2021


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

    TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - INTERIM 200 FT

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


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
             WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  11
         THICKNESS                    =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                          LAYER  2
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1500.00   INCHES
  POROSITY                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5127 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.



                          LAYER  3
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =    900.00   INCHES
  POROSITY                        =      0.5348 VOL/VOL
  FIELD CAPACITY                  =      0.4892 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC



                          LAYER  4
                          --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
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FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                     LAYER  5
                     --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.17   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.   =   3.38000011000     CM/SEC
SLOPE                       =      2.05   PERCENT
DRAINAGE LENGTH             =    305.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                     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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                     LAYER  7
                     --------

             TYPE 3 - BARRIER SOIL LINER
             MATERIAL TEXTURE NUMBER  16
```

THICKNESS	=	36.00	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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	936.950	INCHES
TOTAL INITIAL WATER	=	936.950	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	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	10.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0530	0.0520	0.0574	0.0557	0.0570	0.0551
	0.0572	0.0566	0.0543	0.0566	0.0549	0.0565
STD. DEVIATIONS	0.0095	0.0064	0.0075	0.0065	0.0070	0.0053
	0.0059	0.0052	0.0059	0.0058	0.0046	0.0046

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4772	0.4680	0.5168	0.5011	0.5134	0.4958
	0.5147	0.5097	0.4889	0.5092	0.4944	0.5087
STD. DEVIATIONS	0.0854	0.0578	0.0671	0.0582	0.0627	0.0473
	0.0527	0.0466	0.0529	0.0518	0.0413	0.0412

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0530	0.0520	0.0574	0.0557	0.0570	0.0551
	0.0572	0.0566	0.0543	0.0566	0.0549	0.0565
STD. DEVIATIONS	0.0095	0.0064	0.0075	0.0065	0.0070	0.0053
	0.0059	0.0052	0.0059	0.0058	0.0046	0.0046

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 6

AVERAGES	0.0133	0.0143	0.0144	0.0144	0.0143	0.0143
	0.0143	0.0142	0.0141	0.0142	0.0142	0.0142
STD. DEVIATIONS	0.0024	0.0018	0.0019	0.0017	0.0017	0.0014
	0.0015	0.0013	0.0015	0.0014	0.0012	0.0011

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.66643	(0.05799)	2419.158	1.61638
LATERAL DRAINAGE COLLECTED FROM LAYER 5	5.99791	(0.52189)	21772.432	14.54745
DRAINAGE RECIRCULATED FROM LAYER 5	0.66643	(0.05799)	2419.158	1.61638
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.014	(0.001)		
CHANGE IN WATER STORAGE	3.948	(3.0800)	14329.70	9.575

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00316	11.48564
DRAINAGE COLLECTED FROM LAYER 5	0.02848	103.37073
DRAINAGE RECIRCULATED FROM LAYER 5	0.00316	11.48564
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.025	
MAXIMUM HEAD ON TOP OF LAYER 6	0.049	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	3.6 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	623.6155	0.4157
3	328.3084	0.3648
4	6.5191	0.2716
5	0.0123	0.0722
6	0.0000	0.0000
7	15.3720	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:     C:\TC\C\CS1DEV\I300\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1DEV\I300\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1DEV\I300\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1DEV\I300\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1DEV\I300\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1DEV\I300\OUTPUT1.OUT


TIME:  16: 6     DATE:  10/ 4/2021


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

     TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - INTERIM 300 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  11
          THICKNESS                      =     12.00   INCHES
```

```
  POROSITY                         =      0.4640 VOL/VOL
  FIELD CAPACITY                   =      0.3100 VOL/VOL
  WILTING POINT                    =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =   1500.00   INCHES
  POROSITY                         =      0.6174 VOL/VOL
  FIELD CAPACITY                   =      0.5174 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
        IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =   2100.00   INCHES
  POROSITY                         =      0.4935 VOL/VOL
  FIELD CAPACITY                   =      0.4775 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.999999975000E-04 CM/SEC


                          LAYER  4
                          --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  10
  THICKNESS                        =     24.00   INCHES
  POROSITY                         =      0.3980 VOL/VOL
```

```
FIELD CAPACITY              =       0.2440 VOL/VOL
WILTING POINT               =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
```

```
                    LAYER  5
                    --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =       0.14   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.   =    2.88000011000     CM/SEC
SLOPE                       =       2.05   PERCENT
DRAINAGE LENGTH             =     305.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.
```

```
                    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         =       0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =       0.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1387.825	INCHES
TOTAL INITIAL WATER	=	1387.825	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	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	10.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0795	0.0778	0.0843	0.0808	0.0824	0.0804
	0.0828	0.0816	0.0795	0.0813	0.0787	0.0810
STD. DEVIATIONS	0.0144	0.0139	0.0178	0.0151	0.0138	0.0140
	0.0151	0.0145	0.0148	0.0140	0.0141	0.0150

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.7156	0.7001	0.7583	0.7269	0.7414	0.7237
	0.7449	0.7347	0.7158	0.7314	0.7081	0.7288
STD. DEVIATIONS	0.1295	0.1254	0.1600	0.1357	0.1238	0.1258
	0.1362	0.1306	0.1328	0.1264	0.1266	0.1350

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0795	0.0778	0.0843	0.0808	0.0824	0.0804
	0.0828	0.0816	0.0795	0.0813	0.0787	0.0810
STD. DEVIATIONS	0.0144	0.0139	0.0178	0.0151	0.0138	0.0140
	0.0151	0.0145	0.0148	0.0140	0.0141	0.0150

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 6

AVERAGES	0.0234	0.0252	0.0248	0.0245	0.0242	0.0244
	0.0243	0.0240	0.0242	0.0239	0.0239	0.0238
STD. DEVIATIONS	0.0042	0.0046	0.0052	0.0046	0.0040	0.0042
	0.0044	0.0043	0.0045	0.0041	0.0043	0.0044

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.066 (1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219 (2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.96998 (0.16620)	3521.036	2.35261
LATERAL DRAINAGE COLLECTED FROM LAYER 5	8.72984 (1.49579)	31689.324	21.17352
DRAINAGE RECIRCULATED FROM LAYER 5	0.96998 (0.16620)	3521.036	2.35261
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.024 (0.004)		
CHANGE IN WATER STORAGE	1.216 (3.4699)	4413.25	2.949

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00521	18.90074
DRAINAGE COLLECTED FROM LAYER 5	0.04686	170.10667
DRAINAGE RECIRCULATED FROM LAYER 5	0.00521	18.90074
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.047	
MAXIMUM HEAD ON TOP OF LAYER 6	0.094	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	2.3 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	644.9812	0.4300
3	735.5351	0.3503
4	6.6002	0.2750
5	0.0205	0.1411
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:     C:\TC\C\CS1DEV\I330\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1DEV\I330\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1DEV\I330\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1DEV\I330\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1DEV\I330\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1DEV\I330\OUTPUT1.OUT


TIME:  31:46     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - INTERIM 330 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                          =      0.4640 VOL/VOL
  FIELD CAPACITY                    =      0.3100 VOL/VOL
  WILTING POINT                     =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                            LAYER  2
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =   1500.00   INCHES
  POROSITY                          =      0.6174 VOL/VOL
  FIELD CAPACITY                    =      0.5174 VOL/VOL
  WILTING POINT                     =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                            LAYER  3
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =   2460.00   INCHES
  POROSITY                          =      0.4811 VOL/VOL
  FIELD CAPACITY                    =      0.4739 VOL/VOL
  WILTING POINT                     =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.999999975000E-04 CM/SEC


                            LAYER  4
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                         =     24.00   INCHES
  POROSITY                          =      0.3980 VOL/VOL
```

```
FIELD CAPACITY              =     0.2440 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   = 0.119999997000E-03 CM/SEC


                        LAYER  5
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.14   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.   =  2.68000007000     CM/SEC
SLOPE                       =     2.05   PERCENT
DRAINAGE LENGTH             =   305.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
        LAYER IS RECIRCULATED INTO LAYER #  2.


                        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         =     0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     0.00   HOLES/ACRE
FML PLACEMENT QUALITY       = 3 - GOOD


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
```

THICKNESS	=	36.00 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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1529.749	INCHES
TOTAL INITIAL WATER	=	1529.749	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0916	0.0871	0.0955	0.0949	0.0955	0.0916
	0.0942	0.0946	0.0904	0.0920	0.0884	0.0923
STD. DEVIATIONS	0.0190	0.0177	0.0186	0.0207	0.0180	0.0181
	0.0200	0.0205	0.0159	0.0195	0.0173	0.0165

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.8244	0.7838	0.8596	0.8537	0.8598	0.8248
	0.8478	0.8518	0.8138	0.8281	0.7956	0.8304
STD. DEVIATIONS	0.1708	0.1589	0.1673	0.1863	0.1622	0.1628
	0.1804	0.1846	0.1430	0.1758	0.1559	0.1485

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0916	0.0871	0.0955	0.0949	0.0955	0.0916
	0.0942	0.0946	0.0904	0.0920	0.0884	0.0923
STD. DEVIATIONS	0.0190	0.0177	0.0186	0.0207	0.0180	0.0181
	0.0200	0.0205	0.0159	0.0195	0.0173	0.0165

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 6

AVERAGES	0.0289	0.0303	0.0302	0.0310	0.0302	0.0299
	0.0298	0.0299	0.0295	0.0291	0.0289	0.0292
STD. DEVIATIONS	0.0060	0.0062	0.0059	0.0068	0.0057	0.0059
	0.0063	0.0065	0.0052	0.0062	0.0057	0.0052

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	1.10816	(0.21050)	4022.630	2.68776
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.97346	(1.89448)	36203.680	24.18983
DRAINAGE RECIRCULATED FROM LAYER 5	1.10816	(0.21050)	4022.630	2.68776
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.030	(0.006)		
CHANGE IN WATER STORAGE	-0.028	(3.6601)	-101.78	-0.068

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00608	22.08230
DRAINAGE COLLECTED FROM LAYER 5	0.05475	198.74068
DRAINAGE RECIRCULATED FROM LAYER 5	0.00608	22.08230
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.060	
MAXIMUM HEAD ON TOP OF LAYER 6	0.118	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	3.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	653.1890	0.4355
3	851.6474	0.3462
4	6.6333	0.2764
5	0.0291	0.2105
6	0.0000	0.0000
7	15.3720	0.4270
SNOW WATER	0.000	

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****

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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:     C:\TC\C\CS1DEV\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1DEV\CL\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\CS1DEV\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1DEV\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\CS1DEV\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1DEV\CL\OUTPUT1.OUT


TIME:  10: 6     DATE:  10/ 5/2021


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

     TITLE:  TURKEY CREEK - CLASS 1 DEVELOPED AREA - CLOSED 330 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  10
           THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                          =      0.3980 VOL/VOL
  FIELD CAPACITY                    =      0.2440 VOL/VOL
  WILTING POINT                     =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT        =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.         =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                   MATERIAL TEXTURE NUMBER  36
  THICKNESS                         =      0.04   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.         =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY               =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS          =      4.00   HOLES/ACRE
  FML PLACEMENT QUALITY             =  3 - GOOD


                              LAYER  3
                              --------

                   TYPE 3 - BARRIER SOIL LINER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                         =     48.00   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.         =  0.999999975000E-05 CM/SEC


                              LAYER  4
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  11
  THICKNESS                         =     12.00   INCHES
```

```
POROSITY                      =       0.4640 VOL/VOL
FIELD CAPACITY                =       0.3100 VOL/VOL
WILTING POINT                 =       0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   1500.00   INCHES
POROSITY                      =       0.6174 VOL/VOL
FIELD CAPACITY                =       0.5174 VOL/VOL
WILTING POINT                 =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                     =   2460.00   INCHES
POROSITY                      =       0.4811 VOL/VOL
FIELD CAPACITY                =       0.4739 VOL/VOL
WILTING POINT                 =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                        LAYER  7
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                     =     24.00   INCHES
POROSITY                      =       0.3980 VOL/VOL
FIELD CAPACITY                =       0.2440 VOL/VOL
WILTING POINT                 =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
```

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.14	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.	=	2.32999992000	CM/SEC
SLOPE	=	2.05	PERCENT
DRAINAGE LENGTH	=	305.0	FEET

LAYER 9

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	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	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 6.% AND A SLOPE LENGTH OF 530. FEET.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1553.173	INCHES
TOTAL INITIAL WATER	=	1553.173	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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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	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.570	0.378	0.738	0.252	0.272	0.196
	0.426	0.024	0.223	1.797	0.943	1.383

STD. DEVIATIONS	0.824	0.639	1.325	0.606	0.657	0.399
	0.931	0.058	0.325	2.677	1.581	1.830

EVAPOTRANSPIRATION

TOTALS	1.761	1.865	2.884	3.884	3.833	3.305
	3.179	2.078	3.056	2.034	1.156	1.523
STD. DEVIATIONS	0.367	0.554	0.981	1.130	1.495	1.862
	2.003	1.596	1.553	0.887	0.397	0.408

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0140	0.0125	0.0126	0.0068	0.0021	0.0021
	0.0016	0.0006	0.0022	0.0091	0.0120	0.0151
STD. DEVIATIONS	0.0059	0.0047	0.0045	0.0037	0.0029	0.0024
	0.0025	0.0012	0.0030	0.0077	0.0088	0.0072

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.6060	0.5590	0.6131	0.6019	0.6112	0.5891
	0.6042	0.6022	0.5849	0.5968	0.5731	0.5917
STD. DEVIATIONS	0.2542	0.2467	0.2714	0.2761	0.2737	0.2597
	0.2656	0.2730	0.2501	0.2613	0.2454	0.2526

PERCOLATION/LEAKAGE THROUGH LAYER 10

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 2

AVERAGES	6.8387	6.6644	6.0910	3.2807	0.9775	1.0353
	0.7778	0.2746	1.0604	4.4521	6.1462	7.4608
STD. DEVIATIONS	3.0233	2.6118	2.2803	1.9134	1.3989	1.1766
	1.2326	0.5833	1.4902	3.8471	4.5418	3.6365

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0220	0.0223	0.0223	0.0226	0.0222	0.0221
	0.0220	0.0219	0.0220	0.0217	0.0215	0.0215
STD. DEVIATIONS	0.0092	0.0099	0.0099	0.0104	0.0099	0.0098
	0.0097	0.0099	0.0094	0.0095	0.0092	0.0092

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85 (7.081)	137390.7	100.00
RUNOFF	7.203 (4.1917)	26147.03	19.031
EVAPOTRANSPIRATION	30.557 (4.2180)	110923.15	80.736
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.09071 (0.02698)	329.271	0.23966
AVERAGE HEAD ON TOP OF LAYER 2	3.755 (1.142)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	7.13340 (3.10096)	25894.252	18.84717
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.022 (0.010)		
CHANGE IN WATER STORAGE	-7.045 (3.2671)	-25573.79	-18.614

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

	----------	-------------
PRECIPITATION	5.70	20691.000
RUNOFF	4.030	14628.1094
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000767	2.78354
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.06015	218.35597
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 9	0.068	
MAXIMUM HEAD ON TOP OF LAYER 9	0.134	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	3.2 FEET	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8554	0.2379

2	0.0000	0.0000
3	20.4960	0.4270
4	3.7200	0.3100
5	558.2405	0.3722
6	734.8159	0.2987
7	6.3073	0.2628
8	0.0128	0.0935
9	0.0000	0.0000
10	15.3720	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:     C:\TC\C\CS1UNDEV\AC\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\AC\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1UNDEV\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1UNDEV\AC\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\AC\OUTPUT1.OUT


TIME:  14:53     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - ACTIVE 10 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
          THICKNESS                   =    120.00   INCHES
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```
POROSITY                    =      0.6649 VOL/VOL
FIELD CAPACITY              =      0.5262 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3980 VOL/VOL
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.22   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.   =   20.0200005000     CM/SEC
SLOPE                       =      2.05   PERCENT
DRAINAGE LENGTH             =    355.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
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INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     36.00   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 #11 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
         A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     94.60
FRACTION OF AREA ALLOWING RUNOFF     =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      2.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      6.649  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      0.770  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =     51.230  INCHES
TOTAL INITIAL WATER                  =     51.230  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	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.73	3.33	4.41	4.44	6.41	2.61
	6.99	0.00	5.71	2.68	8.44	3.81
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
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	2.723	2.940	4.018	2.157	4.628	3.727
	2.825	0.000	3.631	2.348	3.055	2.076
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
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0492	0.1387	0.0849	0.1270	0.1565	0.2714
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 5						
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	0.0000	0.0000
	0.0002	0.0007	0.0004	0.0006	0.0008	0.0013
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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.56 (0.000)	183532.8	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.127 (0.0000)	123882.05	67.499
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.82765 (0.00000)	3004.356	1.63696
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.009	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)		
CHANGE IN WATER STORAGE	15.605 (0.0000)	56646.41	30.864

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PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.26	11833.800

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01038	37.68653
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.002	
MAXIMUM HEAD ON TOP OF LAYER 4	0.007	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.35	4901.6436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4211
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0770

*** 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 9

LAYER	(INCHES)	(VOL/VOL)
1	45.2079	0.3767
2	6.2507	0.2604
3	0.0046	0.0211
4	0.0000	0.0000

5	15.3720	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:     C:\TC\C\CS1UNDEV\I50\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\I50\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1UNDEV\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1UNDEV\I50\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\I50\OUTPUT1.OUT


TIME:  15: 0     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - INTERIM 50 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
           THICKNESS                      =      12.00    INCHES
```

```
  POROSITY                       =      0.4640 VOL/VOL
  FIELD CAPACITY                 =      0.3100 VOL/VOL
  WILTING POINT                  =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT     =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.      =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                      =    600.00   INCHES
  POROSITY                       =      0.6483 VOL/VOL
  FIELD CAPACITY                 =      0.5215 VOL/VOL
  WILTING POINT                  =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT     =      0.2500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
        IS RECIRCULATED INTO THIS LAYER.


                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                      =     24.00   INCHES
  POROSITY                       =      0.3980 VOL/VOL
  FIELD CAPACITY                 =      0.2440 VOL/VOL
  WILTING POINT                  =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT     =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.      =  0.119999997000E-03 CM/SEC


                          LAYER  4
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                      =      0.21   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                       =     2.05   PERCENT
  DRAINAGE LENGTH             =   355.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.


                         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         =     0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =     0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                         LAYER  6
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =    36.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	174.950	INCHES
TOTAL INITIAL WATER	=	174.950	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.178	0.331
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.378
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.898	1.877	2.455	2.985	2.987	2.459
	3.334	1.820	3.046	2.252	1.314	1.799
STD. DEVIATIONS	0.280	0.710	0.634	1.201	1.085	1.608

	1.477	1.229	1.205	1.315	0.687	0.560

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0161	0.0156	0.0154	0.0151	0.0190	0.0178
	0.0187	0.0170	0.0169	0.0173	0.0183	0.0180
STD. DEVIATIONS	0.0194	0.0188	0.0185	0.0169	0.0201	0.0182
	0.0197	0.0169	0.0170	0.0177	0.0188	0.0172

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1449	0.1407	0.1382	0.1363	0.1712	0.1601
	0.1683	0.1532	0.1522	0.1558	0.1648	0.1623
STD. DEVIATIONS	0.1748	0.1694	0.1669	0.1519	0.1805	0.1636
	0.1775	0.1523	0.1533	0.1592	0.1693	0.1551

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0161	0.0156	0.0154	0.0151	0.0190	0.0178
	0.0187	0.0170	0.0169	0.0173	0.0183	0.0180
STD. DEVIATIONS	0.0194	0.0188	0.0185	0.0169	0.0201	0.0182
	0.0197	0.0169	0.0170	0.0177	0.0188	0.0172

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 5

AVERAGES	0.0016	0.0017	0.0015	0.0015	0.0019	0.0018
	0.0018	0.0017	0.0017	0.0017	0.0019	0.0018
STD. DEVIATIONS	0.0019	0.0020	0.0018	0.0017	0.0020	0.0019
	0.0019	0.0017	0.0017	0.0017	0.0019	0.0017

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.064	(1.2957)	11122.62	7.432
EVAPOTRANSPIRATION	28.227	(2.9143)	102462.45	68.461
DRAINAGE RECIRCULATED INTO LAYER 2	0.20532	(0.21638)	745.304	0.49798
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.84786	(1.94745)	6707.738	4.48184
DRAINAGE RECIRCULATED FROM LAYER 4	0.20532	(0.21638)	745.304	0.49798
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.005	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.002	(0.002)		
CHANGE IN WATER STORAGE	8.091	(3.6463)	29371.53	19.625

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8379.5771
DRAINAGE RECIRCULATED INTO LAYER 2	0.00293	10.64985
DRAINAGE COLLECTED FROM LAYER 4	0.02640	95.84867

DRAINAGE RECIRCULATED FROM LAYER 4	0.00293	10.64985
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.009	
MAXIMUM HEAD ON TOP OF LAYER 5	0.018	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5985	0.2165
2	231.4427	0.3857
3	6.4437	0.2685
4	0.0064	0.0309
5	0.0000	0.0000
6	15.3720	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:     C:\TC\C\CS1UNDEV\I100\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\I100\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1UNDEV\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1UNDEV\I100\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\I100\OUTPUT1.OUT


TIME:  15:13     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - INTERIM 100 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  11
          THICKNESS                   =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                          LAYER  2
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =    1200.00   INCHES
  POROSITY                        =      0.6277 VOL/VOL
  FIELD CAPACITY                  =      0.5156 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 4
        IS RECIRCULATED INTO THIS LAYER.



                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =      24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
  FIELD CAPACITY                  =      0.2440 VOL/VOL
  WILTING POINT                   =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC



                          LAYER  4
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  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.   =   5.46000004000     CM/SEC
  SLOPE                       =      2.05   PERCENT
  DRAINAGE LENGTH             =    355.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.



                         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         =      0.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD



                         LAYER  6
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
  THICKNESS                   =     36.00   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 #11 WITH A
FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	480.950	INCHES
TOTAL INITIAL WATER	=	480.950	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312
EVAPOTRANSPIRATION						
TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614

	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0607	0.0598	0.0669	0.0673	0.0643	0.0636
	0.0717	0.0685	0.0619	0.0672	0.0636	0.0697
STD. DEVIATIONS	0.0145	0.0111	0.0155	0.0125	0.0078	0.0096
	0.0143	0.0114	0.0122	0.0088	0.0092	0.0109

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5462	0.5384	0.6022	0.6059	0.5784	0.5728
	0.6457	0.6163	0.5569	0.6052	0.5724	0.6275
STD. DEVIATIONS	0.1307	0.0996	0.1397	0.1128	0.0700	0.0863
	0.1287	0.1023	0.1098	0.0796	0.0831	0.0980

LATERAL DRAINAGE RECIRCULATED FROM LAYER 4

TOTALS	0.0607	0.0598	0.0669	0.0673	0.0643	0.0636
	0.0717	0.0685	0.0619	0.0672	0.0636	0.0697
STD. DEVIATIONS	0.0145	0.0111	0.0155	0.0125	0.0078	0.0096
	0.0143	0.0114	0.0122	0.0088	0.0092	0.0109

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 5

AVERAGES	0.0110	0.0119	0.0121	0.0126	0.0116	0.0119
	0.0130	0.0124	0.0115	0.0121	0.0119	0.0126
STD. DEVIATIONS	0.0026	0.0022	0.0028	0.0023	0.0014	0.0018
	0.0026	0.0021	0.0023	0.0016	0.0017	0.0020

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.78534	(0.11004)	2850.799	1.90479
LATERAL DRAINAGE COLLECTED FROM LAYER 4	7.06810	(0.99038)	25657.193	17.14309
DRAINAGE RECIRCULATED FROM LAYER 4	0.78534	(0.11004)	2850.799	1.90479
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.012	(0.002)		
CHANGE IN WATER STORAGE	2.877	(3.1828)	10444.67	6.979

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00559	20.29061
DRAINAGE COLLECTED FROM LAYER 4	0.05031	182.61545

DRAINAGE RECIRCULATED FROM LAYER 4	0.00559	20.29061
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.031	
MAXIMUM HEAD ON TOP OF LAYER 5	0.062	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	1.0 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	485.2302	0.4044
3	6.5109	0.2713
4	0.0119	0.0610
5	0.0000	0.0000
6	15.3720	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:     C:\TC\C\CS1UNDEV\I200\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\I200\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\CS1UNDEV\I200\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\I200\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\CS1UNDEV\I200\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\I200\OUTPUT1.OUT


TIME:  15:17     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - INTERIM 200 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  11
          THICKNESS                      =     12.00   INCHES
```

```
  POROSITY                         =      0.4640 VOL/VOL
  FIELD CAPACITY                   =      0.3100 VOL/VOL
  WILTING POINT                    =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                              LAYER  2
                              --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =   1500.00   INCHES
  POROSITY                         =      0.6174 VOL/VOL
  FIELD CAPACITY                   =      0.5174 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                              LAYER  3
                              --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                        =    900.00   INCHES
  POROSITY                         =      0.5348 VOL/VOL
  FIELD CAPACITY                   =      0.4892 VOL/VOL
  WILTING POINT                    =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT       =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.        =  0.999999975000E-04 CM/SEC


                              LAYER  4
                              --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
  THICKNESS                        =     24.00   INCHES
  POROSITY                         =      0.3980 VOL/VOL
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FIELD CAPACITY              =     0.2440 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  5
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.17   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.   =   3.38000011000     CM/SEC
SLOPE                       =     2.05   PERCENT
DRAINAGE LENGTH             =   355.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
        LAYER IS RECIRCULATED INTO LAYER #  2.


                        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         =     0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  7
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
```

```
THICKNESS                    =     36.00   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 #11 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER              =     87.10
FRACTION OF AREA ALLOWING RUNOFF     =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE   =      1.000  ACRES
EVAPORATIVE ZONE DEPTH               =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE    =      3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE   =      4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE   =      1.870  INCHES
INITIAL SNOW WATER                   =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS     =    936.950  INCHES
TOTAL INITIAL WATER                  =    936.950  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                   =   2.00
     START OF GROWING SEASON (JULIAN DATE)     =     63
     END OF GROWING SEASON (JULIAN DATE)       =    329
     EVAPORATIVE ZONE DEPTH                    =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

RUNOFF

TOTALS	0.098	0.117	0.104	0.091	0.177	0.332
	0.637	0.124	0.429	0.623	0.086	0.248
STD. DEVIATIONS	0.100	0.218	0.125	0.113	0.186	0.379
	0.881	0.189	0.369	1.286	0.146	0.312

EVAPOTRANSPIRATION

TOTALS	1.899	1.877	2.445	2.983	2.984	2.462
	3.333	1.827	3.048	2.255	1.305	1.801
STD. DEVIATIONS	0.278	0.703	0.634	1.203	1.092	1.614
	1.476	1.228	1.207	1.319	0.687	0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER 2

TOTALS	0.0536	0.0527	0.0582	0.0560	0.0563	0.0550
	0.0575	0.0569	0.0546	0.0572	0.0547	0.0561
STD. DEVIATIONS	0.0096	0.0061	0.0076	0.0061	0.0075	0.0049
	0.0055	0.0051	0.0055	0.0053	0.0051	0.0050

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.4826	0.4746	0.5241	0.5042	0.5070	0.4948
	0.5177	0.5124	0.4910	0.5146	0.4925	0.5045
STD. DEVIATIONS	0.0862	0.0547	0.0680	0.0547	0.0677	0.0443
	0.0499	0.0455	0.0496	0.0475	0.0455	0.0453

LATERAL DRAINAGE RECIRCULATED FROM LAYER 5

TOTALS	0.0536	0.0527	0.0582	0.0560	0.0563	0.0550
	0.0575	0.0569	0.0546	0.0572	0.0547	0.0561
STD. DEVIATIONS	0.0096	0.0061	0.0076	0.0061	0.0075	0.0049
	0.0055	0.0051	0.0055	0.0053	0.0051	0.0050

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 6

AVERAGES	0.0156	0.0169	0.0170	0.0169	0.0164	0.0166
	0.0168	0.0166	0.0164	0.0167	0.0165	0.0163
STD. DEVIATIONS	0.0028	0.0020	0.0022	0.0018	0.0022	0.0015
	0.0016	0.0015	0.0017	0.0015	0.0015	0.0015

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.066 (1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219 (2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.66889 (0.05693)	2428.071	1.62234
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.02001 (0.51239)	21852.641	14.60105
DRAINAGE RECIRCULATED FROM LAYER 5	0.66889 (0.05693)	2428.071	1.62234
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.017 (0.001)		
CHANGE IN WATER STORAGE	3.925 (3.0642)	14249.30	9.521

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00308	11.16770
DRAINAGE COLLECTED FROM LAYER 5	0.02769	100.50928
DRAINAGE RECIRCULATED FROM LAYER 5	0.00308	11.16770
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.028	
MAXIMUM HEAD ON TOP OF LAYER 6	0.056	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	0.4 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1870

*** 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	2.5981	0.2165
2	623.1599	0.4154
3	328.5321	0.3650
4	6.5276	0.2720
5	0.0142	0.0833
6	0.0000	0.0000
7	15.3720	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:     C:\TC\C\CS1UNDEV\I270\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\I270\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1UNDEV\I270\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\I270\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1UNDEV\I270\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\I270\OUTPUT1.OUT


TIME:  31:39     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - INTERIM 270 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  11
          THICKNESS                     =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                         LAYER  2
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1500.00   INCHES
  POROSITY                        =      0.6174 VOL/VOL
  FIELD CAPACITY                  =      0.5174 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
        IS RECIRCULATED INTO THIS LAYER.


                         LAYER  3
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1740.00   INCHES
  POROSITY                        =      0.5059 VOL/VOL
  FIELD CAPACITY                  =      0.4810 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC


                         LAYER  4
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
```

```
FIELD CAPACITY              =      0.2440 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                        LAYER  5
                        --------

          TYPE 2 - LATERAL DRAINAGE LAYER
            MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.15   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   2.74000001000     CM/SEC
SLOPE                       =      2.05   PERCENT
DRAINAGE LENGTH             =    355.0    FEET
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
         LAYER IS RECIRCULATED INTO LAYER #  2.


                        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         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  7
                        --------

            TYPE 3 - BARRIER SOIL LINER
            MATERIAL TEXTURE NUMBER  16
```

THICKNESS	=	36.00 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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1256.149	INCHES
TOTAL INITIAL WATER	=	1256.149	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05

```
RUNOFF
------
  TOTALS                 0.098    0.117    0.104    0.091    0.177    0.332
                         0.637    0.124    0.429    0.623    0.086    0.248

  STD. DEVIATIONS        0.100    0.218    0.125    0.113    0.186    0.379
                         0.881    0.189    0.369    1.286    0.146    0.312

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.899    1.877    2.445    2.983    2.984    2.462
                         3.333    1.827    3.048    2.255    1.305    1.801

  STD. DEVIATIONS        0.278    0.703    0.634    1.203    1.092    1.614
                         1.476    1.228    1.207    1.319    0.687    0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0700   0.0680   0.0743   0.0712   0.0741   0.0704
                         0.0733   0.0736   0.0686   0.0722   0.0699   0.0711

  STD. DEVIATIONS        0.0123   0.0124   0.0130   0.0113   0.0129   0.0111
                         0.0139   0.0116   0.0103   0.0108   0.0111   0.0097

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.6298   0.6121   0.6683   0.6409   0.6673   0.6336
                         0.6598   0.6628   0.6178   0.6495   0.6292   0.6398

  STD. DEVIATIONS        0.1111   0.1117   0.1170   0.1015   0.1161   0.1003
                         0.1250   0.1045   0.0926   0.0976   0.0999   0.0875

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0700   0.0680   0.0743   0.0712   0.0741   0.0704
                         0.0733   0.0736   0.0686   0.0722   0.0699   0.0711

  STD. DEVIATIONS        0.0123   0.0124   0.0130   0.0113   0.0129   0.0111
                         0.0139   0.0116   0.0103   0.0108   0.0111   0.0097

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 6

AVERAGES	0.0252	0.0269	0.0267	0.0265	0.0267	0.0262
	0.0264	0.0265	0.0255	0.0260	0.0260	0.0256
STD. DEVIATIONS	0.0044	0.0050	0.0047	0.0042	0.0046	0.0041
	0.0050	0.0042	0.0038	0.0039	0.0041	0.0035

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.066 (1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219 (2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	0.85674 (0.12853)	3109.975	2.07796
LATERAL DRAINAGE COLLECTED FROM LAYER 5	7.71068 (1.15678)	27989.775	18.70163
DRAINAGE RECIRCULATED FROM LAYER 5	0.85674 (0.12853)	3109.975	2.07796
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.026 (0.004)		
CHANGE IN WATER STORAGE	2.235 (3.2684)	8112.02	5.420

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE RECIRCULATED INTO LAYER 2	0.00444	16.12357
DRAINAGE COLLECTED FROM LAYER 5	0.03998	145.11211
DRAINAGE RECIRCULATED FROM LAYER 5	0.00444	16.12357
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.050	
MAXIMUM HEAD ON TOP OF LAYER 6	0.099	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.7 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4640
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1870

*** 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	2.5981	0.2165
2	637.2814	0.4249
3	616.6342	0.3544
4	6.5919	0.2747
5	0.0190	0.1261
6	0.0000	0.0000
7	15.3720	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:     C:\TC\C\CS1UNDEV\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\CS1UNDEV\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\CS1UNDEV\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\CS1UNDEV\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\CS1UNDEV\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\CS1UNDEV\CL\OUTPUT1.OUT


TIME:  10: 9     DATE:  10/ 5/2021


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

     TITLE:  TURKEY CREEK - CLASS 1 UNDEVELOPED AREA - CLOSED 270 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     12.00   INCHES
```

```
     POROSITY                        =      0.3980 VOL/VOL
     FIELD CAPACITY                  =      0.2440 VOL/VOL
     WILTING POINT                   =      0.1360 VOL/VOL
     INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
     EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC
   NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
          FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                            LAYER  2
                            --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  36
     THICKNESS                       =      0.04   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.       =  0.399999993000E-12 CM/SEC
     FML PINHOLE DENSITY             =      1.00   HOLES/ACRE
     FML INSTALLATION DEFECTS        =      4.00   HOLES/ACRE
     FML PLACEMENT QUALITY           =  3 - GOOD


                            LAYER  3
                            --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
     THICKNESS                       =     48.00   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.       =  0.999999975000E-05 CM/SEC


                            LAYER  4
                            --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  11
     THICKNESS                       =     12.00   INCHES
```

```
POROSITY                     =      0.4640 VOL/VOL
FIELD CAPACITY               =      0.3100 VOL/VOL
WILTING POINT                =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC


                          LAYER  5
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    1500.00   INCHES
POROSITY                     =      0.6174 VOL/VOL
FIELD CAPACITY               =      0.5127 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                          LAYER  6
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    1740.00   INCHES
POROSITY                     =      0.5059 VOL/VOL
FIELD CAPACITY               =      0.4810 VOL/VOL
WILTING POINT                =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                          LAYER  7
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
THICKNESS                    =      24.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
```

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.15	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.	=	2.50000000000	CM/SEC
SLOPE	=	2.05	PERCENT
DRAINAGE LENGTH	=	355.0	FEET

LAYER 9

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	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	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 6.% AND A SLOPE LENGTH OF 530. FEET.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1279.573	INCHES
TOTAL INITIAL WATER	=	1279.573	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.570	0.378	0.738	0.252	0.272	0.196
	0.426	0.024	0.223	1.797	0.943	1.383

STD. DEVIATIONS	0.824	0.639	1.325	0.606	0.657	0.399
	0.931	0.058	0.325	2.677	1.581	1.830

EVAPOTRANSPIRATION

TOTALS	1.761	1.865	2.884	3.884	3.833	3.305
	3.179	2.078	3.056	2.034	1.156	1.523
STD. DEVIATIONS	0.367	0.554	0.981	1.130	1.495	1.862
	2.003	1.596	1.553	0.887	0.397	0.408

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0140	0.0125	0.0126	0.0068	0.0021	0.0021
	0.0016	0.0006	0.0022	0.0091	0.0120	0.0151
STD. DEVIATIONS	0.0059	0.0047	0.0045	0.0037	0.0029	0.0024
	0.0025	0.0012	0.0030	0.0077	0.0088	0.0072

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.4595	0.4365	0.4736	0.4554	0.4698	0.4466
	0.4652	0.4651	0.4462	0.4569	0.4451	0.4543
STD. DEVIATIONS	0.1763	0.1806	0.1929	0.1815	0.1928	0.1762
	0.1942	0.1864	0.1698	0.1758	0.1750	0.1741

PERCOLATION/LEAKAGE THROUGH LAYER 10

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 2

AVERAGES	6.8387	6.6644	6.0910	3.2807	0.9775	1.0353
	0.7778	0.2746	1.0604	4.4521	6.1462	7.4608
STD. DEVIATIONS	3.0233	2.6118	2.2803	1.9134	1.3989	1.1766
	1.2326	0.5833	1.4902	3.8471	4.5418	3.6365

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0181	0.0189	0.0187	0.0186	0.0185	0.0182
	0.0183	0.0183	0.0182	0.0180	0.0181	0.0179
STD. DEVIATIONS	0.0070	0.0079	0.0076	0.0074	0.0076	0.0072
	0.0077	0.0073	0.0069	0.0069	0.0071	0.0069

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85 (7.081)	137390.7	100.00
RUNOFF	7.203 (4.1917)	26147.03	19.031
EVAPOTRANSPIRATION	30.557 (4.2180)	110923.15	80.736
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.09071 (0.02698)	329.271	0.23966
AVERAGE HEAD ON TOP OF LAYER 2	3.755 (1.142)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	5.47410 (2.14989)	19870.977	14.46312
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.009	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.018 (0.007)		
CHANGE IN WATER STORAGE	-5.386 (2.4177)	-19550.48	-14.230

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

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PRECIPITATION	5.70	20691.000
RUNOFF	4.030	14628.1094
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000767	2.78354
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.04396	159.58435
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.054	
MAXIMUM HEAD ON TOP OF LAYER 9	0.107	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	1.4 FEET	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8554	0.2379

2	0.0000	0.0000
3	20.4960	0.4270
4	3.7200	0.3100
5	541.9096	0.3613
6	527.4008	0.3031
7	6.2352	0.2598
8	0.0101	0.0681
9	0.0000	0.0000
10	15.3720	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:      C:\TC\C\OL\AC\DATA4.D4
TEMPERATURE DATA FILE:        C:\TC\C\OL\AC\DATA7.D7
SOLAR RADIATION DATA FILE:    C:\TC\C\OL\AC\DATA13.D13
EVAPOTRANSPIRATION DATA:      C:\TC\C\OL\AC\DATA11.D11
SOIL AND DESIGN DATA FILE:    C:\TC\C\OL\AC\DATA10.D10
OUTPUT DATA FILE:             C:\TC\C\OL\AC\OUTPUT1.OUT


TIME:  31:51     DATE:  10/ 4/2021


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    TITLE:  TURKEY CREEK - OVERLINER AREA - ACTIVE 10 FT

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
             WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
         THICKNESS                      =     120.00   INCHES
```

```
POROSITY                      =      0.6649 VOL/VOL
FIELD CAPACITY                =      0.5262 VOL/VOL
WILTING POINT                 =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2500 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                        LAYER  2
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
THICKNESS                     =     24.00   INCHES
POROSITY                      =      0.3980 VOL/VOL
FIELD CAPACITY                =      0.2440 VOL/VOL
WILTING POINT                 =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC


                        LAYER  3
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.30   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.     =   40.6300011000     CM/SEC
SLOPE                         =      1.00   PERCENT
DRAINAGE LENGTH               =    300.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  36
THICKNESS                     =      0.04   INCHES
POROSITY                      =      0.0000 VOL/VOL
FIELD CAPACITY                =      0.0000 VOL/VOL
WILTING POINT                 =      0.0000 VOL/VOL
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INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                       LAYER  5
                       --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #11 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF  2.% AND
         A SLOPE LENGTH OF  200. FEET.

SCS RUNOFF CURVE NUMBER            =     94.60
FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
EVAPORATIVE ZONE DEPTH             =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      6.649  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.770  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     36.046  INCHES
TOTAL INITIAL WATER                =     36.046  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	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 9 THROUGH 9

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.73	3.33	4.41	4.44	6.41	2.61
	6.99	0.00	5.71	2.68	8.44	3.81
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
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	2.696	2.931	4.002	2.162	4.531	3.568
	2.825	0.289	3.624	2.272	3.045	2.080
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
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0522	0.1326	0.0949	0.1317	0.1486	0.2800
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 5						
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	0.0000	0.0000
	0.0002	0.0006	0.0004	0.0006	0.0006	0.0012
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

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 9 THROUGH 9

	INCHES		CU. FEET	PERCENT
PRECIPITATION	50.56	(0.000)	183532.8	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	34.024	(0.0000)	123507.03	67.294
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.84008	(0.00000)	3049.482	1.66155
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.009	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	(0.000)		
CHANGE IN WATER STORAGE	15.696	(0.0000)	56976.24	31.044

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PEAK DAILY VALUES FOR YEARS 9 THROUGH 9

	(INCHES)	(CU. FT.)
PRECIPITATION	3.26	11833.800

RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.01095	39.76265
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.003	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.35	4901.6436

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4259
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0770

*** 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 9

LAYER	(INCHES)	(VOL/VOL)
1	45.2901	0.3774
2	6.2612	0.2609
3	0.0037	0.0122
4	0.0000	0.0000

5	0.1875	0.7500

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:    C:\TC\C\OL\I50\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\OL\I50\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\OL\I50\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\OL\I50\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\OL\I50\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\OL\I50\OUTPUT1.OUT


TIME:  31:53     DATE:  10/ 4/2021


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     TITLE:  TURKEY CREEK - OVERLINER AREA - INTERIM 50 FT

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                        =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                         LAYER  2
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =    600.00   INCHES
  POROSITY                        =      0.6483 VOL/VOL
  FIELD CAPACITY                  =      0.5215 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.2500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC


                         LAYER  3
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00   INCHES
  POROSITY                        =      0.3980 VOL/VOL
  FIELD CAPACITY                  =      0.2440 VOL/VOL
  WILTING POINT                   =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC


                         LAYER  4
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =      0.29   INCHES
  POROSITY                        =      0.8500 VOL/VOL
  FIELD CAPACITY                  =      0.0100 VOL/VOL
  WILTING POINT                   =      0.0050 VOL/VOL
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INITIAL SOIL WATER CONTENT    =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   27.8299999000     CM/SEC
SLOPE                         =      1.00   PERCENT
DRAINAGE LENGTH               =    300.0    FEET


                        LAYER  5
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
THICKNESS                     =      0.04   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.     = 0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY           =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS      =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY         = 3 - GOOD


                        LAYER  6
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  17
THICKNESS                     =      0.25   INCHES
POROSITY                      =      0.7500 VOL/VOL
FIELD CAPACITY                =      0.7470 VOL/VOL
WILTING POINT                 =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.     = 0.300000003000E-08 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.
```

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	159.766	INCHES
TOTAL INITIAL WATER	=	159.766	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	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.109	0.121	0.107	0.093	0.176	0.343
	0.627	0.124	0.448	0.603	0.099	0.289
STD. DEVIATIONS	0.106	0.224	0.124	0.117	0.178	0.390
	0.857	0.189	0.380	1.255	0.177	0.327
EVAPOTRANSPIRATION						
TOTALS	1.894	1.908	2.513	3.029	2.971	2.522
	3.418	1.877	3.096	2.315	1.359	1.780
STD. DEVIATIONS	0.278	0.689	0.658	1.222	1.104	1.616
	1.581	1.269	1.224	1.333	0.663	0.558

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.1254	0.1208	0.1371	0.1202	0.1283	0.1222
	0.1279	0.1315	0.1250	0.1509	0.1558	0.1563
STD. DEVIATIONS	0.1412	0.1415	0.1583	0.1369	0.1475	0.1398
	0.1470	0.1544	0.1327	0.1527	0.1543	0.1518

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 5

AVERAGES	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
	0.0008	0.0008	0.0008	0.0009	0.0010	0.0010
STD. DEVIATIONS	0.0009	0.0010	0.0010	0.0009	0.0009	0.0009
	0.0009	0.0009	0.0008	0.0009	0.0010	0.0009

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.139 (1.2444)	11395.24	7.614
EVAPOTRANSPIRATION	28.682 (3.0048)	104114.29	69.565
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.60144 (1.73850)	5813.231	3.88416
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.010	0.00001

AVERAGE HEAD ON TOP OF LAYER 5	0.001 (	0.001)		
CHANGE IN WATER STORAGE	7.808 (	3.4323)	28342.13	18.937

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PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.110	7660.6748
DRAINAGE COLLECTED FROM LAYER 4	0.01871	67.91264
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 5	0.004	
MAXIMUM HEAD ON TOP OF LAYER 5	0.006	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	52.0 FEET	
SNOW WATER	1.31	4756.4434
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4510
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1870

*** 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	2.6325	0.2194
2	228.7240	0.3812
3	6.2954	0.2623
4	0.0044	0.0152
5	0.0000	0.0000
6	0.1875	0.7500
SNOW WATER	0.000	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    C:\TC\C\OL\I100\DATA4.D4
TEMPERATURE DATA FILE:      C:\TC\C\OL\I100\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\C\OL\I100\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\TC\C\OL\I100\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\C\OL\I100\DATA10.D10
OUTPUT DATA FILE:           C:\TC\C\OL\I100\OUTPUT1.OUT


TIME:   8:48     DATE:  10/29/2021


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

     TITLE:  TURKEY CREEK - OVERLINER AREA - INTERIM 100 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  11
           THICKNESS                      =     12.00   INCHES
```

```
  POROSITY                        =      0.4640 VOL/VOL
  FIELD CAPACITY                  =      0.3100 VOL/VOL
  WILTING POINT                   =      0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =   1200.00    INCHES
  POROSITY                        =      0.6277 VOL/VOL
  FIELD CAPACITY                  =      0.5156 VOL/VOL
  WILTING POINT                   =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC


                          LAYER  3
                          --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  10
  THICKNESS                       =     24.00    INCHES
  POROSITY                        =      0.3980 VOL/VOL
  FIELD CAPACITY                  =      0.2440 VOL/VOL
  WILTING POINT                   =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT      =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC


                          LAYER  4
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER   0
  THICKNESS                       =      0.28    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.   =   18.6900005000     CM/SEC
SLOPE                       =      1.00   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                        LAYER  5
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  6
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC


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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #11 WITH A
         FAIR STAND OF GRASS, A SURFACE SLOPE OF  2.%
         AND A SLOPE LENGTH OF  200. FEET.
```

```
SCS RUNOFF CURVE NUMBER                =     87.10
FRACTION OF AREA ALLOWING RUNOFF       =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE     =      1.000  ACRES
EVAPORATIVE ZONE DEPTH                 =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE      =      3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE     =      4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE     =      1.870  INCHES
INITIAL SNOW WATER                     =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS       =    465.766  INCHES
TOTAL INITIAL WATER                    =    465.766  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                   =   2.00
START OF GROWING SEASON (JULIAN DATE)     =     63
END OF GROWING SEASON (JULIAN DATE)       =    329
EVAPORATIVE ZONE DEPTH                    =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.104	0.121	0.100	0.092	0.171	0.341
	0.629	0.123	0.438	0.611	0.090	0.279
STD. DEVIATIONS	0.099	0.225	0.115	0.117	0.172	0.386
	0.861	0.188	0.361	1.253	0.148	0.325
EVAPOTRANSPIRATION						
TOTALS	1.914	1.896	2.493	3.021	2.952	2.474
	3.402	1.870	3.098	2.298	1.334	1.780
STD. DEVIATIONS	0.270	0.688	0.644	1.220	1.056	1.603
	1.566	1.277	1.240	1.324	0.668	0.545

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.5477	0.5100	0.5937	0.5549	0.5883	0.5459
	0.5773	0.5856	0.5562	0.5929	0.5654	0.5855
STD. DEVIATIONS	0.1424	0.0847	0.0986	0.0843	0.0819	0.0917
	0.0824	0.0867	0.0519	0.0843	0.0615	0.0841

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 5

AVERAGES	0.0050	0.0051	0.0054	0.0052	0.0054	0.0052
	0.0053	0.0053	0.0053	0.0054	0.0053	0.0053
STD. DEVIATIONS	0.0013	0.0009	0.0009	0.0008	0.0007	0.0009
	0.0008	0.0008	0.0005	0.0008	0.0006	0.0008

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.102 (1.2583)	11259.38	7.523
EVAPOTRANSPIRATION	28.531 (3.0024)	103566.91	69.199
LATERAL DRAINAGE COLLECTED FROM LAYER 4	6.80340 (0.91799)	24696.352	16.50110
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.018	0.00001

```
 AVERAGE HEAD ON TOP              0.005 (    0.001)
   OF LAYER  5

 CHANGE IN WATER STORAGE          2.794   (  3.0129)      10142.23      6.777

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


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

              PEAK DAILY VALUES FOR YEARS    21 THROUGH   30
   ------------------------------------------------------------------------
                                                   (INCHES)      (CU. FT.)
                                                  ----------    -------------
      PRECIPITATION                                 5.13          18621.900

      RUNOFF                                        2.167          7865.0342

      DRAINAGE COLLECTED FROM LAYER  4              0.04145         150.44844

      PERCOLATION/LEAKAGE THROUGH LAYER  6          0.000000          0.00005

      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)                   6.5 FEET

      SNOW WATER                                    1.31           4756.4434


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4513

      MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.1870

       ***  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	2.6433	0.2203
2	484.3618	0.4036
3	6.5071	0.2711
4	0.0066	0.0237
5	0.0000	0.0000
6	0.1875	0.7500
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:     C:\TC\C\OL\I170\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\OL\I170\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\OL\I170\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\OL\I170\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\OL\I170\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\OL\I170\OUTPUT1.OUT
```

TIME: 8:49   DATE: 10/29/2021

```
******************************************************************************

     TITLE:  TURKEY CREEK - OVERLINER AREA - INTERIM 170 FT

******************************************************************************
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE SPECIFIED BY THE USER.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 11

THICKNESS   =   12.00   INCHES

```
  POROSITY                      =       0.4640 VOL/VOL
  FIELD CAPACITY                =       0.3100 VOL/VOL
  WILTING POINT                 =       0.1870 VOL/VOL
  INITIAL SOIL WATER CONTENT    =       0.3100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
       FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
  THICKNESS                     =    1500.00   INCHES
  POROSITY                      =       0.6174 VOL/VOL
  FIELD CAPACITY                =       0.5127 VOL/VOL
  WILTING POINT                 =       0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT    =       0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
  THICKNESS                     =     540.00   INCHES
  POROSITY                      =       0.5472 VOL/VOL
  FIELD CAPACITY                =       0.4927 VOL/VOL
  WILTING POINT                 =       0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT    =       0.3800 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-04 CM/SEC


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  10
  THICKNESS                     =      24.00   INCHES
  POROSITY                      =       0.3980 VOL/VOL
  FIELD CAPACITY                =       0.2440 VOL/VOL
  WILTING POINT                 =       0.1360 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                    LAYER  5
                    --------

          TYPE 2 - LATERAL DRAINAGE LAYER
           MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.25   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.   =   13.0500002000     CM/SEC
SLOPE                       =      1.00   PERCENT
DRAINAGE LENGTH             =    300.0    FEET


                    LAYER  6
                    --------

          TYPE 4 - FLEXIBLE MEMBRANE LINER
           MATERIAL TEXTURE NUMBER  36
THICKNESS                   =      0.04   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.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      0.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                    LAYER  7
                    --------

           TYPE 3 - BARRIER SOIL LINER
           MATERIAL TEXTURE NUMBER  17
THICKNESS                   =      0.25   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
```

```
    INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
    EFFECTIVE SAT. HYD. COND.   =  0.300000003000E-08 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

```
SCS RUNOFF CURVE NUMBER               =     87.10
FRACTION OF AREA ALLOWING RUNOFF      =     80.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE    =      1.000  ACRES
EVAPORATIVE ZONE DEPTH                =     10.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE     =      3.100  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE    =      4.640  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE    =      1.870  INCHES
INITIAL SNOW WATER                    =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS      =    784.966  INCHES
TOTAL INITIAL WATER                   =    784.966  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                  =   2.00
    START OF GROWING SEASON (JULIAN DATE)    =     63
    END OF GROWING SEASON (JULIAN DATE)      =    329
    EVAPORATIVE ZONE DEPTH                   =  10.0  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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38
	3.78	1.50	2.11	3.47	1.89	2.05
RUNOFF						
TOTALS	0.098	0.117	0.104	0.091	0.177	0.332

```
                         0.637    0.124    0.429    0.623    0.086    0.248

  STD. DEVIATIONS        0.100    0.218    0.125    0.113    0.186    0.379
                         0.881    0.189    0.369    1.286    0.146    0.312

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.899    1.877    2.445    2.983    2.984    2.462
                         3.333    1.827    3.048    2.255    1.305    1.801

  STD. DEVIATIONS        0.278    0.703    0.634    1.203    1.092    1.614
                         1.476    1.228    1.207    1.319    0.687    0.561

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.4812   0.4813   0.5148   0.4991   0.5167   0.4934
                         0.5104   0.5105   0.4919   0.5134   0.4922   0.5110

  STD. DEVIATIONS        0.0844   0.0577   0.0521   0.0567   0.0508   0.0490
                         0.0484   0.0431   0.0358   0.0389   0.0382   0.0393

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  6
-------------------------------------
  AVERAGES               0.0063   0.0069   0.0067   0.0067   0.0068   0.0067
                         0.0067   0.0067   0.0066   0.0067   0.0067   0.0067

  STD. DEVIATIONS        0.0011   0.0009   0.0007   0.0008   0.0007   0.0007
                         0.0006   0.0006   0.0005   0.0005   0.0005   0.0005

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   21 THROUGH   30
```

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.23 (5.000)	149664.9	100.00
RUNOFF	3.066 (1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219 (2.9081)	102435.06	68.443
LATERAL DRAINAGE COLLECTED FROM LAYER 5	6.01581 (0.45227)	21837.383	14.59085
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.018	0.00001
AVERAGE HEAD ON TOP OF LAYER 6	0.007 (0.001)		
CHANGE IN WATER STORAGE	3.930 (2.9925)	14264.50	9.531

****

****

PEAK DAILY VALUES FOR YEARS 21 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.13	18621.900
RUNOFF	2.308	8376.4365
DRAINAGE COLLECTED FROM LAYER 5	0.03102	112.59100
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 6	0.013	
MAXIMUM HEAD ON TOP OF LAYER 6	0.025	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	5.6 FEET	
SNOW WATER	1.31	4756.4434

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4640

MINIMUM VEG. SOIL WATER (VOL/VOL)   0.1870

*** 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	2.5981	0.2165
2	616.1878	0.4108
3	198.7843	0.3681
4	6.4968	0.2707
5	0.0075	0.0296
6	0.0000	0.0000
7	0.1875	0.7500
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:     C:\TC\C\OL\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\C\OL\CL\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\C\OL\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\C\OL\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\C\OL\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\C\OL\CL\OUTPUT1.OUT


TIME:   8:50     DATE:  10/29/2021


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

     TITLE:  TURKEY CREEK - OVERLINER POC - CLOSED 170 FT

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                    LAYER  1
                                    --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER  10
          THICKNESS                          =     12.00   INCHES
```

```
  POROSITY                      =      0.3980 VOL/VOL
  FIELD CAPACITY                =      0.2440 VOL/VOL
  WILTING POINT                 =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT    =      0.2440 VOL/VOL
  EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                         LAYER  2
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  36
  THICKNESS                     =      0.04   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.     =  0.399999993000E-12 CM/SEC
  FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS      =      4.00   HOLES/ACRE
  FML PLACEMENT QUALITY         =  3 - GOOD


                         LAYER  3
                         --------

               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  4
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  11
  THICKNESS                     =     12.00   INCHES
```

```
POROSITY                       =       0.4640 VOL/VOL
FIELD CAPACITY                 =       0.3100 VOL/VOL
WILTING POINT                  =       0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.639999998000E-04 CM/SEC


                          LAYER  5
                          --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                      =    1500.00   INCHES
POROSITY                       =       0.6174 VOL/VOL
FIELD CAPACITY                 =       0.5127 VOL/VOL
WILTING POINT                  =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000005000E-02 CM/SEC


                          LAYER  6
                          --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                      =     540.00   INCHES
POROSITY                       =       0.5472 VOL/VOL
FIELD CAPACITY                 =       0.4927 VOL/VOL
WILTING POINT                  =       0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.3800 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.999999975000E-04 CM/SEC


                          LAYER  7
                          --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  10
THICKNESS                      =      24.00   INCHES
POROSITY                       =       0.3980 VOL/VOL
FIELD CAPACITY                 =       0.2440 VOL/VOL
WILTING POINT                  =       0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.119999997000E-03 CM/SEC
```

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.25	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.	=	9.35000038000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	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.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	0.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	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 5.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	81.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.928	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	795.580	INCHES
TOTAL INITIAL WATER	=	795.580	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	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	12.0	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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

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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	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19
	2.81	1.53	2.12	3.85	1.97	2.18
RUNOFF						
TOTALS	0.576	0.391	0.751	0.263	0.283	0.212
	0.444	0.033	0.237	1.803	0.951	1.393

STD. DEVIATIONS	0.831	0.645	1.331	0.611	0.656	0.402
	0.933	0.073	0.323	2.674	1.582	1.838

EVAPOTRANSPIRATION

TOTALS	1.761	1.865	2.881	3.897	3.827	3.286
	3.163	2.071	3.048	2.031	1.156	1.523
STD. DEVIATIONS	0.368	0.554	0.982	1.124	1.492	1.857
	1.984	1.586	1.550	0.885	0.398	0.409

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0005	0.0005	0.0005	0.0003	0.0001	0.0001
	0.0001	0.0000	0.0001	0.0004	0.0005	0.0006
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
	0.0001	0.0000	0.0001	0.0003	0.0003	0.0003

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.2944	0.2804	0.3063	0.2941	0.3015	0.2912
	0.3017	0.2997	0.2877	0.2959	0.2855	0.2952
STD. DEVIATIONS	0.0758	0.0921	0.0949	0.0936	0.0922	0.0893
	0.0896	0.0881	0.0808	0.0841	0.0795	0.0778

PERCOLATION/LEAKAGE THROUGH LAYER 10

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 2

AVERAGES	6.8822	6.7299	6.1626	3.3204	0.9582	1.0028
	0.7578	0.2648	1.0262	4.4304	6.1545	7.4749
STD. DEVIATIONS	3.0170	2.6030	2.2627	1.9154	1.3860	1.1554
	1.2053	0.5618	1.4706	3.8550	4.5503	3.6470

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0054	0.0056	0.0056	0.0055	0.0055	0.0055
	0.0055	0.0055	0.0054	0.0054	0.0054	0.0054
STD. DEVIATIONS	0.0014	0.0019	0.0017	0.0018	0.0017	0.0017
	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.85 (7.081)	137390.7	100.00
RUNOFF	7.338 (4.2176)	26638.35	19.389
EVAPOTRANSPIRATION	30.509 (4.1926)	110747.81	80.608
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00353 (0.00106)	12.814	0.00933
AVERAGE HEAD ON TOP OF LAYER 2	3.764 (1.144)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	3.53349 (1.01440)	12826.551	9.33582
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (0.00000)	0.018	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.005 (0.002)		
CHANGE IN WATER STORAGE	-3.532 (1.5370)	-12822.06	-9.333

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)

PRECIPITATION	5.70	20691.000
RUNOFF	3.968	14403.1973
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000030	0.10951
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 8	0.02887	104.81271
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00005
AVERAGE HEAD ON TOP OF LAYER 9	0.016	
MAXIMUM HEAD ON TOP OF LAYER 9	0.033	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.3 FEET	
SNOW WATER	1.51	5486.8149

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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	2.8593	0.2383

2	0.0000	0.0000
3	7.6860	0.4270
4	3.7200	0.3100
5	505.1741	0.3368
6	163.8755	0.3035
7	6.1053	0.2544
8	0.0049	0.0192
9	0.0000	0.0000
10	0.1875	0.7500
SNOW WATER	0.000	

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APPENDIX IIIC-A.1

SUMMARY OF LEACHATE GENERATION MODEL WITH 50 PERCENT RECIRCULATION

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-A.1-1 through IIIC-A.1-5

This appendix includes the summary sheets for the HELP model analyses performed assuming that the working face is "parked" over a 1-acre area for 50 percent of the site's life. The table below compares the leachate generation results from the HELP model runs included in Appendix IIIC-A (which assume that the time that the working face is "parked" over a 1-acre area is 10 percent) with the leachate generation results for the case that assumes that the working face is "parked" over a 1-acre area for 50 percent of the site's life.

As shown in the table below, the increase in leachate recirculation amounts did not significantly affect the leachate generation rates and peak head on the liner values.

Item	Developed Subtitle D MSW Sectors	Undeveloped Subtitle D MSW Sectors	Developed Subtitle D Class 1 Sector	Undeveloped Subtitle D Class 1 Sector
Time (in percent) that Recirculation Occurs over Any Given Area - 10%				
Summary Sheet Location	IIIC-A-30	IIIC-A-31	IIIC-A-32	IIIC-A-33
Waste Column Thickness	Average for 50 ft to 320 ft of waste	Average for 50 ft to 140 ft of waste	Average for 50 ft to 330 ft of waste	Average for 50 ft to 270 ft of waste
Average Leachate Generation Rate (cf/yr/ac)	26,580	19,153	26,903	22,835
Average Leachate Recirculation Rate (cf/yr/ac)	2,658	1,915	2,690	2,284
Average of Peak Head on Liner (in)	0.014 - 0.105	0.02 - 0.067	0.009 - 0.118	0.018 - 0.099
Time (in percent) that Recirculation Occurs over Any Given Area - 50%				
Summary Sheet Location	IIIC-A.1-2	IIIC-A.1-3	IIIC-A.1-4	IIIC-A.1-5
Waste Column Thickness	Average for 50 ft to 320 ft of waste	Average for 50 ft to 140 ft of waste	Average for 50 ft to 330 ft of waste	Average for 50 ft to 270 ft of waste
Average Leachate Generation Rate (cf/yr/ac)	28,930	22,204	29,273	25,498
Average Leachate Recirculation Rate (cf/yr/ac)	14,465	11,102	14,636	12,749
Average of Peak Head on Liner (in)	0.015 - 0.105	0.025 - 0.122	0.011 - 0.118	0.018 - 0.113

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (320 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5
	No. of Years	10	10	10	10	10
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1	87.1
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	80	80	80	80	80
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10	10
EROSION LAYER (Texture = 10)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					
	Hyd. Conductivity (cm/s)					
	Pinhole Density (holes/acre)					
	Install. Defects (holes/acre)					
	Placement Quality					
INFILTRATION LAYER (Texture = 0)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500	1500	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			900	2100	2340
	Porosity (vol/vol)			0.5348	0.4935	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.189	0.179	0.155	0.131	0.127
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	8.02	4.57	3.38	2.74	2.57
	Slope (%)	1.8	1.8	1.8	1.8	1.8
	Slope Length (ft)	230	230	230	230	230
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23
RUNOFF	Average Annual (in)	3.10	3.07	3.07	3.07	3.07
EVAPOTRANSPIRATION	Average Annual (in)	28.54	28.22	28.22	28.22	28.22
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	6,847.2	34,870.6	25,907.6	36,966.4	40,059.3
	Peak Daily (cf/day)	48.3	186.2	59.2	95.1	110.2
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	3,423.6	17,435.3	12,953.8	18,483.2	20,029.7
	Peak Daily (cf/day)	48.3	186.2	59.2	95.1	110.2
HEAD ON LINER	Average Annual (in)	0.001	0.013	0.013	0.023	0.027
	Peak Daily (in)	0.015	0.100	0.043	0.085	0.105

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
MSW UNDEVELOPED SUBTITLE D AREAS - 50% RECIRCULATION

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (140 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3
	No. of Years	10	10	10
	Ground Cover	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	87.1	87.1	87.1
	Model Area (acre)	1	1	1
	Runoff Area (%)	80	80	80
	Maximum Leaf Area Index	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10
EROSION LAYER (Texture = 10)	Thickness (in)			
	Porosity (vol/vol)			
	Field Capacity (vol/vol)			
	Wilting Point (vol/vol)			
	Init. Moisture Content (vol/vol)			
	Hyd. Conductivity (cm/s)			
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)			
	Hyd. Conductivity (cm/s)			
	Pinhole Density (holes/acre)			
	Install. Defects (holes/acre)			
	Placement Quality			
INFILTRATION LAYER (Texture = 0)	Thickness (in)			
	Porosity (vol/vol)			
	Field Capacity (vol/vol)			
	Wilting Point (vol/vol)			
	Init. Moisture Content (vol/vol)			
	Hyd. Conductivity (cm/s)			
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			180
	Porosity (vol/vol)			0.5596
	Field Capacity (vol/vol)			0.4963
	Wilting Point (vol/vol)			0.0770
	Init. Moisture Content (vol/vol)			0.3800
	Hyd. Conductivity (cm/s)			1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.189	0.179	0.169
	Porosity (vol/vol)	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	8.00	4.58	3.99
	Slope (%)	1.8	1.8	1.8
	Slope Length (ft)	285	285	285
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0
	Install. Defects (holes/acre)	0	0	0
	Placement Quality	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23
RUNOFF	Average Annual (in)	3.06	3.07	3.07
EVAPOTRANSPIRATION	Average Annual (in)	28.23	28.22	28.22
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	8,297.6	34,887.4	23,427.4
	Peak Daily (cf/day)	64.6	183.9	59.7
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	4,148.8	17,443.7	11,713.7
	Peak Daily (cf/day)	64.6	183.9	59.7
HEAD ON LINER	Average Annual (in)	0.002	0.016	0.012
	Peak Daily (in)	0.025	0.122	0.046

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirc

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention o,* *Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (330 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4	5
	No. of Years	10	15	10	5	5
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	87.1	87.1	87.1	86.8	86.8
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	70	80	80	80	80
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10	10
EROSION LAYER (Texture = 10)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)					
	Hyd. Conductivity (cm/s)					
	Pinhole Density (holes/acre)					
	Install. Defects (holes/acre)					
	Placement Quality					
INFILTRATION LAYER (Texture = 0)	Thickness (in)					
	Porosity (vol/vol)					
	Field Capacity (vol/vol)					
	Wilting Point (vol/vol)					
	Init. Moisture Content (vol/vol)					
	Hyd. Conductivity (cm/s)					
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500	1500	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			900	2100	2340
	Porosity (vol/vol)			0.5348	0.4935	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.208	0.196	0.170	0.145	0.138
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	10.00	5.46	3.38	2.88	2.68
	Slope (%)	2.05	2.05	2.05	2.05	2.05
	Slope Length (ft)	305	305	305	305	305
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23
RUNOFF	Average Annual (in)	3.10	3.07	3.07	3.07	3.07
EVAPOTRANSPIRATION	Average Annual (in)	28.54	28.22	28.22	28.22	28.22
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	6,859.9	35,056.9	25,764.2	36,941.8	41,741.2
	Peak Daily (cf/day)	47.3	165.3	57.4	94.5	110.4
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	3,429.9	17,528.4	12,882.1	18,470.9	20,870.6
	Peak Daily (cf/day)	47.3	165.3	57.4	94.5	110.4
HEAD ON LINER	Average Annual (in)	0.001	0.013	0.015	0.025	0.031
	Peak Daily (in)	0.011	0.087	0.049	0.094	0.118

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (270 FT WASTE)
GENERAL INFORMATION	Case No.	1	2	3	4
	No. of Years	10	10	10	10
	Ground Cover	FAIR	FAIR	FAIR	FAIR
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1
	Model Area (acre)	1	1	1	1
	Runoff Area (%)	80	80	80	80
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0
	Evaporative Zone Depth (inch)	10	10	10	10
EROSION LAYER (Texture = 10)	Thickness (in)				
	Porosity (vol/vol)				
	Field Capacity (vol/vol)				
	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)				
	Hyd. Conductivity (cm/s)				
	Pinhole Density (holes/acre)				
	Install. Defects (holes/acre)				
	Placement Quality				
INFILTRATION LAYER (Texture = 0)	Thickness (in)				
	Porosity (vol/vol)				
	Field Capacity (vol/vol)				
	Wilting Point (vol/vol)				
	Init. Moisture Content (vol/vol)				
	Hyd. Conductivity (cm/s)				
INTERMEDIATE COVER (Texture = 11)	Thickness (in)	12	12	12	12
	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2] (Texture = 0)	Thickness (in)	600	1200	1500	1500
	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2] (Texture = 0)	Thickness (in)			1740	1740
	Porosity (vol/vol)			0.5348	0.5596
	Field Capacity (vol/vol)			0.4892	0.4963
	Wilting Point (vol/vol)			0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04
PROTECTIVE COVER (Texture = 10)	Thickness (in)	24	24	24	24
	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980
	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE COLLECTION LAYER (Texture = 0)	Thickness (in)	0.208	0.196	0.170	0.151
	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500
	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100
	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	10.00	5.46	3.38	2.74
	Slope (%)	2.05	2.05	2.05	2.05
	Slope Length (ft)	355	355	355	355
FLEXIBLE MEMBRANE LINER (Texture = 35)	Thickness (in)	0.06	0.06	0.06	0.06
	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13
	Pinhole Density (holes/acre)	0	0	0	0
	Install. Defects (holes/acre)	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD
COMPACTED CLAY LINER (Texture = 16)	Thickness (in)	24	24	24	24
	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270
	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23
RUNOFF	Average Annual (in)	3.06	3.07	3.07	3.07
EVAPOTRANSPIRATION	Average Annual (in)	28.23	28.22	28.22	28.22
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	8,232.0	35,063.9	25,940.8	32,757.0
	Peak Daily (cf/day)	68.8	184.3	55.8	80.6
LATERAL DRAINAGE RECIRCULATED	Average Annual (cf/year)	4,116.0	17,532.0	12,970.4	16,378.5
	Peak Daily (cf/day)	68.8	184.3	55.8	80.6
HEAD ON LINER	Average Annual (in)	0.002	0.015	0.018	0.028
	Peak Daily (in)	0.023	0.113	0.056	0.099

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Lanc Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

APPENDIX IIIC-A.2

SUMMARY OF LEACHATE GENERATION MODEL FOR SIDESLOPES

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LICENSED PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-A.2-1 through IIIC-A.2-23

INTRODUCTION

This appendix contains the analysis of the sideslope geocomposite for both the undeveloped and developed Subtitle D areas. This appendix includes the following:

- Sheets IIIC-A.2-2 through IIIC-A.2-17. Geocomposite calculations using transmissivity values for the sideslope. The same waste thicknesses used for the floor geocomposite calculations (included in Appendix IIIC-A) are used for the sideslope gecomposite calculations to provide a conservative analysis.
- Sheets IIIC-A.2-18 and IIIC-A.2-19. The required double-sided geocomposite properties for the sideslopes of undeveloped areas.
- Sheets IIIC-A.2-20 through IIIC-A.2-23. HELP summary sheets for sideslope geocomposite HELP analysis.

As shown in the following HELP model summary sheets, the LCS design is adequate (i.e., the calculated head on the liner is within the compressed thickness of the geocomposite).

TURKEY CREEK LANDFILL
0771-368-11
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
MSW DEVELOPED SUBTITLE D AREAS - SIDESLOPES

Required:

Estimate the properties of the 200-mil-thick geocomposite leachate collection layer for the developed Subtitle D sectors.

Note: Sectors 1, 2B, 3B, 4C, 5, 6B, 7, and 8 were constructed with a 200-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

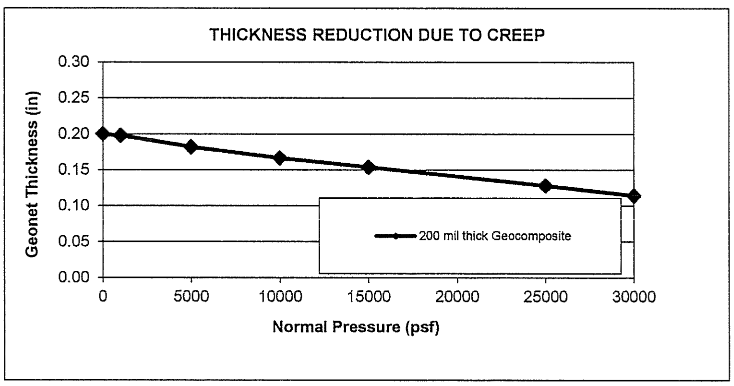
Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)= 0.20 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,110	0.189	0.005
Interim - 100'	100	3	57	6,060	0.179	0.005
Interim - 200'	200	3	71	14,560	0.155	0.004
Interim - 300'	300	3	78	23,760	0.131	0.003
Interim - 320'	320	3	78	25,320	0.127	0.003
Closed - 320'	320	5.5	78	25,620	0.127	0.003

1 d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.
2 d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.
3 The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.
4 P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.
5 t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (320' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.43	1.98	2.11	2.38	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.86	3.96	4.22	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 200-mil-thick double-sided geocomposite is shown on Sheet IIIC-A.2-18. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,110	0.189	1.08E-04	2.86	3.76E-05	0.78
Interim - 100'	100	6,060	0.179	7.24E-05	3.96	1.83E-05	0.40
Interim - 200'	200	14,560	0.155	3.44E-05	4.22	8.14E-06	0.21
Interim - 300'	300	23,760	0.131	1.75E-05	4.75	3.69E-06	0.11
Interim - 320'	320	25,320	0.127	1.59E-05	5.02	3.18E-06	0.10
Closed - 320'	320	25,620	0.127	1.56E-05	5.72	2.74E-06	0.08

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A.2-18.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

Required:

Estimate the properties of the 200-mil-thick geocomposite leachate collection layer for the developed Subtitle D sectors.

Note: Sectors 13 and 14 are currenty undeveloped.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.
5. Specify Drainage Geocomposite Properties for the Leachate Collection Layer

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (200 mil)=	0.20	in
Unit Weight of Soil =	120	pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	3	55	910	0.198	0.005
Interim - 50'	50	3	55	3,110	0.189	0.005
Interim - 100'	100	3	57	6,060	0.179	0.005
Interim - 140'	140	3	63	9,180	0.169	0.004
Closed - 140'	140	5.5	63	9,480	0.168	0.004

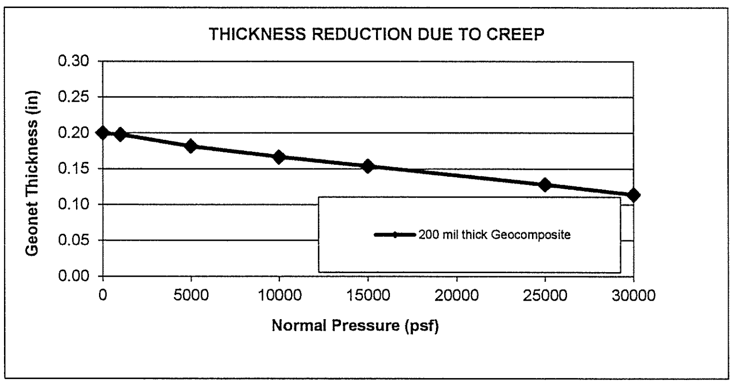
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition				
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (140' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	2.0
RF_{BC}	Biological Clogging	1.0	1.0	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.43	1.98	2.11	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	2.86	3.96	4.22	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 200-mil-thick double-sided geocomposite is shown on Sheet IIIC-A.2-18. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	910	0.198	1.52E-04	2.20	6.92E-05	1.37
Interim - 50'	50	3,110	0.189	1.08E-04	2.86	3.76E-05	0.78
Interim - 100'	100	6,060	0.179	7.24E-05	3.96	1.83E-05	0.40
Interim - 140'	140	9,180	0.169	5.40E-05	4.22	1.28E-05	0.30
Closed - 140'	140	9,480	0.168	5.25E-05	5.72	9.18E-06	0.21

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A.2-189.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

TURKEY CREEK LANDFILL
0771-368-11
GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
CLASS 1 DEVELOPED SUBTITLE D AREAS - SIDESLOPE

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 9 and 10 were constructed with a 220-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)= 0.22 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	55	3,110	0.208	0.005
Interim - 100'	100	3	57	6,060	0.196	0.005
Interim - 200'	200	3	71	14,560	0.170	0.004
Interim - 300'	300	3	78	23,760	0.145	0.004
Interim - 330'	330	3	78	26,100	0.138	0.004
Closed - 330'	330	8	78	26,700	0.137	0.003

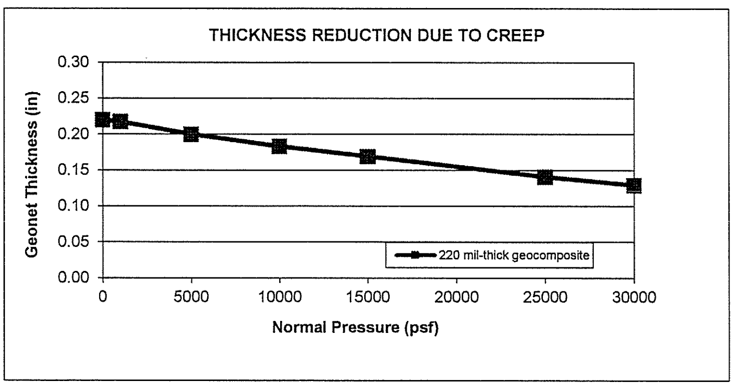
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (330' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.57	1.98	2.11	2.38	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		3.15	3.96	4.22	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A.2-19. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	3,110	0.208	1.66E-04	3.15	5.29E-05	1.00
Interim - 100'	100	6,060	0.196	7.95E-05	3.96	2.01E-05	0.40
Interim - 200'	200	14,560	0.170	3.78E-05	4.22	8.94E-06	0.21
Interim - 300'	300	23,760	0.145	2.16E-05	4.75	4.56E-06	0.12
Interim - 330'	330	26,100	0.138	1.89E-05	5.02	3.76E-06	0.11
Closed - 330'	330	26,700	0.137	1.82E-05	5.72	3.18E-06	0.09

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A.2-19.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 11 and 12 are currently undeveloped.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

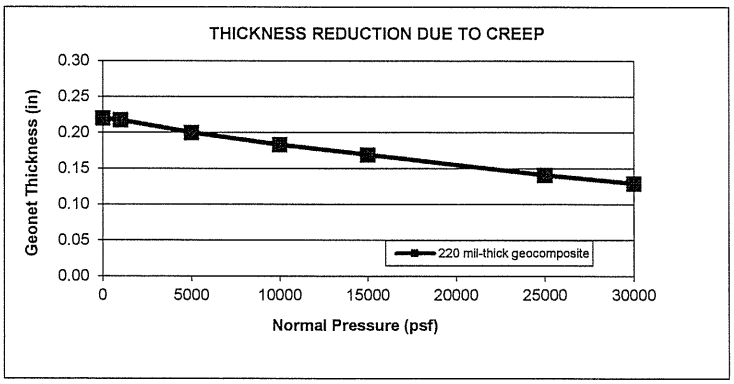
Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)= 0.22 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	3	55	910	0.218	0.006
Interim - 50'	50	3	55	3,110	0.208	0.005
Interim - 100'	100	3	57	6,060	0.196	0.005
Interim - 200'	200	3	71	14,560	0.170	0.004
Interim - 270'	270	3	78	21,420	0.151	0.004
Closed - 270'	270	8	78	22,020	0.148	0.004

[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.
[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.
[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.
[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.
[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (270' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.11	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	3.15	3.96	4.22	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A.2-19. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	910	0.218	3.34E-04	2.20	1.52E-04	2.74
Interim - 50'	50	3,110	0.208	2.43E-04	3.15	7.74E-05	1.46
Interim - 100'	100	6,060	0.196	1.59E-04	3.96	4.01E-05	0.80
Interim - 200'	200	14,560	0.170	5.27E-05	4.22	1.25E-05	0.29
Interim - 270'	270	21,420	0.151	2.27E-05	5.02	4.52E-06	0.12
Closed - 270'	270	22,020	0.148	2.40E-05	5.72	4.19E-06	0.11

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A.2-19.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

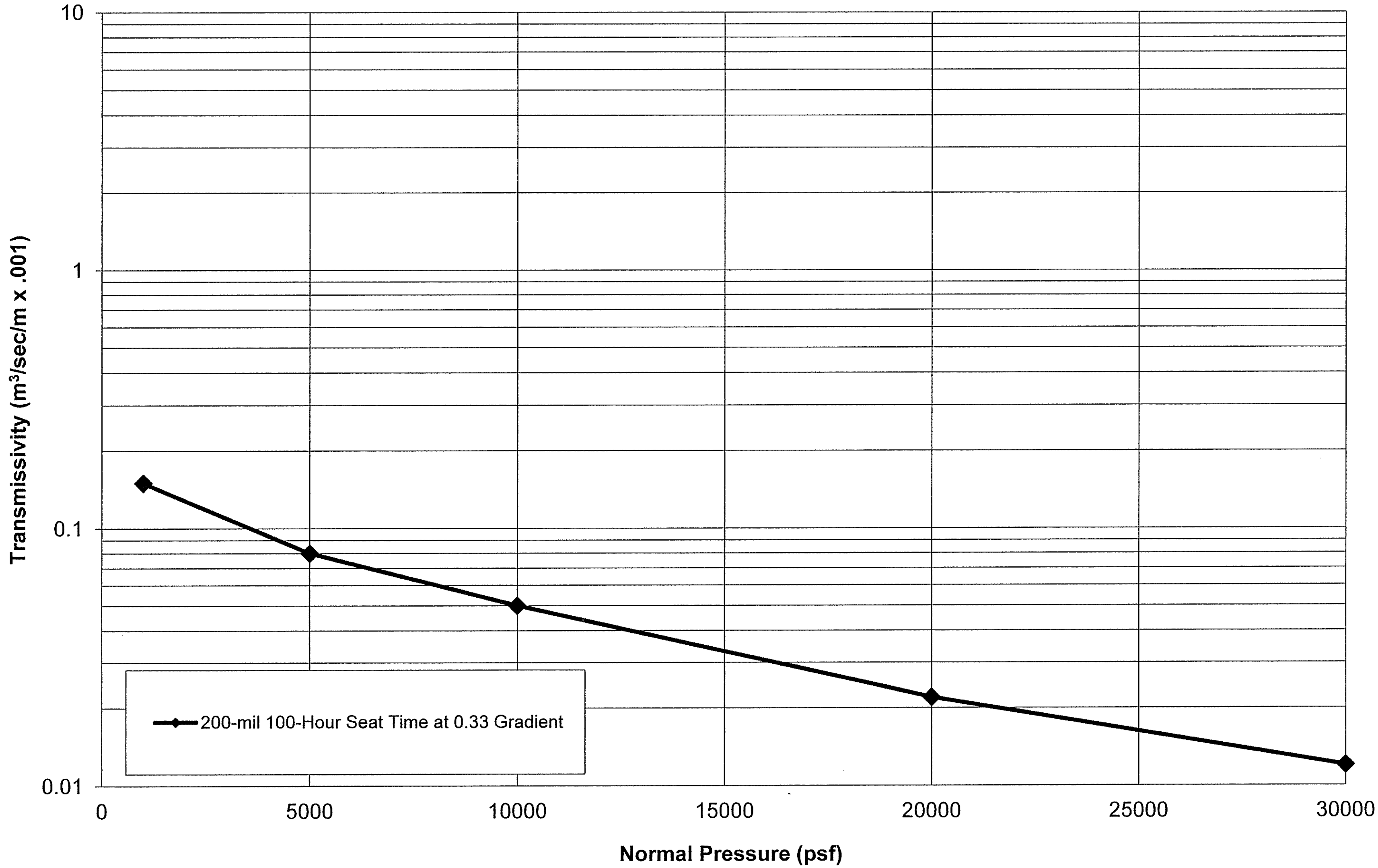
[6] T_{DES} is the design transmissivity value calculated using the following equation:

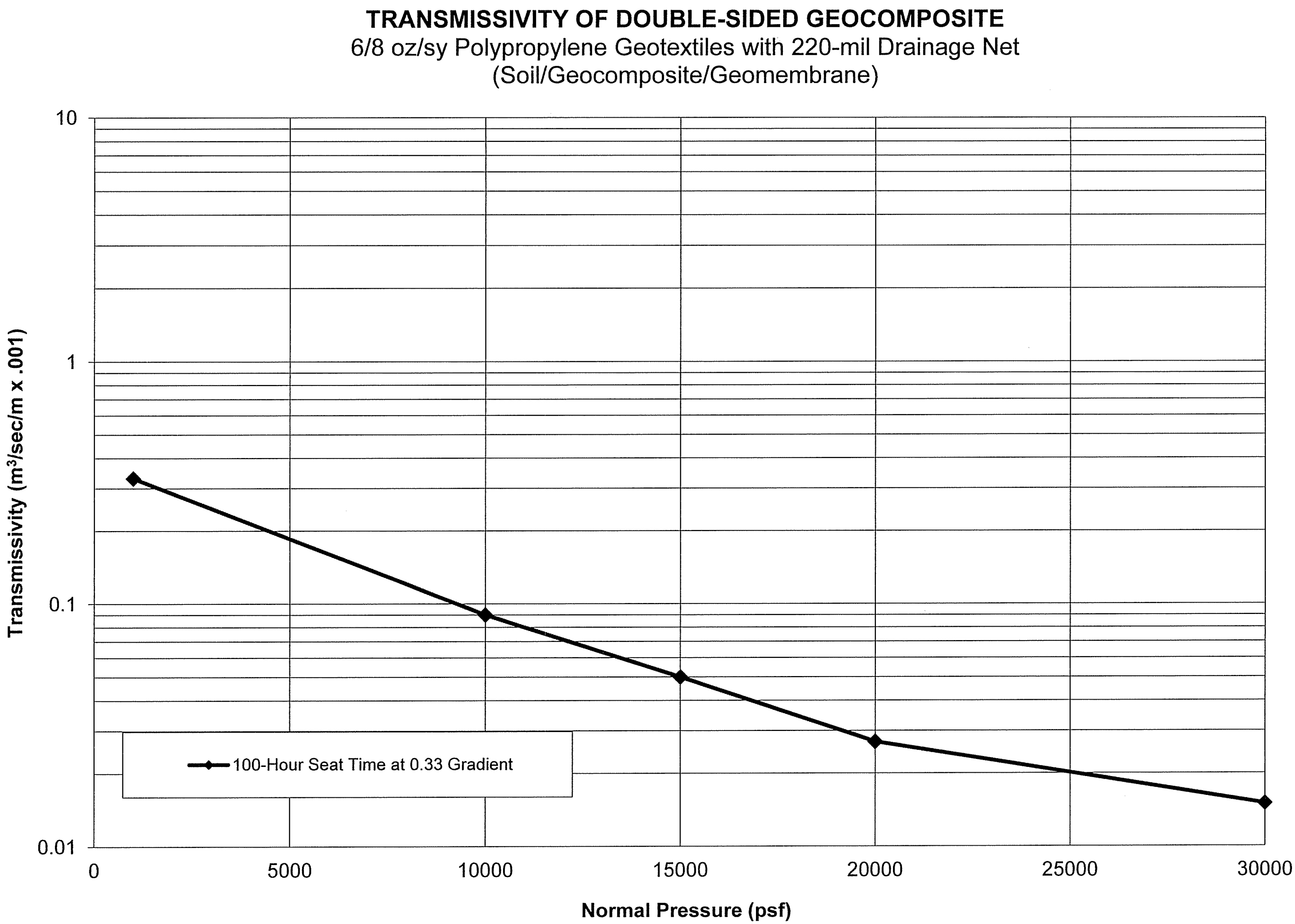
$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
8 oz/sy Polypropylene Geotextiles with 200-mil Drainage Net
(Soil/Geocomposite/Geomembrane)





TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE
6/8 oz/sy Polypropylene Geotextiles with 220-mil Drainage Net
(Soil/Geocomposite/Geomembrane)
Transmissivity (m3/sec/m x .001)
10
1
0.1
0.01
0
5000
10000
15000
20000
25000
30000
Normal Pressure (psf)
100-Hour Seat Time at 0.33 Gradient

Prep By: BPY
Date: 10/6/2021

Chkd By: BPY
Date: 10/6/2021

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
MSW DEVELOPED SUBTITLE D AREAS - SIDESLOPES

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (320 FT WASTE)	CLOSED (320 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	10	10	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	80	80	80	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						18
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-05
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	2100	2340	2340
(Texture = 0)	Porosity (vol/vol)			0.5348	0.4935	0.4852	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.189	0.179	0.155	0.131	0.127	0.127
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	0.78	0.40	0.21	0.11	0.10	0.08
	Slope (%)	33.3	33.3	33.3	33.3	33.3	33.3
	Slope Length (ft)	135	135	135	135	135	135
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	3.31	3.14	3.07	3.07	3.07	6.99
EVAPOTRANSPIRATION	Average Annual (in)	28.81	28.64	28.22	28.22	28.22	30.50
LATERAL	Average Annual (cf/year)	5,365.4	24,346.8	24,369.8	35,217.7	38,275.4	24,784.5
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	63.3	144.3	133.7	195.7	225.2	213.9
LATERAL	Average Annual (cf/year)	536.5	2,434.7	2,437.0	3,521.8	3,827.5	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	6.3	14.4	13.4	19.6	22.5	
HEAD ON LINER	Average Annual (in)	0.000	0.004	0.007	0.019	0.023	0.019
	Peak Daily (in)	0.003	0.014	0.041	0.057	0.112	0.119

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

		Active (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (140 FT WASTE)	CLOSED (140 FT WASTE)
GENERAL	Case No.	1	2	3	4	6
INFORMATION	No. of Years	1	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	12
EROSION	Thickness (in)					12
LAYER	Porosity (vol/vol)					0.3980
(Texture = 10)	Field Capacity (vol/vol)					0.2440
	Wilting Point (vol/vol)					0.1360
	Init. Moisture Content (vol/vol)					0.2440
	Hyd. Conductivity (cm/s)					1.2E-04
FLEXIBLE	Thickness (in)					0.04
MEMBRANE	Hyd. Conductivity (cm/s)					4.0E-13
LINER	Pinhole Density (holes/acre)					1
(Texture = 36)	Install. Defects (holes/acre)					4
	Placement Quality					GOOD
INFILTRATION	Thickness (in)					48
LAYER	Porosity (vol/vol)					0.4270
(Texture = 0)	Field Capacity (vol/vol)					0.4180
	Wilting Point (vol/vol)					0.3670
	Init. Moisture Content (vol/vol)					0.4270
	Hyd. Conductivity (cm/s)					1.0E-07
INTERMEDIATE	Thickness (in)		12	12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6649	0.6483	0.6277	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5215	0.5156	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				180	180
(Texture = 0)	Porosity (vol/vol)				0.5596	0.5596
	Field Capacity (vol/vol)				0.4963	0.4963
	Wilting Point (vol/vol)				0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.189	0.189	0.179	0.169	0.168
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	1.37	0.78	0.40	0.30	0.21
	Slope (%)	33.3	33.3	33.3	33.3	33.3
	Slope Length (ft)	115	115	115	115	115
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.38	3.07	3.07	6.99
EVAPOTRANSPIRATION	Average Annual (in)	33.70	28.85	28.22	28.22	30.50
LATERAL	Average Annual (cf/year)	3,185.3	5,156.7	28,510.1	20,693.7	11,385.1
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	36.6	54.9	200.6	103.8	86.6
LATERAL	Average Annual (cf/year)		515.7	2,851.0	2,069.4	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		5.5	20.1	10.4	
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.013	0.004	0.003
	Peak Daily (in)	0.043	0.002	0.067	0.012	0.043

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
CLASS 1 DEVELOPED SUBTITLE D AREAS - SIDESLOPE

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (330 FT WASTE)	CLOSED (330 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	10	15	10	5	5	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	86.8	86.8	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	70	80	80	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						48
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6483	0.6277	0.6174	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5215	0.5156	0.5127	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.3800	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)			900	2100	2340	2340
(Texture = 0)	Porosity (vol/vol)			0.5348	0.4935	0.4852	0.4852
	Field Capacity (vol/vol)			0.4892	0.4775	0.4751	0.4751
	Wilting Point (vol/vol)			0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)			0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)			1.0E-04	1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.208	0.196	0.170	0.145	0.138	0.137
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	1.00	0.40	0.21	0.12	0.11	0.09
	Slope (%)	33.30	33.30	33.30	33.30	33.30	33.30
	Slope Length (ft)	160	160	160	160	160	160
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	3.38	3.10	3.07	3.07	3.07	7.20
EVAPOTRANSPIRATION	Average Annual (in)	28.85	28.53	28.22	28.22	28.22	30.56
LATERAL	Average Annual (cf/year)	5,173.0	25,606.1	24,229.0	35,205.9	40,054.0	25,894.4
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	53.6	172.2	129.0	192.2	223.5	219.8
LATERAL	Average Annual (cf/year)	517.3	2,560.6	2,422.9	3,520.6	4,005.4	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	5.4	17.2	12.9	19.2	22.4	
HEAD ON LINER	Average Annual (in)	0.000	0.005	0.008	0.021	0.026	0.020
	Peak Daily (in)	0.031	0.004	0.029	0.112	0.080	0.109

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
CLASS 1 UNDEVELOPED SUBTITLE D AREAS - SIDESLOPES

		Active (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (270 FT WASTE)	CLOSED (270 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						48
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE	Thickness (in)		12	12	12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.6649	0.6483	0.6277	0.6174	0.6174	0.6174
	Field Capacity (vol/vol)	0.5262	0.5215	0.5156	0.5127	0.5127	0.5127
	Wilting Point (vol/vol)	0.0770	0.0770	0.0770	0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)	0.2500	0.2500	0.3800	0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
WASTE BOTTOM[2]	Thickness (in)				1740	1740	1470
(Texture = 0)	Porosity (vol/vol)				0.5348	0.5596	0.5596
	Field Capacity (vol/vol)				0.4892	0.4963	0.4963
	Wilting Point (vol/vol)				0.0770	0.0770	0.0770
	Init. Moisture Content (vol/vol)				0.3800	0.3800	0.3800
	Hyd. Conductivity (cm/s)				1.0E-04	1.0E-04	1.0E-04
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.218	0.208	0.196	0.170	0.151	0.148
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	2.74	1.46	0.80	0.29	0.12	0.11
	Slope (%)	33.30	33.30	33.30	33.30	33.30	33.30
	Slope Length (ft)	120	120	120	120	120	120
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.54	3.37	3.10	3.07	7.20
EVAPOTRANSPIRATION	Average Annual (in)	33.81	28.91	28.85	28.53	28.22	30.56
LATERAL	Average Annual (cf/year)	3,130.3	5,004.4	20,926.0	23,488.6	31,136.5	19,871.5
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	36.4	48.7	116.6	122.5	175.2	173.0
LATERAL	Average Annual (cf/year)		500.4	2,092.6	2,348.9	3,113.6	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		4.9	11.7	12.3	17.5	
HEAD ON LINER	Average Annual (in)	0.000	0.000	0.001	0.004	0.014	0.010
	Peak Daily (in)	0.000	0.028	0.031	0.015	0.026	0.078

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

APPENDIX IIIC-A.3

SUMMARY OF LEACHATE GENERATION MODEL
FOR CLASS 1 WASTE

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-A.3-1 through IIIC-A.3-25

INTRODUCTION

This appendix contains the analysis and design of the Class 1 LCS assuming a heavier density (i.e., 100 pcf) and soil-like characteristics for the Class 1 waste. This appendix includes the following:

- Sheets IIIC-A.3-2 through IIIC-A.3-9. Geocomposite calculations assuming a heavier density of 100 pcf for Sectors 9, 10, 11, and 12.
- Sheets IIIC-A.3-10 and IIIC-A.3-11. HELP summary sheets for Sectors 9, 10, 11, and 12.
- Sheets IIIC-A.3-12 through IIIC-A.3-17. Pipe capacity calculations.
- Sheets IIIC-A.3-18 through IIIC-A.3-22. Sump calculations.
- Sheets IIIC-A.3-23 through IIIC-A.3-25. Chimney drain calculations.

As shown in the following calculations, the LCS design is adequate even when considering a heavier density and soil-like characteristics for Class 1 waste.

GEOCOMPOSITE LEACHATE COLLECTION LAYER PROPERTIES
CLASS 1 DEVELOPED SUBTITLE D AREAS

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 9 and 10 were constructed with a 220-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 9 and 10 were constructed with a 220-mil-thick geocomposite.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)= 0.22 in
Unit Weight of Soil = 120 pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Interim - 50'	50	3	100	5,360	0.199	0.005
Interim - 100'	100	3	100	10,360	0.182	0.005
Interim - 200'	200	3	100	20,360	0.154	0.004
Interim - 300'	300	3	100	30,360	0.129	0.003
Interim - 330'	330	3	100	33,360	0.125	0.003
Closed - 330'	330	8	100	33,960	0.124	0.003

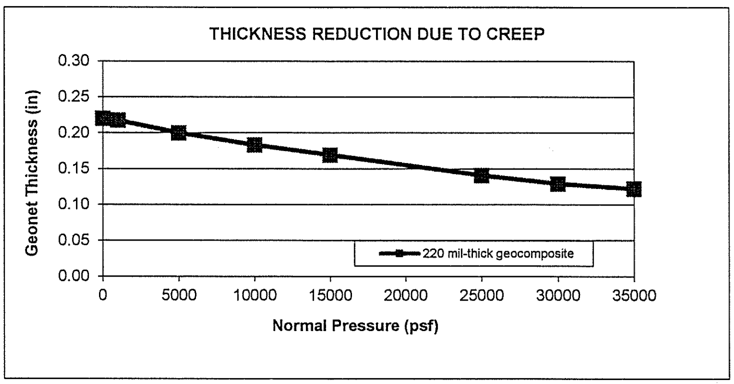
[1] d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

[2] d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

[3] The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

[4] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

[5] t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (300' Waste)	Interim (330' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.3	1.5	1.6	1.8	1.9	2.0
RF_{BC}	Biological Clogging	1.1	1.2	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.57	1.98	2.11	2.38	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		3.15	3.96	4.22	4.75	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-28. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Interim - 50'	50	5,360	0.199	1.13E-03	3.15	3.58E-04	7.08
Interim - 100'	100	10,360	0.182	8.29E-04	3.96	2.09E-04	4.52
Interim - 200'	200	20,360	0.154	5.38E-04	4.22	1.27E-04	3.26
Interim - 300'	300	30,360	0.129	4.16E-04	4.75	8.76E-05	2.68
Interim - 330'	330	33,360	0.125	3.86E-04	5.02	7.69E-05	2.43
Closed - 330'	330	33,960	0.124	3.80E-04	5.72	6.64E-05	2.11

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-28.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

Required:

Estimate the properties of the 220-mil-thick geocomposite leachate collection layer for the developed Class 1 sectors

Note: Sectors 11 and 12 are currently undeveloped.

Method:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.
3. Identify the minimum transmissivity for the geocomposite collection layer.
4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

References:

1. Koerner, R.M., Designing With Geosynthetics, Third Edition, 1994.
2. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
3. Geosynthetic Institute, GRI Standard GC-8, 2001.
4. GSE Drainage Design Manual, May 2004.
5. Acar, Yalcin B.& Daniel, David E., *Geoenvironment 2000 Characterization, Containment, Remediation, and Performance in Environmental Geotechnics,* Volume 2, American Society of Civil Engineers, 1995.

Solution:

1. Determine the geocomposite leachate collection layer thickness under the expected loading conditions.

Assume the geocomposite leachate collection layer will undergo compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness (220 mil)=	0.22	in
Unit Weight of Soil =	120	pcf

Table 1-1 - Geocomposite Thickness

Fill Condition	d_W[1] (ft)	d_S[2] (ft)	γ[3] (pcf)	P[4] (psf)	t[5] (in)	t[5] (m)
Active - 10'	10	3	100	1,360	0.216	0.005
Interim - 50'	50	3	100	5,360	0.199	0.005
Interim - 100'	100	3	100	10,360	0.182	0.005
Interim - 200'	200	3	100	20,360	0.154	0.004
Interim - 270'	270	3	100	27,360	0.136	0.003
Closed - 270'	270	8	100	27,960	0.134	0.003

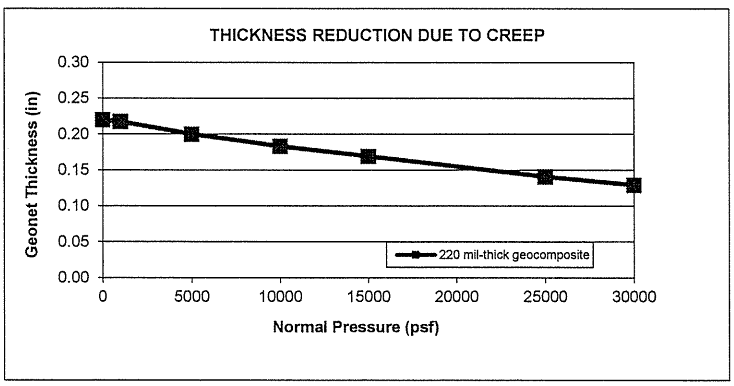
1 d_W is the depth of waste and daily cover soil above the geocomposite leachate collection layer.

2 d_S is the depth of soil (protective cover, intermediate cover, and final cover) above the geocomposite leachate collection layer.

3 The unit weight of waste/soil is selected at the midpoint of the waste column thickness using the Unit Weight Profile for MSW graph provided in Ref 5.

4 P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil.

5 t is the thickness of the geocomposite leachate collection layer after being subjected to compression based on the chart below page adapted from Reference 4.



2. Determine factors of safety for strength and environmental conditions based on the expected duration of each stage of landfill development.

Table 2 - Reduction Factors and Factor of Safety

Reduction Factors[1]		Fill Condition					
		Active (10' Waste)	Interim (50' Waste)	Interim (100' Waste)	Interim (200' Waste)	Interim (270' Waste)	Closed Final Cover
RF_{IN}	Delayed Intrusion	1.1	1.1	1.1	1.1	1.1	1.1
RF_{CC}	Chemical Clogging	1.0	1.3	1.5	1.6	1.9	2.0
RF_{BC}	Biological Clogging	1.0	1.1	1.2	1.2	1.2	1.3
Total Reduction Factor[2]		1.10	1.57	1.98	2.11	2.51	2.86
Overall Factor of Safety to Account For Uncertainties		2.0	2.0	2.0	2.0	2.0	2.0
Overall Reduction Factor (ORF)[3]		2.20	3.15	3.96	4.22	5.02	5.72

[1] Values are obtained from References 1, 2, and 3.

[2] The Total Reduction Factors are a product of all the reduction factors for each fill condition.

[3] The Overall Reduction Factors are a product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties for each fill condition.

3. Identify the minimum transmissivity for the geocomposite collection layer.

The minimum required transmissivity for the 220-mil-thick double-sided geocomposite is shown on Sheet IIIC-A-28. These values are developed based on engineering judgment and experience with similar geocomposite products at numerous MSW sites in Texas.

4. Compute the transmissivity of the geocomposite leachate collection layer for each stage of landfill development using the calculated thicknesses and the reduction factors.

Table 3-1 - Estimate the Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	ORF[5]	T_{DES}[6] (m^2/s)	k[7] (cm/s)
Active - 10'	10	1,360	0.216	2.35E-03	2.20	1.07E-03	19.44
Interim - 50'	50	5,360	0.199	1.13E-03	3.15	3.58E-04	7.08
Interim - 100'	100	10,360	0.182	8.29E-04	3.96	2.09E-04	4.52
Interim - 200'	200	20,360	0.154	5.38E-04	4.22	1.27E-04	3.26
Interim - 270'	270	27,360	0.136	4.56E-04	5.02	9.08E-05	2.64
Closed - 270'	270	27,960	0.134	4.47E-04	5.72	7.82E-05	2.29

[1] d_W is the depth of waste above the geocomposite leachate collection layer.

[2] P is the pressure on the geocomposite leachate collection layer due to the weight of the waste and soil from Tables 1-1 and 1-2.

[3] t is the calculated geocomposite leachate collection layer thickness from Tables 1-1 and 1-2 for the drainage geocomposites.

[4] T is obtained from the specified transmissivity values for a representative geocomposite leachate collection layer as shown on Sheet IIIC-A-28.

[5] ORF is the Overall Reduction Factor obtained from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

[7] k is hydraulic conductivity and calculated using the following equation:

$$k = T_{DES}/t$$

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
CLASS 1 DEVELOPED SUBTITLE D AREAS

		INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (300 FT WASTE)	INTERIM (330 FT WASTE)	CLOSED (330 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	10	15	10	10	10	30
	Ground Cover	FAIR	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	87.1	87.1	87.1	86.8	86.8	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	70	80	80	80	80	100
	Maximum Leaf Area Index	2.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						48
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE	Thickness (in)	12	12	12	12	12	12
COVER	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	600	1200	1500	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE BOTTOM[2]	Thickness (in)			900	2100	2340	2340
(Texture = 0)	Porosity (vol/vol)			0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)			0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)			0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)			0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)			6.4E-05	6.4E-05	6.4E-05	6.4E-05
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.199	0.182	0.154	0.129	0.125	0.124
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	7.08	4.52	3.26	2.68	2.43	2.11
	Slope (%)	2.05	33.30	33.30	33.30	33.30	33.30
	Slope Length (ft)	305	305	305	305	305	305
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	41.23	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	3.07	3.07	3.07	3.07	3.07	7.20
EVAPOTRANSPIRATION	Average Annual (in)	28.22	28.22	28.22	28.22	28.22	30.56
LATERAL	Average Annual (cf/year)	29,955.7	19,009.3	3,060.4	1,685.5	1,605.7	329.3
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	251.6	211.8	58.0	34.2	32.3	2.8
LATERAL	Average Annual (cf/year)	2,995.6	1,900.9	306.0	168.6	160.6	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)	25.2	21.2	5.8	3.4	3.2	
HEAD ON LINER	Average Annual (in)	0.008	0.008	0.002	0.001	0.001	0.000
	Peak Daily (in)	0.051	0.067	0.024	0.019	0.020	0.002

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

TURKEY CREEK LANDFILL
0771-368-11
HELP SUMMARY SHEET
CLASS 1 UNDEVELOPED SUBTITLE D AREAS

		Active (10 FT WASTE)	INTERIM (50 FT WASTE)	INTERIM (100 FT WASTE)	INTERIM (200 FT WASTE)	INTERIM (270 FT WASTE)	CLOSED (270 FT WASTE)
GENERAL	Case No.	1	2	3	4	5	6
INFORMATION	No. of Years	1	10	10	10	10	30
	Ground Cover	BARE	FAIR	FAIR	FAIR	FAIR	GOOD
	SCS Runoff Curve No.	94.6	87.1	87.1	87.1	87.1	80.3
	Model Area (acre)	1	1	1	1	1	1
	Runoff Area (%)	0	80	80	80	80	100
	Maximum Leaf Area Index	0.0	2.0	2.0	2.0	2.0	4.5
	Evaporative Zone Depth (inch)	10	10	10	10	10	12
EROSION	Thickness (in)						12
LAYER	Porosity (vol/vol)						0.3980
(Texture = 10)	Field Capacity (vol/vol)						0.2440
	Wilting Point (vol/vol)						0.1360
	Init. Moisture Content (vol/vol)						0.2440
	Hyd. Conductivity (cm/s)						1.2E-04
FLEXIBLE	Thickness (in)						0.04
MEMBRANE	Hyd. Conductivity (cm/s)						4.0E-13
LINER	Pinhole Density (holes/acre)						1
(Texture = 36)	Install. Defects (holes/acre)						4
	Placement Quality						GOOD
INFILTRATION	Thickness (in)						48
LAYER	Porosity (vol/vol)						0.4270
(Texture = 0)	Field Capacity (vol/vol)						0.4180
	Wilting Point (vol/vol)						0.3670
	Init. Moisture Content (vol/vol)						0.4270
	Hyd. Conductivity (cm/s)						1.0E-07
INTERMEDIATE	Thickness (in)		12	12	12	12	12
COVER	Porosity (vol/vol)		0.4640	0.4640	0.4640	0.4640	0.4640
(Texture = 11)	Field Capacity (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)		0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)		0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)		6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE TOP[2]	Thickness (in)	120	600	1200	1500	1500	1500
(Texture = 0)	Porosity (vol/vol)	0.4640	0.4640	0.4640	0.4640	0.4640	0.4640
	Field Capacity (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Wilting Point (vol/vol)	0.1870	0.1870	0.1870	0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)	0.3100	0.3100	0.3100	0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05	6.4E-05
WASTE BOTTOM[2]	Thickness (in)				1740	1740	1470
(Texture = 0)	Porosity (vol/vol)				0.4640	0.4640	0.4640
	Field Capacity (vol/vol)				0.3100	0.3100	0.3100
	Wilting Point (vol/vol)				0.1870	0.1870	0.1870
	Init. Moisture Content (vol/vol)				0.3100	0.3100	0.3100
	Hyd. Conductivity (cm/s)				6.4E-05	6.4E-05	6.4E-05
PROTECTIVE	Thickness (in)	24	24	24	24	24	24
COVER	Porosity (vol/vol)	0.3980	0.3980	0.3980	0.3980	0.3980	0.3980
(Texture = 10)	Field Capacity (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Wilting Point (vol/vol)	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
	Init. Moisture Content (vol/vol)	0.2440	0.2440	0.2440	0.2440	0.2440	0.2440
	Hyd. Conductivity (cm/s)	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04	1.2E-04
LEACHATE	Thickness (in)	0.216	0.199	0.182	0.154	0.136	0.134
COLLECTION	Porosity (vol/vol)	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
LAYER	Field Capacity (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
(Texture = 0)	Wilting Point (vol/vol)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
	Init. Moisture Content (vol/vol)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
	Hyd. Conductivity (cm/s)	19.44	7.08	4.52	3.26	2.64	2.29
	Slope (%)	2.05	2.05	2.05	2.05	2.05	2.05
	Slope Length (ft)	355	355	355	355	355	355
FLEXIBLE	Thickness (in)	0.06	0.06	0.06	0.06	0.06	0.06
MEMBRANE	Hyd. Conductivity (cm/s)	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13	2.0E-13
LINER	Pinhole Density (holes/acre)	0	0	0	0	0	0
(Texture = 35)	Install. Defects (holes/acre)	0	0	0	0	0	0
	Placement Quality	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
COMPACTED	Thickness (in)	24	24	24	24	24	24
CLAY LINER	Porosity (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
(Texture = 16)	Field Capacity (vol/vol)	0.4180	0.4180	0.4180	0.4180	0.4180	0.4180
	Wilting Point (vol/vol)	0.3670	0.3670	0.3670	0.3670	0.3670	0.3670
	Init. Moisture Content (vol/vol)	0.4270	0.4270	0.4270	0.4270	0.4270	0.4270
	Hyd. Conductivity (cm/s)	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07	1.0E-07
PRECIPITATION	Average Annual (in)	50.56	41.23	41.23	41.23	41.23	37.85
RUNOFF	Average Annual (in)	0.00	3.07	3.07	3.07	3.07	7.20
EVAPOTRANSPIRATION	Average Annual (in)	33.06	28.22	28.22	28.22	28.22	30.56
LATERAL	Average Annual (cf/year)	38,733.5	29,954.8	19,008.1	3,060.4	1,814.9	329.3
DRAINAGE COLLECTED[1]	Peak Daily (cf/day)	855.0	251.7	210.5	57.8	38.0	2.8
LATERAL	Average Annual (cf/year)		2,995.5	1,900.8	306.0	181.5	
DRAINAGE RECIRCULATED	Peak Daily (cf/day)		25.2	21.0	5.8	3.8	
HEAD ON LINER	Average Annual (in)	0.005	0.010	0.010	0.002	0.002	0.000
	Peak Daily (in)	0.074	0.060	0.078	0.031	0.024	0.002

[1] Drainage collected includes actual leachate pumped by the leachate pumps (i.e., the total of the collected and recirculated leachate).

[2] The field capacity and porosity values for the waste layer were obtained from: Zornberg, Jorge G. et. al, *Retention of Free Liquids in Landfills Undergoing Vertical Expansion.* Journal of Geotechnical and Geoenvironmental Engineering, July 1999, pp. 583-594.

REQUIRED: Size leachate collection system pipe in the undeveloped area and analyze the leachate collection pipe in the developed area.

METHOD:

A. Use leachate production rates determined from the HELP model analysis (see Appendix IIIC-A) to size the leachate collection pipes. The largest sector in the developed and the undeveloped areas is analyzed to provide for a conservative analysis.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems* , Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook* , 30 TAC 330.201, 1993.

3. Driscopipe, *Leachate Pipe Systems* , Phillips Drisco Inc., 1992.

SOLUTION:

Determine the peak daily flow rate estimate:

The following tables summarize the fill conditions that are likely to be present and have the greatest contribution of leachate into the LCS. The peak flow rate (lateral drainage in the LCS layer) is shown for each condition.

Developed Sectors:
From the HELP model results in Appendix IIIC-A.3 (highest leachate generation values used from all HELP runs for developed sectors using soil like characteristics for the class 1 waste).

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Interim, 50' Waste	251.6	1,881.9
Interim, 100' Waste	211.8	1,584.3
Interim, 200' Waste	58.0	433.8
Interim, 300' Waste	34.2	255.8
Interim, 330' Waste	32.3	241.8

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the developed sectors the largest area draining to a leachate collection pipe is 14.3 acres (pipe in Sector 9).

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Interim condition, 50' waste over 1.5 ac
2. Interim condition, 100' waste over 4.0 ac
3. Interim condition, 200' waste over 4.7 ac
4. Interim condition, 300' waste over 2.6 ac
5. Interim condition, 330' waste over 1.5 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Interim, 50' Waste	1.5	1,881.9	2,822.9	4.37E-03
Interim, 100' Waste	4.0	1,584.3	6,337.0	9.81E-03
Interim, 200' Waste	4.7	433.8	2,038.7	3.15E-03
Interim, 300' Waste	2.6	255.8	665.0	1.03E-03
Interim, 330' Waste	1.5	241.8	362.7	5.61E-04
Total =	14.3		12,226.3	1.89E-02

Undeveloped Sectors:
From the HELP model results in Appendix IIIC-A.3 :

CONDITION	PEAK[1] cfd/ac	PEAK gpd/ac
Active, 10' Waste	855.0	6,395.1
Interim, 50' Waste	251.7	1,883.0
Interim, 100' Waste	210.5	1,574.5
Interim, 200' Waste	57.8	432.2
Interim, 270' Waste	38.0	284.5

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

TURKEY CREEK LANDFILL
0771-368-11
LEACHATE COLLECTION PIPE
CAPACITY CALCULATIONS

The area draining to a leachate collection pipe in Sector 12 is 12.7 acres.

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Active condition, 10' waste over 2.0 ac
2. Interim condition, 50' waste over 3.8 ac
3. Interim condition, 100' waste over 4.5 ac
4. Interim condition, 200' waste over 2.2 ac
5. Interim condition, 270' waste over 2.0 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	1.5	6,395.1	9,592.7	1.48E-02
Interim, 50' Waste	3.6	1,883.0	6,778.6	1.05E-02
Interim, 100' Waste	4.0	1,574.5	6,298.1	9.75E-03
Interim, 200' Waste	2.1	432.2	907.7	1.40E-03
Interim, 270' Waste	1.5	284.5	426.8	6.60E-04
Total=	12.7		24,003.9	3.71E-02

Developed Sectors Peak Leachate Production = 1.89E-02 cfs

Undeveloped Sector Peak Leachate Production = 3.71E-02 cfs

Determination of flow capacity (Q_{full}) for proposed 6-inch ADS N-12 perforated pipe (Developed Areas):
*Use Developed Sectors Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:

A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

ID = 6.00 in
= 0.500 ft

A = 0.196 sq ft

R = 0.125 ft

S^1 = 0.002 ft / ft

[1]The 0.2 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number   n = 0.012

Q_{full} =	0.272	cfs

Compare Peak Q_{max} and Q_{full} for the 6" ADS N-12 pipe:

Q_{full} =	0.272	cfs	>>	Q_{max} =	0.0371	cfs

An ADS N-12 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

Determination of flow capacity (Q_{full}) for proposed 6-inch SDR 17 perforated pipe (Undeveloped Area):
*Use Undeveloped Sectors Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:

A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

ID = 6.00 in
= 0.500 ft

A = 0.196 sq ft

R = 0.125 ft

S[1] = 0.002 ft / ft

[1]The 0.2 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number n = 0.015

Q_{full} =	0.217	cfs

Compare Peak Q_{max} and Q_{full} for the 6" ADS N-12 pipe:

Q_{full} =	0.217	cfs	>>	Q_{max} =	0.0371	cfs

An SDR 17 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

B. Perforation configuration for a 6-inch perforated pipes:

Pipe perforations must allow free passage of leachate and also prevent migration of drainage media into collection pipes. Therefore, size of perforations depends on media particle size. Two perforations alternatives are evaluated below:

For leachate collection pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

D_{85} = 25 mm
= 0.984 in

Standard slot width: d = 0.125 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 7.9 > 2.0$$ (acceptable)

For leachate collection pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

D_{85} = 25 mm
= 0.984 in

Standard hole diameter d = 0.5 in

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7$$ (acceptable)

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE SUMP DESIGN

REQUIRED: Size leachate collection sumps.

METHOD:

A. Use leachate production rates from HELP model and the sump drainage area in the class 1 area. The largest drainage area was used to provide for a conservative analysis. Sump details are provided in Appendix IIIA-A Liner, Overliner, and Final Cover System Details.
B. Determine geometry of sump and its corresponding storage capacity.
C. Assume pump size and determine the average pump cycle time.

REFERENCES:

1. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
2. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
3. Phillips 66 Driscopipe, *System Design*, 1991.
4. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average flow rate into sump

A.1 Determine the per acre flow rate for specific leachate collection sumps.

The following tables summarize the fill conditions that are likely to be present within each cell and have the greatest contribution of leachate into the LCS and sump system. The average flow rates (lateral drainage in the LCS layer) are shown for each condition.

Developed Sectors:
From the HELP model results in Appendix IIIC-A.3:

For the developed sectors, the largest area draining to the sump is 14.3 acres (sump located in Sector 9). For each fill condition, the highest leachate generation rate from the HELP runs for developed sectors was used to be conservative.

Condition	Average cfy/ac	Average gpd/ac
Interim, 50' Waste	29,955.7	613.9
Interim, 100' Waste	19,009.3	389.6
Interim, 200' Waste	5,177.3	106.1
Interim, 300' Waste	1,685.5	34.5
Interim, 330' Waste	1,605.7	32.9
Closed, 330' Waste	329.3	6.7

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Undeveloped Sectors:
From the HELP model results in Appendix IIIC-A:

The largest area draining to a sump is 12.7 acres (sump located in Sector 12). The leachate generation rate from the HELP runs for the undeveloped sectors was used.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	38,733.5	793.8
Interim, 50' Waste	29,954.8	613.9
Interim, 100' Waste	19,008.1	389.5
Interim, 200' Waste	3,060.4	62.7
Interim, 270' Waste	1,814.9	37.2
Closed, 270' Waste	329.3	6.7

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE SUMP DESIGN

1. Sump for Developed Sectors

14.3 acres

Condition	Rate (gpd/ac)	Active		Inactive		Closed	
		area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Interim, 50' Waste	613.9	1.0	613.9	0.0	0.0	0.0	0.0
Interim, 100' Waste	389.6	3.8	1,480.3	0.0	0.0	0.0	0.0
Interim, 200' Waste	106.1	4.6	488.1	0.0	0.0	0.0	0.0
Interim, 300' Waste	34.5	2.5	86.4	1.0	34.5	1.0	34.5
Interim, 330' Waste	34.5	1.4	48.4	14.3	494.0	0.0	0.0
Closed, 330' Waste	6.7	1.0	6.7	0.0	0.0	14.3	96.5
Total		14.3	2,723.7	15.3	528.5	15.3	131.0

2. Sump for Undeveloped Sectors

12.7 acres

Condition	Rate (gpd/ac)	Active		Inactive		Closed	
		area (ac)	rate (gpd)	area (ac)	rate (gpd)	area (ac)	rate (gpd)
Active, 10' Waste	793.8	1.5	1,190.7	0.0	0.0	0.0	0.0
Interim, 50' Waste	613.9	2.6	1,596.1	0.0	0.0	0.0	0.0
Interim, 100' Waste	389.5	3.0	1,168.6	0.0	0.0	0.0	0.0
Interim, 200' Waste	62.7	2.1	131.7	1.0	62.7	1.0	62.7
Interim, 270' Waste	37.2	2.0	74.4	12.7	796.5	0.0	0.0
Closed, 270' Waste	6.7	1.5	10.1	0.0	0.0	12.7	85.7
Total		12.7	4,171.5	13.7	859.2	13.7	148.4

B. Required storage capacity of sump

Assumed porosity of drainage stone: P = 0.35

$V_{Daily\ Inflow} = V_C / P$

1. Active

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	2,723.7	364.1	1,040.4
Undeveloped Sectors	4,171.5	557.7	1,593.4

2. Inactive with Intermediate Cover

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	528.5	70.7	201.9
Undeveloped Sectors	859.2	114.9	328.2

3. Closed

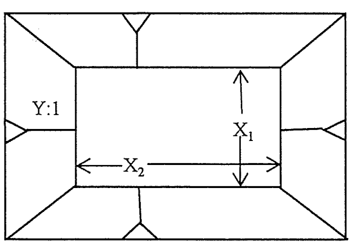
	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	131.0	17.5	50.1
Undeveloped Sectors	148.4	19.8	56.7

Total sump volume:

(Ref. 4, page 17)

$$V_{TOT} = 1/3\left(A_1 + A_2 + \sqrt{(A_1 \cdot A_2)}\right)h$$

Where:
A_1 = Area of bottom of sump
A_2 = Area of top of sump
h = Depth of sump



Y = Slope of sump side walls
$A_1 = X_1 * X_2$
$A_2 = (X_1 + 2(h*Y))*(X_2 + 2(h*Y))$

	X_1 (ft)	X_2 (ft)	Y (ft)	h (ft)	A_1 (ft^2)	A_2 (ft^2)	V_{TOT} (ft^3)
Developed Sectors							
-Sector 9	28.5	28.5	3	3	812	2,162	4,300
-Sector 10	29.67	29.67	3	3	880	2,272	4,567
Undeveloped Sectors							
-Sector 11	27	27	3	3	729	2,025	3,969
-Sector 12	27	27	3	3	729	2,025	3,969

Compute the number of days storage provided for the following:

$$\text{STORAGE (Detention Time)} = \frac{V_{TOT}}{V_{\text{Daily Inflow}}}$$

1. Active

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	1,040.4	4,300	4.1
Undeveloped Sectors	1,593.4	3,969	2.5

2. Inactive with Intermediate Cover

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	201.9	4,300	21.3
Undeveloped Sectors	328.2	3,969	12.1

3. Closed

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	50.1	4,300	85.9
Undeveloped Sectors	56.7	3,969	70.0

* The smallest total volume of the developed sectors' sumps is used.

C. Estimated rate of leachate removal.

Submersible pump capacity = 15 gpm

	Production (gpd)	Average Pump Time (min/day)	(hr/day)
Developed Sectors			
-Active	2,723.7	181.6	3.0
-Inactive with Interm. Cover	528.5	35.2	0.6
-Closed	131.0	8.7	0.1
Undeveloped Sectors			
-Active	4,171.5	278.1	4.6
-Inactive with Interm. Cover	859.2	57.3	1.0
-Closed	148.4	9.9	0.2

Average pump time is less than 24 hours per day, therefore the design is acceptable.

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION SYSTEM
CHIMNEY DRAIN CALCULATIONS

Required: Evaluate the adequacy of the chimney drain design along the leachate collection pipe for the maximum leachate impingement rate.

Method:

1. Determine the maximum leachate inflow rate into the chimney drain.
2. Determine the minimum drainage capacity of the chimney drain.
3. Compare the allowable flow rate to the required flow rate.

References:

1. GSE Nonwoven Geotextile (6 oz/sy).
2. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.
3. HELP results from Appendix IIIC, Appendix IIIC-A.3.

Solution:

1. Determine the maximum leachate inflow rate into the chimney drain.

A comparison of the developed Class 1 area, and undeveloped Class 1 area, was developed to determine the worst case scenario (i.e., which scenario generates the maximum leachate inflow rate). The peak daily generation rate is from HELP model analyses in Appendix IIIC, Appendix IIIC-A.3.

Sectors	Peak Daily Generation Rate, q		Maximum Drainage Length, L[1]	Inflow Rate, Q_{req}
	(cf/ac/day)	(cfs/sf)	(ft)	(cfs)
Developed Class 1 Areas	251.6	6.69E-08	610	4.08E-05
Undeveloped Class 1 Areas	855.0	2.27E-07	710	1.61E-04

[1] The maximum drainage length as shown takes in to account both sides draining to the chimney drain.

Maximum leachate inflow rate to the chimney drain per unit length (1 ft) is calculated using the following equation:

$$Q_{req} = L * 1 * q$$

where:

Q_{req} = Maximum leachate inflow rate into chimney drain, cfs
L = Maximum length draining to chimney drain from both sides
q = Peak daily leachate generation rate from HELP model listed above, cfs/sf

Maximum Leachate Generation Rate from above table:

Q_{req} =	1.61E-04	cfs

2. Determine the minimum drainage capacity of the chimney drain.

Minimum drainage capacity of the chimney drain per unit length (1 ft):

Q_{ult} = k * i * w * 1

where:

Q_{ult} = Ultimate flow rate
k = Minimum permeability of the geotextile wrap
i = Hydraulic gradient = 1 under free drainage
w = Width of the chimney drain keyed into the waste layer, measured at the top of protective layer, min. 3 ft, as shown in Appendix IIIA-A, Drawing A.4

k = 0.2 cm/s = 6.56E-03 fps (Ref. 1)
i = 1
w = 3 ft

Q_{ult} =	1.97E-02	cfs

To determine the allowable drainage capacity of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 2.

Q_{allow} = Q_{ult} / ORF

where:

Q_{allow} = Allowable flow rate
Q_{ult} = Ultimate flow rate
ORF = Overall reduction factor from Table 1

Q_{allow} =	1.37E-03	cfs

Q_{allow} =	1.37E-03	cfs	>>	Q_{req} =	1.61E-04	cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

APPENDIX IIIC-B

LEACHATE COLLECTION SYSTEM DESIGN CALCULATIONS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-B-1 through IIIC-B-95

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STATE OF TEXAS
NEVZAT TURAN
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PROFESSIONAL ENGINEER

02/22/22

LEACHATE COLLECTION PIPE
CAPACITY CALCULATIONS

REQUIRED: Size leachate collection system pipe in the undeveloped area and analyze the leachate collection pipe in the developed area.

METHOD:

A. Use leachate production rates determined from the HELP model analysis (see Appendix IIIC-A) to size the leachate collection pipes. The largest sector in the developed and the undeveloped areas is analyzed to provide for a conservative analysis.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Driscopipe, *Leachate Pipe Systems*, Phillips Drisco Inc., 1992.

SOLUTION:

Determine the peak daily flow rate estimate:

The following tables summarize the fill conditions that are likely to be present and have the greatest contribution of leachate into the LCS. The peak flow rate (lateral drainage in the LCS layer) is shown for each condition.

Developed Sectors:
From the HELP model results in Appendix IIIC-A (highest leachate generation values used from all HELP runs for developed sectors).

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Interim, 50' Waste	84.7	633.6
Interim, 100' Waste	216.3	1,617.9
Interim, 200' Waste	118.4	885.6
Interim, 300' Waste	190.2	1,422.7
Interim, 320'/330' Waste	220.8	1,651.6

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

For the developed sectors the largest area draining to a leachate collection pipe is 16.4 acres (pipe in Sector 4A/4B/4C).

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Interim condition, 50' waste over 2.0 ac
2. Interim condition, 100' waste over 3.0 ac
3. Interim condition, 200' waste over 4.1 ac
4. Interim condition, 300' waste over 5.3 ac
5. Interim condition, 320'/330' waste over 2.0 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Interim, 50' Waste	2.0	633.6	1,267.1	1.96E-03
Interim, 100' Waste	3.0	1,617.9	4,853.8	7.51E-03
Interim, 200' Waste	4.1	885.6	3,631.1	5.62E-03
Interim, 300' Waste	5.3	1,422.7	7,540.3	1.17E-02
Interim, 320'/330' Waste	2.0	1,651.6	3,303.2	5.11E-03
Total =	16.4		20,595.4	3.19E-02

Undeveloped Sectors:
From the HELP model results in Appendix IIIC-A :

CONDITION	PEAK[1] cfd/ac	PEAK gpd/ac
Active, 10' Waste	43.8	327.6
Interim, 50' Waste	106.5	796.6
Interim, 100' Waste	202.9	1,517.7
Interim, 200' Waste	111.7	835.5
Interim, 270' Waste	161.2	1,205.8

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

TURKEY CREEK LANDFILL
0771-368-11
LEACHATE COLLECTION PIPE
CAPACITY CALCULATIONS

The area draining to a leachate collection pipe in Sector 12 is 12.7 acres.

Therefore, the maximum leachate production expected in the leachate collection pipe is predicted to occur assuming the following scenario:

1. Active condition, 10' waste over 1.5 ac
2. Interim condition, 50' waste over 3.6 ac
3. Interim condition, 100' waste over 4.0 ac
4. Interim condition, 200' waste over 2.1 ac
5. Interim condition, 270' waste over 1.5 ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	1.5	327.6	491.4	7.60E-04
Interim, 50' Waste	3.6	796.6	2,867.8	4.44E-03
Interim, 100' Waste	4.0	1,517.7	6,070.8	9.39E-03
Interim, 200' Waste	2.1	835.5	1,754.6	2.71E-03
Interim, 270' Waste	1.5	1,205.8	1,808.7	2.80E-03
Total=	12.7		12,993.3	2.01E-02

Developed Sectors Peak Leachate Production = 3.19E-02 cfs

Undeveloped Sector Peak Leachate Production = 2.01E-02 cfs

Determination of flow capacity (Q_{full}) for proposed 6-inch ADS N-12 perforated pipe (Developed Areas):
*Use Developed Sectors Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Where:

A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

ID = 6.00 in
= 0.500 ft

A = 0.196 sq ft

R = 0.125 ft

S[1] = 0.002 ft / ft

[1]The 0.2 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number n = 0.012

Q_{full} =	0.272	cfs

Compare Peak Q_{max} and Q_{full} for the 6" ADS N-12 pipe:

Q_{full} =	0.272	cfs	>>	Q_{max} =	0.0319	cfs

An ADS N-12 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

Determination of flow capacity (Q_{full}) for proposed 6-inch SDR 17 perforated pipe (Undeveloped Area):
*Use Undeveloped Sectors Peak Leachate Production

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Where:
A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

ID =	6.00	in
=	0.500	ft
A =	0.196	sq ft
R =	0.125	ft
S[1] =	0.002	ft / ft

[1]The 0.2 percent slope was chosen as the minimum slope for the leachate collection pipes. Refer to Appendix IIIE-B.

n = Manning's number n = 0.015

Q_{full} =	0.217	cfs

Compare Peak Q_{max} and Q_{full} for the 6" ADS N-12 pipe:

Q_{full} =	0.217	cfs	>>	Q_{max} =	0.0201	cfs

An SDR 17 pipe with a nominal diameter of 6 inches exceeds flow capacity requirements.

B. Perforation configuration for a 6-inch perforated pipes:

Pipe perforations must allow free passage of leachate and also prevent migration of drainage media into collection pipes. Therefore, size of perforations depends on media particle size. Two perforations alternatives are evaluated below:

For leachate collection pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

	D_{85} =	25	mm
	=	0.984	in
Standard slot width:	d =	0.125	in

Check values to find that:

$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}}$ = 7.9 > 2.0 (acceptable)

For leachate collection pipes with circular holes:

$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

	D_{85} =	25	mm
	=	0.984	in
Standard hole diameter	d =	0.5	in

$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}}$ = 2.0 > 1.7 (acceptable)

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

OVERLINER LEACHATE COLLECTION PIPE CAPACITY CALCULATIONS

REQUIRED: Size overliner leachate collection system pipe:

METHOD:

A. Use leachate production rates determined from the HELP model analysis (see Appendix IIIC-A) to size the overliner leachate collection pipes.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.
2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.
3. Driscopipe, *Leachate Pipe Systems*, Phillips Drisco Inc., 1992.

SOLUTION:

Determine the peak daily flow rate estimate:

The following table summarizes the fill conditions that are likely to be present and have the greatest contribution of leachate into the overliner leachate drainage collection system.

From the HELP model (Appendix IIIC-A) :

CONDITION	PEAK cfd/ac	PEAK gpd/ac
Active, 10' Waste	39.8	297.7
Interim, 50' Waste	67.9	507.9
Interim, 100' Waste	150.4	1,125.0
Interim, 170' Waste	112.6	842.2

The largest overliner area draining to a pipe is 15.5 acres (Sector 01).

Therefore, the maximum leachate production expected in the leachate collection pipe for the overliner area is predicted to occur assuming the following scenario:

1. Active, 10' Waste	2.7	ac
2. Interim, 50' Waste	4.6	ac
3. Interim, 100' Waste	5.5	ac
4. Interim, 170' Waste	2.7	ac

CONDITION	AREA ac	PEAK gpd/ac	PEAK gpd	PEAK cfs
Active, 10' Waste	2.7	297.7	803.8	1.24E-03
Interim, 50' Waste	4.6	507.9	2,336.3	3.62E-03
Interim, 100' Waste	5.5	1,125.0	6,187.5	9.57E-03
Interim, 170' Waste	2.7	842.2	2,274.1	3.52E-03
Total=	15.5		11,601.6	1.80E-02

The total pre-Subtitle D overliner peak leachate production (cfs)= 1.80E-02

Determination of flow capacity (Q_{full}) for a 6-inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:

A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions
S = Design slope of pipe
n = Manning's number

From Pipe Structural Stability Calculations:

Standard Dimension Ratio (SDR) = 17

	ID =	5.845	in
	=	0.487	ft
$A = \frac{\Pi \times d^2}{4}$	A =	0.186	sq ft
$R = \frac{d}{4}$	R =	0.122	ft
	S[1] =	0.005	ft / ft

[1]The 0.5 percent slope was chosen as the minimum slope for the overliner leachate collection pipes. The leachate collection pipes will be placed at a slope that ensures a minimum 0.5 percent slope after settlement. Refer to Appendix IIIE-B.

n = 0.015

Q_{full} =	0.321	cfs

Compare Peak Q_{max} and Q_{full}:

Q_{full} =	0.321	cfs	>>	Q_{max} =	1.80E-02	cfs

Conclusion:

An SDR 17 pipe with an outer diameter of 6 inches exceeds flow capacity requirements. A perforated SDR 17 HDPE pipe will be used in the leachate collection trenches.

B. Perforation configuration for a 6-inch SDR 17 perforated pipe:

Pipe perforations must allow free passage of leachate and also prevent migration of drainage media into collection pipes. Therefore size of perforations depends on media particle size. Two perforations alternatives are evaluated below:

For leachate collection pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D 448 number 467 aggregate
Refer to Section 3.5 of Appendix IIIC for size gradation requirements.

D_{85} = 25 mm
= 0.984 in

Standard slot width: d = 0.125 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 7.9 > 2.0 \quad \text{(acceptable)}$$

For leachate collection pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.7$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D 448 number 467 aggregate
Refer to Section 3.5 of Appendix IIIC for size gradation requirements.

D_{85} = 25 mm
= 0.984 in

Standard hole diameter d = 0.5 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 2.0 > 1.7 \quad \text{(acceptable)}$$

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

LEACHATE COLLECTION PIPE
STRUCTURAL STABILITY

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
DEVELOPED AREAS

REQUIRED: Analyze structural stability of the 6 inch diameter leachate collection system pipe in developed areas.

METHOD:

A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

NOTE:

1. The leachate trench details shown on pages IIIC-B-33 and IIIC-B-34 are for illustration purposes only to show parameters used in the following calcualtions. Leachate collection system details can be found in Appendix IIIA-A.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

7. www.ads-pipe.com

8. Advanced Drainage Systems, Inc. *Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution,* October 2003.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight =	190,500	lb
Tire pressure =	80	psi
Number of tires =	4	

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

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

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z = 24 in

y =	27.8	psi

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
DEVELOPED AREAS

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z =	24	in
w =	120	pcf

P_D =	1.67	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft protective cover @	120	pcf =	240	psf	
3.5	ft final & intrm cover @	120	pcf =	420	psf	
330.0	ft solid waste/soil @	78	pcf =	25,740	psf	Highest waste column thickness
			Σ =	26,400	psf	over a 6" LCS pipe.

P_T =	183.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	183.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

Determine design stress:

1. Adjust critical stress to account for loss of strength in the pipe due to perforations:

$P_{DES1} = 12P_T / (12 - l_p)$

Where:

l_p	=	Cumulative length of perforations per foot of pipe
P_T	=	Critical pipe stress (psi)
P_{DES1}	=	Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	183.3	psi

P_{DES1} =	244.4	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-33), the pipe may be classified as a positive projecting conduit.

2b. Because the pipe is flexible and will deflect in the vertical plane as shown on Figure 2 (page IIIC-B-34), the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIIC-B-34).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\,2} \quad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right)e^{\pm 2k\mu(H_e/B_c)} \quad (2)$$

Where:

W_c	=	Load per unit length of conduit (lb/ft)
γ	=	Unit weight of soil above conduit (pcf)
B_c	=	Outer diameter of conduit (ft)
H	=	Height of fill above conduit (ft)
H_e	=	Height of plane of equal settlement above critical plane (ft)
k	=	Lateral pressure ratio (earth pressure coefficient)
μ	=	tan ϕ
ϕ	=	Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \qquad (3)$$

Where:
- r_{sd} = Settlement ratio
- p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

Where:
- S_m = Compression deformation of soil column adjacent to conduit
- S_g = Settlement of natural ground adjacent to conduit
- S_f = Settlement of conduit into foundation material
- dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.51

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$S_m = P_{DES1}\, D / E_s$

Where:
- P_{DES1} = Pipe stress adjusted for loss of strength (psi)
- D = Pipe diameter (in)
- E_s = PZB soil modulus (psi)

P_{DES1} =	244.4	psi
D =	6.92	in
E_s =	3,000	psi

S_m =	0.564	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m (1 - r_{sd})$$

dc =	0.849	in

Step 4: Use the Iowa Formula (provided below) to calculate load per unit length (W_c).

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
- DL = Deflection lag factor
- k = Bedding factor
- E = Young's modulus for pipe material (psi)
- I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
- r = Pipe radius (in)
- E' = Modulus of soil reaction (psi)

DL =	2.5	(Ref 6)
k =	0.1	(Ref 6)
E =	26,000	psi (refer to chart 25 on page IIIC-B-35, based on P_{DES1} above)
t =	0.92	in (ADS N-12 HDPE pipe)
I =	0.065	in^4/in
r =	3.5	in
E' =	3,000	psi

W_c =	760	lb/in

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\ 2}}$$

Composite unit weight for waste and soil:

5.5	ft soil @	120	pcf =	660	psf
330.0	ft waste @	78	pcf =	25,740	psf
			Total =	26,400	psf

γ =	78.69	pcf (weighted average based on above table)
B_c =	6.92	in

C_c =	348.5	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

	H =	330	ft
	H/B_c =	572.3	
Assume:	H_e/B_c =	1.91	
	kμ =	0.13	(Ref 4)
	$e^{-2k\mu(He/Bc)}-1$ =	-0.39	
	-2kμ =	-0.26	
	$(H/B_c - H_e/B_c)$ =	570.3	
	$e^{-2k\mu(He/Bc)}$ =	0.61	

Left-hand-side of equation (LHS) = 349
Right-hand-side of equation (RHS) = 349

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$
$$\pm \frac{r_{sd}p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

p =	1
kμ =	0.13
H/B_c =	572.3
H_e/B_c =	1.91
r_{sd} =	-0.51
LHS =	290
RHS =	290

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

2e. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

W_c =	760	lb/in
D =	6.9	in
P_{DES2} =	**110**	**psi**

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR = OD / t

SDR	= Standard dimension ratio	=	7.5	
S_Y	= compressive yield strength	=	2,000	psi (Ref. 8, page 4)
RD_{all}	= allowable ring deflection	=	5.0	% (see page IIIC-B-37)

1. Wall crushing (Ref 3)

$S_A = P_{DES2}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
- S_A = Actual compressive stress (psi)
- SDR = Standard dimension ratio
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- S_Y = Compressive yield strength (psi)
- FS = Factor of safety against wall crushing

P_{DES2} = 110 psi

S_A =	358.1	psi
FS =	5.6	

Compare calculated and suggested factor of safety:	5.6	> 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
- P_{cb} = Critical buckling pressure at top of pipe (psi)
- E' = Soil modulus (psi)
- E = Stress/time dependent tensile modulus for design loading conditions (psi)
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- FS = Factor of safety against wall buckling

E' =	3,000	psi
E =	23,000	psi for 50 years based on S_A above (see chart page IIIC-B-35)
P_{DES2} =	109.8	psi

P_{cb} =	490.7	psi
FS =	4.5	

Compare calculated and suggested factor of safety:	4.5	> 1.0

3. Ring deflection (Ref 3)

$$E_S = P_{DES2} / E'$$

Where:
E_S = Soil strain (%)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
E' = Soil modulus (psi)

P_{DES2} =	109.8	psi
E' =	3,000	psi

E_S =	3.7	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} = 3.7 %

Allowable ring deflection, RD_{all} = 5.00 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the leachate collection system due to the presence of a gravel envelope surrounding the leachate collection pipe. The gravel layer will transmit leachate in the event that the leachate collection pipe becomes plugged or crushed.

TURKEY CREEK LANDFILL
0023-406-11
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE
UNDEVELOPED AREA

REQUIRED: Analyze structural stability of the 6 inch diameter leachate collection system pipe for the undeveloped area.

METHOD:

A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

NOTE:

1. The leachate trench details shown on pages IIIC-B-33 and IIIC-B-34 are for illustration purposes only to show parameters used in the following calcualtions. Leachate collection system details can be found in Appendix IIIA-A.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight =	190,500	lb
Tire pressure =	80	psi
Number of tires =	4	

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
- r = Radius of contact (in)
- F = Force exerted by one tire (lb)
- p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

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

Where:
- y = Change in vertical stress (psi)
- p = Tire pressure (psi)
- r = Radius of contact (in)
- z = Protective cover thickness (in)

z = 24 in

y =	27.8	psi

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z = 24 in
w = 120 pcf

P_D =	1.67	psi

P_T = $P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft protective cover @	120	pcf =	240	psf	
3.5	ft final & intrm cover @	120	pcf =	420	psf	
270.0	ft solid waste/soil @	78	pcf =	21,060	psf	Highest waste column thickness
			Σ =	21,720	psf	over a 6" LCS pipe.

P_T =	150.8	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	150.8	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

Determine design stress:

1. Adjust critical stress to account for loss of strength in the pipe due to perforations:

$P_{DES1} = 12P_T / (12 - l_p)$

Where:

l_p	= Cumulative length of perforations per foot of pipe
P_T	= Critical pipe stress (psi)
P_{DES1}	= Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	150.8	psi
P_{DES1} =	201.1	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-33), the pipe may be classified as a positive projecting conduit.

2b. Because the pipe is flexible and will deflect in the vertical plane as shown on Figure 2 (page IIIC-B-34), the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIIC-B-34).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^2 \quad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \quad (2)$$

Where:

W_c	= Load per unit length of conduit (lb/ft)
γ	= Unit weight of soil above conduit (pcf)
B_c	= Outer diameter of conduit (ft)
H	= Height of fill above conduit (ft)
H_e	= Height of plane of equal settlement above critical plane (ft)
k	= Lateral pressure ratio (earth pressure coefficient)
μ	= tan ϕ
ϕ	= Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \quad (3)$$

Where:
- r_{sd} = Settlement ratio
- p = Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \quad (4)$$

Where:
- S_m = Compression deformation of soil column adjacent to conduit
- S_g = Settlement of natural ground adjacent to conduit
- S_f = Settlement of conduit into foundation material
- dc = Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \quad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

<u>Step 1:</u> Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.66

<u>Step 2:</u> Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$S_m = P_{DES1}\, D / E_s$

Where:
- P_{DES1} = Pipe stress adjusted for loss of strength (psi)
- D = Pipe diameter (in)
- E_s = PZB soil modulus (psi)

P_{DES1} =	201.1	psi
D =	6.625	in
E_s =	3,000	psi

S_m =	0.444	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.736	in

Step 4: Use the Iowa Formula (provided below) to calculate load per unit length (W_c).

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
- DL = Deflection lag factor
- k = Bedding factor
- E = Young's modulus for pipe material (psi)
- I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
- r = Pipe radius (in)
- E' = Modulus of soil reaction (psi)

DL =	2.5	(Ref 6)
k =	0.1	(Ref 6)
E =	28,000	psi (refer to chart 25 on page IIIC-B-35, based on P_{DES1} above)
t =	0.390	in (SDR 17 pipe)
I =	0.005	in^4/in
r =	3.3	in
E' =	3,000	psi

W_c =	550	lb/in

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\,2}}$$

Composite unit weight for waste and soil:

5.5	ft soil @	120	pcf =	660	psf
270.0	ft waste @	78	pcf =	21,060	psf
			Total =	21,720	psf

γ =	78.84	pcf (weighted average based on above table)
B_c =	6.625	in

C_c =	274.6	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

	H =	270	ft
	H/B_c =	489.1	
Assume:	H_e/B_c =	2.23	
	kμ =	0.13	(Ref 4)
	$e^{-2k\mu(He/Bc)}-1$ =	-0.44	
	-2kμ =	-0.26	
	$(H/B_c - H_e/B_c)$ =	486.8	
	$e^{-2k\mu(He/Bc)}$ =	0.56	

Left-hand-side of equation (LHS) = 275
Right-hand-side of equation (RHS) = 275

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}p}{3}\right] \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$
$$\pm \frac{r_{sd}p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\, p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

p =	1
kμ =	0.13
H/B_c =	489.1
H_e/B_c =	2.23
r_{sd} =	-0.66
LHS =	321
RHS =	321

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

2e. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

W_c =	550	lb/in
D =	6.6	in

P_{DES2} =	83	psi

A summary table for the structural stability analysis is provided on page IIIC-B-32 for the 6-inch-diameter leachate collection pipe. A pipe will be selected from this table for use in the collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES2} (SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
- S_A = Actual compressive stress (psi)
- SDR = Standard dimension ratio
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- S_Y = Compressive yield strength (psi)
- FS = Factor of safety against wall crushing

P_{DES2} = 83 psi

S_A =	664.1	psi
FS =	2.3	

Compare calculated and suggested factor of safety:	2.3	> 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8 (E' (2.32E / SDR^3))^{1/2}$ $FS = P_{cb} / P_{DES2}$

Where:

P_{cb}	=	Critical buckling pressure at top of pipe (psi)
E'	=	Soil modulus (psi)
E	=	Stress/time dependent tensile modulus for design loading conditions (psi)
P_{DES2}	=	Load pipe adjusted to account for effects of soil arching (psi)
FS	=	Factor of safety against wall buckling

E' =	3,000	psi
E =	16,500	psi for 50 years based on S_A above (see chart page IIIC-B-35)
P_{DES2} =	83	psi

P_{cb} =	122.3	psi
FS =	1.5	

Compare calculated and suggested factor of safety:	1.5	> 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:

E_S	=	Soil strain (%)
P_{DES2}	=	Load pipe adjusted to account for effects of soil arching (psi)
E'	=	Soil modulus (psi)

P_{DES2} =	83	psi
E' =	3,000	psi

E_S =	2.8	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} = 2.8 %

Allowable ring deflection, RD_{all} = 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the leachate collection system due to the presence of a gravel envelope surrounding the leachate collection pipe. The gravel layer will transmit leachate in the event that the leachate collection pipe becomes plugged or crushed.

Prep By: BPY
Date: 2/22/2022

Chkd By: NT
Date: 2/22/2022

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
6" DIA PIPE

Adjusted load to account for soil arching = 83 psi

	Wall Crushing			Wall Buckling				Ring Deflection			
SDR	S_Y	S_A	FS_{WC}	E^2	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	1,307.4	1.1	13,000	3,000	41.1	0.5	8.1	3,000	2.8	2.9
26.0	1,500	1,037.7	1.4	13,000	3,000	57.4	0.7	6.5	3,000	2.8	2.3
21.0	1,500	830.1	1.8	13,000	3,000	79.1	1.0	5.2	3,000	2.8	1.9
19.0	1,500	747.1	2.0	14,000	3,000	95.4	1.1	4.7	3,000	2.8	1.7
17.0 [1]	1,500	664.1	2.3	16,500	3,000	122.3	1.5	4.2	3,000	2.8	1.5
15.5	1,500	601.8	2.5	17,000	3,000	142.6	1.7	3.9	3,000	2.8	1.4
13.5	1,500	519.2	2.9	18,500	3,000	182.8	2.2	3.4	3,000	2.8	1.2
11.0	1,500	415.1	3.6	21,000	3,000	265.1	3.2	2.7	3,000	2.8	1.0

denotes standard size

[1] Select 6-inch-diameter HDPE SDR 17.0 pipe for use in the leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the chart (page IIIC-B-35), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

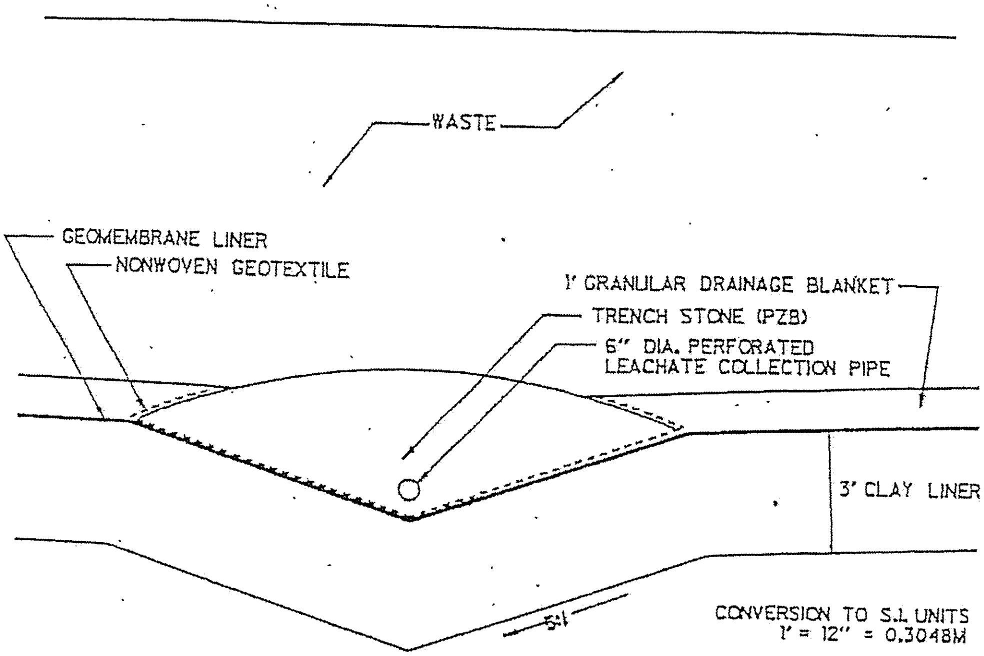

FIGURE 1: TYPICAL V-SHAPED TRENCH FOR LANDFILLS WITH COMPOSITE LINERS

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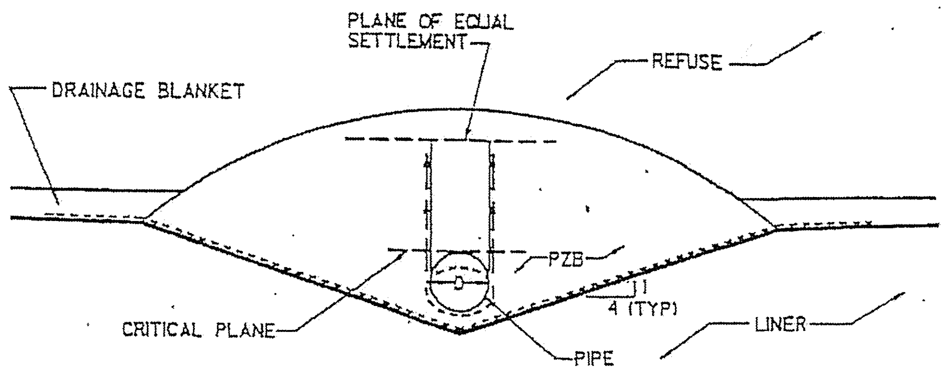

FIGURE 2: SETTLEMENT OF LEACHATE PIPE INDUCING SHEAR STRESSES IN PZB

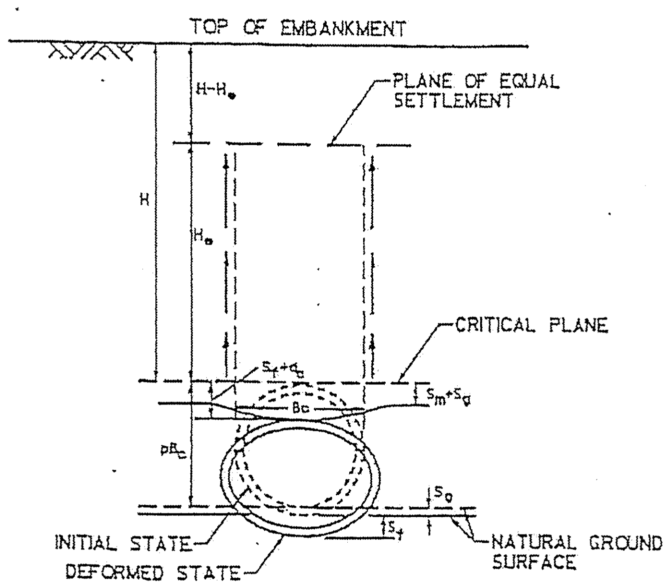

FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

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here: S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

P_t = Total vertical soil pressure at the top of the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_c = Hydrostatic, critical-collapse differential pressure, psi

$$P_c = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: $(D_{MIN}/D_{MAX}) = .95$
μ = Poission's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling should be examined.

Design by Wall Buckling Guidelines:
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$.

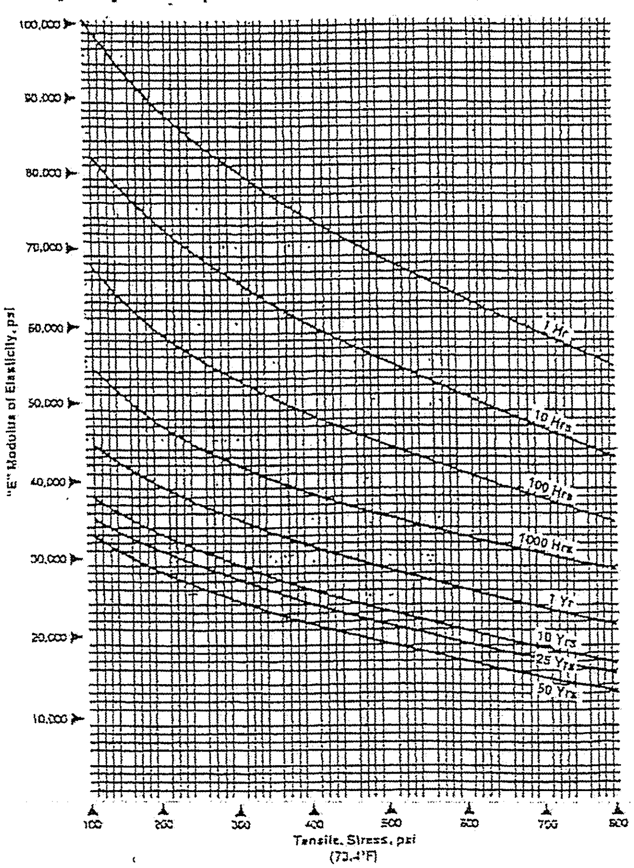
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR - 1)\,P_t}{2}$$

3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi.

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

Simplified Burial Design: A conservative estimate of the ability of Driscopipe pipelines to perform in a buried environment is found in Chart 24. It is based on a minimum 2:1 safety factor and 50 year design service life. A detailed burial design starts on page 37. The detailed design should be used for critical or marginal applications or whenever a more precise solution is desired.

Detailed Burial Design:
Design by Wall Crushing: Wall crushing would theoretically occur when the stress in a pipe wall, due to the external vertical pressure, exceeded the long-term compressive strength of the pipe material. To ensure that the Driscopipe wall is strong enough to endure the external pressure the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Values of E'

Based on Soil Type (ASTM D2321) and Degree of Compaction

Soil Type of Initial Backfill Embedment Material	Description	E' (psi) for Degree of Compaction (Proctor Density, %)			
		Loose	Slight (70-85%)	Moderate (85-95%)	High (95%)
I	Manufactured angular, granular materials (crushed stone or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	N.R.	1,000	2,000	3,000
III	Coarse grained soils with fines	N.R.	N.R.	1,000	2,000
IV	Fine-grained soils	N.R.	N.R.	N.R.	N.R.
V	Organic soils (peat, muck, clay, etc.)	N.R.	N.R.	N.R.	N.R.

N.R. = Not Recommended for use by ASTM D2321 for pipe wall support

Chart 24

SDR	Maximum Burial Depth, ft. in dry soil of 100 lbs/cu. ft. Soil Modulus, psi*			Maximum External Pressure psi Soil Modulus, psi*			Maximum Deflection, % after installation Soil Modulus, psi*		
	1000	2000	3000	1000	2000	3000	1000	2000	3000
32.5	25	32	37	17	22	26	1.7	0.9	0.6
26	33	45	52	23	31	36	2.3	1.2	0.8
21	46	61	71	32	42	49	3.2	1.6	1.1
19	52	69	81	36	48	56	3.6	1.8	1.2
17	61	121	181	42	84	126	4.2	2.1	1.4
15.5	56	112	168	39	78	117	3.9	2.0	1.3
13.5	49	98	147	34	68	102	3.4	1.7	1.1
11	39	78	117	27	54	81	2.7	1.4	0.9
9.3	33	68	101	23	47	70	2.3	1.2	0.8
8.3	30	61	89	21	42	62	2.1	1.1	0.7
7.3	26	52	79	18	36	55	1.8	0.9	0.6

*assumes no external loads

LEACHATE GRADE ADS N-12 PRODUCT INFORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Inner Liner Thickness, Minimum	Minimum Pipe Stiffness @ 5% Deflection	Weight kg./6m (lbs./20 ft.)	Area mm^2/mm	"I" cm^4/cm	"C" mm
100 mm (4")	104 mm (4.10")	120 mm (4.78")	0.635 mm (0.025")	485 kN/m^2 70 psi	5.10 kg (11.24 lbs)	2.87 (0.113 in^2/in)	0.026 (0.0016 in^4/in)	3.56 (0.14 in)
150 mm (6")	152 mm (6.00")	176 mm (6.92")	0.635 mm (0.025")	450 kN/m^2 65 psi	9.90 kg (21.83 lbs)	3.63 (0.143 in^2/in)	0.062 (0.0038 in^4/in)	5.08 (0.20 in)
200 mm (8")	200 mm (7.90")	233 mm (9.11")	0.9 mm (0.035")	415 kN/m^2 60 psi	15.80 kg (34.83 lbs)	4.22 (0.166 in^2/in)	0.128 (0.0078 in^4/in)	6.35 (0.25 in)
250 mm (10")	251 mm (9.90")	287 mm (11.36")	0.6 mm (0.024")	345 kN/m^2 50 psi	20.50 kg (45.20 lbs)	3.48 (0.137 in^2/in)	0.134 (0.008 in^4/in)	7.68 (0.30 in)
300 mm (12")	308 mm (12.15")	367 mm (14.45")	0.9 mm (0.035")	345 kN/m^2 50 psi	28.96 kg (63.80 lbs)	5.50 (0.217 in^2/in)	0.574 (0.035 in^4/in)	10.92 (0.43 in)
375 mm (15")	380 mm (14.98")	448 mm (17.62")	1.0 mm (0.039")	290 kN/m^2 42 psi	42.00 kg (92.50 lbs)	6.91 (0.272 in^2/in)	0.901 (0.055 in^4/in)	13.21 (0.52 in)
450 mm (18")	459 mm (18.07")	536 mm (21.20")	1.3 mm (0.051")	275 kN/m^2 40 psi	58.38 kg (128.60 lbs)	6.93 (0.273 in^2/in)	1.327 (0.081 in^4/in)	14.48 (0.57 in)
600 mm (24")	612 mm (24.08")	719 mm (27.80")	1.5 mm (0.059")	235 kN/m^2 34 psi	101.97 kg (224.60 lbs)	8.23 (0.324 in^2/in)	2.245 (0.137 in^4/in)	18.80 (0.74 in)
750 mm (30")	762 mm (30.00")	892 mm (35.10")	1.5 mm (0.059")	195 kN/m^2 28 psi	139.97 kg (308.30 lbs)	9.60 (0.378 in^2/in)	4.539 (0.277 in^4/in)	21.84 (0.86 in)
900 mm (36")	914 mm (36.00")	1059 mm (41.70")	1.7 mm (0.067")	150 kN/m^2 22 psi	163.98 kg (361.20 lbs)	10.19 (0.401 in^2/in)	6.555 (0.400 in^4/in)	25.40 (1.00 in)

Date: December, 1999

REQUIRED: Analyze structural stability of the 18 inch diameter leachate collection system pipe for developed and undeveloped areas.

METHOD:

A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

NOTE: The leachate trench details shown on pages IIIC-B-33 and IIIC-B-34 are for illustration purposes only to show parameters used in the following calcualtions. Leachate collection system details can be found in Appendix IIIA-A.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight =	190,500	lb
Tire pressure =	80	psi
Number of tires =	4	

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
- r = Radius of contact (in)
- F = Force exerted by one tire (lb)
- p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

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

Where:
- y = Change in vertical stress (psi)
- p = Tire pressure (psi)
- r = Radius of contact (in)
- z = Protective cover thickness (in)

z =	24	in

y =	27.8	psi

Assume only one wheel load on pipe and add 50% for impact loading:

P_L = 1.5y

Where: P_L = Maximum live load (psi)

P_L =	41.7	psi

P_D = (zw)/1728

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z =	24	in
w =	120	pcf

P_D =	1.67	psi

P_T = P_L + P_D

Where: P_T = Maximum construction load (psi)

P_T =	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft gravel & cover @	120	pcf =	240	psf
3.5	ft final & intrm cover @	120	pcf =	420	psf
70	ft solid waste/soil @	55	pcf =	3,850	psf
			Σ =	4,510	psf

P_T =	31.3	psi

Determine critical loading condition:

Construction loading:	P_T =	43.3	psi
Overburden loading:	P_T =	31.3	psi

Construction loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

Determine Desing Stress:

1. Adjust critical stress to account for loss of strength in the pipe due to perforations:

$$P_{DES1} = 12P_T / (12 - l_p)$$

Where:
- l_p = Cumulative length of perforations per foot of pipe
- P_T = Critical pipe stress (psi)
- P_{DES1} = Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	43.3	psi
P_{DES1} =	41.8	psi

Adjust pipe stress determined above to account for effects of soil arching:

2. The design pipe stress is estimated by accounting for the soil structure interaction between the buried leachate collection pipe and its backfill to obtain a realistic loading condition on the pipe.

2a. For the burial conditions shown on Figure 1 (page IIIC-B-33), the pipe may be classified as a positive projecting conduit.

2b. Because the pipe is flexible and will deflect in the vertical plane as shown on Figure 2 (page IIIC-B-34), the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page IIIC-B-34).

2c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^{\,2} \qquad (1)$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) e^{\pm 2k\mu(H_e/B_c)} \qquad (2)$$

Where:

W_c	= Load per unit length of conduit (lb/ft)
γ	= Unit weight of soil above conduit (pcf)
B_c	= Outer diameter of conduit (ft)
H	= Height of fill above conduit (ft)
H_e	= Height of plane of equal settlement above critical plane (ft)
k	= Lateral pressure ratio (earth pressure coefficient)
μ	= tan ϕ
ϕ	= Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p \left(\frac{H}{B_c}\right) \qquad (3)$$

Where:

r_{sd}	= Settlement ratio
p	= Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \qquad (4)$$

Where:

S_m	= Compression deformation of soil column adjacent to conduit
S_g	= Settlement of natural ground adjacent to conduit
S_f	= Settlement of conduit into foundation material
dc	= Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \qquad (5)$$

Since the trench aggregate (PZB) is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

2d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.69

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$S_m = P_{DES1}\, D / E_s$

Where:
- P_{DES1} = Pipe stress adjusted for loss of strength (psi)
- D = Pipe diameter (in)
- E_s = PZB soil modulus (psi)

P_{DES1} =	41.8	psi
D =	18	in
E_s =	3,000	psi

S_m =	0.251	in

Step 3: Calculate dc using Equation (5):

$dc = S_m (1 - r_{sd})$

dc =	0.422	in

Step 4: Use the Iowa Formula (provided below) to calculate load per unit length (W_c).

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
- DL = Deflection lag factor
- k = Bedding factor
- E = Young's modulus for pipe material (psi)
- I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
- r = Pipe radius (in)
- E' = Modulus of soil reaction (psi)

DL =	2.5	(Ref 6)
k =	0.1	(Ref 6)
E =	33,000	psi (refer to chart 25 on page IIIC-B-35, based on P_{DES1} above)
t =	1.059	in (SDR 17 pipe)
I =	0.099	in^4/in
r =	9.0	in
E' =	3,000	psi

W_c =	317	lb/in

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\,2}}$$

Composite unit weight for waste and soil:

5.5	ft soil @	120	pcf =	660	psf
70.0	ft waste/soil @	55	pcf =	3,850	psf
			Total =	4,510	psf

γ =	59.7	pcf (weighted average based on above table)
B_c =	18	in

C_c =	28.3	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	76	ft
H/B_c =	50.3	

Assume: H_e/B_c = 2.27

$k\mu$ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.45	
$-2k\mu$ =	-0.26	
$(H/B_c - H_e/B_c)$ =	48.1	
$e^{-2k\mu(He/Bc)}$ =	0.55	

Left-hand-side of equation (LHS) = 28
Right-hand-side of equation (RHS) = 28

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}\,p}{3}\right]\frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$

$$\pm \frac{r_{sd}\,p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right)e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}\,p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

p =	1
kμ =	0.13
H/B_c =	50.3
H_e/B_c =	2.265
r_{sd} =	-0.69
LHS =	34
RHS =	34

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

2e. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

W_c =	317	lb/in
D =	18.0	in

P_{DES2} =	18	psi

A summary table for the structural stability analysis is provided on page IIIC-B-48 for the 18-inch-diameter leachate collection pipe. A pipe will be selected from this table for use in the collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES2}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
- S_A = Actual compressive stress (psi)
- SDR = Standard dimension ratio
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- S_Y = Compressive yield strength (psi)
- FS = Factor of safety against wall crushing

P_{DES2} = 18 psi

S_A =	140.7	psi
FS =	10.7	

Compare calculated and suggested factor of safety:	10.7	> 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
- P_{cb} = Critical buckling pressure at top of pipe (psi)
- E' = Soil modulus (psi)
- E = Stress/time dependent tensile modulus for design loading conditions (psi)
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- FS = Factor of safety against wall buckling

E' =	3,000	psi
E =	31,000	psi for 50 years based on S_A above (see chart page IIIC-B-35)
P_{DES2} =	18	psi

P_{cb} =	167.6	psi
FS =	9.5	

Compare calculated and suggested factor of safety:	9.5	> 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES2} / E'$

Where:
E_S = Soil strain (%)
P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
E' = Soil modulus (psi)

P_{DES2} =	18	psi
E' =	3,000	psi

E_S =	0.6	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RDact) is equal to soil strain.

RD_{act} = 0.6 %

Allowable ring deflection, RD_{all} = 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION PIPE STRUCTURAL STABILITY
18"-DIA PIPE

Adjusted load to account for soil arching = 18 psi

SDR	Wall Crushing			Wall Buckling				Ring Deflection			
	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
32.5	1,500	277.0	5.4	25,000	3,000	57.0	3.2	8.1	3,000	0.6	13.8
26.0	1,500	219.9	6.8	27,500	3,000	83.5	4.7	6.5	3,000	0.6	11.1
21.0	1,500	175.9	8.5	29,500	3,000	119.1	6.8	5.2	3,000	0.6	8.9
19.0	1,500	158.3	9.5	30,000	3,000	139.6	7.9	4.7	3,000	0.6	8.0
17.0 [1]	1,500	140.7	10.7	31,000	3,000	167.6	9.5	4.2	3,000	0.6	7.2
15.5	1,500	127.5	11.8	31,500	3,000	194.1	11.0	3.9	3,000	0.6	6.7
13.5	1,500	110.0	13.6	32,500	3,000	242.3	13.8	3.4	3,000	0.6	5.8
11.0	1,500	87.9	17.1	33,000	3,000	332.3	18.9	2.7	3,000	0.6	4.6

(shaded) denotes standard size

[1] Select 18-inch-diameter HDPE SDR 17.0 pipe for use in the leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-35), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

OVERLINER LEACHATE COLLECTION PIPE STRUCTURAL STABILITY

TURKEY CREEK LANDFILL
0771-368-11
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

REQUIRED: Analyze structural stability of the 6 inch diameter overliner leachate collection system pipe.

METHOD:

A. Determine the critical load and calculate stress under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage,* Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook,* Edition 27, October 1996.

6. Quian, Xuede, R.M. Koerner, D. H. Gray, "Geotechnical Aspects of Landfill Design and Construction." Prentice-Hall, Inc., New Jersey, 2002.

SOLUTION:

A. Determine the critical load and stress:

A.1. Maximum construction loading:

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight =	190,500	lb
Tire pressure =	80	psi
Number of tires =	4	

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

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

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Protective cover thickness (in)

z = 24 in

y =	27.8	psi

Assume only one wheel load on pipe and add 50% for impact loading:

$P_L =$ 1.5y

Where: P_L = Maximum live load (psi)

$P_L =$	41.7	psi

$P_D =$ (zw)/1728

Where:
P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z = 24 in
w = 120 pcf

$P_D =$	1.67	psi

$P_T =$ $P_L + P_D$

Where: P_T = Maximum construction load (psi)

$P_T =$	43.3	psi

A.2. Overburden loading (postclosure load):

For maximum fill load on pipe:

2.0	ft protective cover @	120	pcf =	240	psf
3.5	ft final & intrm cover @	120	pcf =	420	psf
170.0	ft solid waste/soil @	78	pcf =	13,260	psf
			Σ =	13,920	psf

$P_T =$	96.7	psi

Determine critical loading condition:

Construction loading:	$P_T =$	43.3	psi
Overburden loading:	$P_T =$	96.7	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to analyze pipe stability.

A summary table for the structural stability analysis is provided on page IIIC-B-55 for the 6-inch-diameter overliner leachate collection pipe. A pipe will be selected from this table for use in the overliner leachate collection system based on the calculated factors of safety for each possible failure condition. An example calculation is provided below that outlines the procedures used to determine the factors of safety for all pipe SDR sizes shown in the summary table.

B. Use the critical loading pressure to analyze pipe stability:

Example pipe structural stability calculations:

SDR	= Standard dimension ratio	=	17	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES}\,(SDR - 1) / 2$ FS $= S_Y / S_A$

Where:
- S_A = Actual compressive stress (psi)
- SDR = Standard dimension ratio
- P_{DES} = Critical pipe load (psi)
- S_Y = Compressive yield strength (psi)
- FS = Factor of safety against wall crushing

P_{DES} = 96.7 psi

S_A = 773.3 psi
FS = 1.9

Compare calculated and suggested factor of safety: 1.9 > 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES}$

Where:
- P_{cb} = Critical buckling pressure at top of pipe (psi)
- E' = Soil modulus (psi)
- E = Stress/time dependent tensile modulus for design loading conditions (psi)
- P_{DES} = Critical pipe load (psi)
- FS = Factor of safety against wall buckling

E' = 3,000 psi
E = 14,000 psi for 50 years based on S_A above (see chart page IIIC-B-35)
P_{DES} = 96.7 psi

P_{cb} = 112.7 psi
FS = 1.2

Compare calculated and suggested factor of safety: 1.2 > 1.0

3. Ring deflection (Ref 3)

$E_S = P_{DES} / E'$

Where:

E_S = Soil strain (%)
P_{DES} = Critical pipe load (psi)
E' = Soil modulus (psi)

P_{DES} =	96.7	psi
E' =	3,000	psi

E_S =	3.2	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} =	3.2	%
Allowable ring deflection, RD_{all} =	4.2	%

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the overliner leachate collection system due to the presence of a gravel envelope surrounding the overliner leachate collection pipe. The gravel layer will transmit leachate in the event that the overliner leachate collection pipe becomes plugged or crushed.

TURKEY CREEK LANDFILL
9771-368-11
OVERLINER PIPE STRUCTURAL STABILITY
6" DIA PIPE

Critical pipe load = 96.7 psi

	Wall Crushing			Wall Buckling				Ring Deflection			
SDR	S_Y	S_A	FS_{WC}	E[2]	E'	P_{cb}	FS_{WB}	RD_{all}	E'	RD_{act}	FS_{RD}
21.0	1,500	966.7	1.6	20,500	3,000	99.3	1.0	5.2	3,000	3.2	1.6
19.0	1,500	870.0	1.7	21,500	3,000	118.2	1.2	4.7	3,000	3.2	1.5
17.0 [1]	1,500	773.3	1.9	23,000	3,000	144.4	1.5	4.2	3,000	3.2	1.3
15.5	1,500	700.8	2.1	24,000	3,000	169.4	1.8	3.9	3,000	3.2	1.2
13.5	1,500	604.7	2.5	25,500	3,000	214.6	2.2	3.4	3,000	3.2	1.1
11.0	1,500	483.3	3.1	27,500	3,000	303.4	3.1	2.7	3,000	3.2	0.8

(shaded) denotes standard size

[1] Select 6-inch-diameter HDPE SDR 17.0 pipe for use in the overliner leachate collection system based on the calculated factors of safety.

[2] Values for the modulus of elasticity were selected from the attached chart (page IIIC-B-35), Reference 3, using the calculated stress in the pipe wall (S_A under the wall crushing heading in the above table) for a 50 year duration (maximum loading is the overburden load on the pipe).

LEACHATE SUMP DESIGN

REQUIRED: Size leachate collection sumps.

METHOD:

A. Use leachate production rates from HELP model and the sump drainage area from Sheet IIIC-B-62. The largest drainage area in the developed and the undeveloped area are analyzed to provide for a conservative analysis. Sump details are provided in Appendix IIIA-A Liner, Overliner, and Final Cover System Details.
B. Determine geometry of sump and its corresponding storage capacity.
C. Assume pump size and determine the average pump cycle time.

REFERENCES:

1. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

2. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Heisler, Sanford I., P.E., Wiley Engineer's Desk Reference, John Wiley & Sons, Inc., New York, 1998.

SOLUTION:

A. Average flow rate into sump

A.1 Determine the per acre flow rate for specific leachate collection sumps.

The following tables summarize the fill conditions that are likely to be present within each cell and have the greatest contribution of leachate into the LCS and sump system. The average flow rates (lateral drainage in the LCS layer) are shown for each condition.

Leachate sump drainage areas are shown on Sheet IIIC-B-62 - Sump Drainage Areas.

Developed Sectors:
From the HELP model results in Appendix IIIC-A:

For the developed sectors, the largest area draining to the sump is 16.4 acres (sump located in Sector 4A/4B/4C)
For each fill condition, the highest leachate generation rate from the HELP runs for developed sectors and overliner area was used to be conservative.

Condition	Average cfy/ac	Average gpd/ac
Interim, 50' Waste	6,315.2	129.4
Interim, 100' Waste	28,618.0	586.5
Interim, 200' Waste	24,311.4	498.2
Interim, 200' Waste	35,284.7	723.1
Interim, 300' Waste	40,226.3	824.4
Closed, 320'/330' Waste	25,894.3	530.7

[1]This leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

Undeveloped Sectors:
From the HELP model results in Appendix IIIC-A:

The largest area draining to a sump is 20.2 acres (sump located in Sector 14). The leachate generation rate from the HELP runs for the undeveloped sectors and overliner areas was used. The higher of the two runs was used.

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	3,004.4	61.6
Interim, 50' Waste	7,453.0	152.7
Interim, 100' Waste	28,510.1	584.3
Interim, 200' Waste	24,280.7	497.6
Interim, 270' Waste	31,099.8	637.3
Closed, 270' Waste	19,871.0	407.2

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.

1. Sump for Developed Sectors

16.4 acres

Condition	Rate (gpd/ac)	Active area (ac)	Active rate (gpd)	Inactive area (ac)	Inactive rate (gpd)	Closed area (ac)	Closed rate (gpd)
Interim, 50' Waste	129.4	1.5	194.1	0.0	0.0	0.0	0.0
Interim, 100' Waste	586.5	3.2	1,876.7	0.0	0.0	0.0	0.0
Interim, 200' Waste	498.2	5.8	2,889.7	0.0	0.0	0.0	0.0
Interim, 200' Waste	723.1	4.4	3,181.6	16.4	11,858.8	0.0	0.0
Closed, 320'/330' Waste	530.7	1.5	796.0	0.0	0.0	16.4	8,702.8
Total		16.4	8,938.1	16.4	11,858.8	16.4	8,702.8

2. Sump for Undeveloped Sector

20.2 acres

Condition	Rate (gpd/ac)	Active area (ac)	Active rate (gpd)	Inactive area (ac)	Inactive rate (gpd)	Closed area (ac)	Closed rate (gpd)
Active, 10' Waste	61.6	2.0	123.1	0.0	0.0	0.0	0.0
Interim, 50' Waste	152.7	4.6	702.6	0.0	0.0	0.0	0.0
Interim, 100' Waste	584.3	6.9	4,031.4	0.0	0.0	0.0	0.0
Interim, 200' Waste	497.6	4.7	2,338.7	20.2	10,051.3	0.0	0.0
Closed, 270' Waste	407.2	2.0	814.4	0.0	0.0	20.2	8,225.8
Total		20.2	8,010.2	20.2	10,051.3	20.2	8,225.8

B. Required storage capacity of sump

Assumed porosity of drainage stone: P = 0.35

$V_{Daily\ Inflow} = V_C / P$

1. Active

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	8,938.1	1,194.9	3,414.1
Undeveloped Sector	8,010.2	1,070.9	3,059.7

2. Inactive with Intermediate Cover

	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	11,858.8	1,585.4	4,529.7
Undeveloped Sector	10,051.3	1,343.8	3,839.3

3. Closed

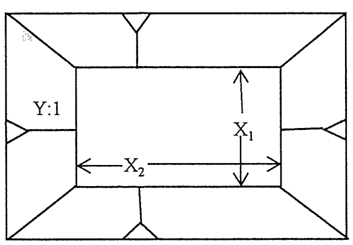
	V_C (gpd)	V_C (cu ft/day)	$V_{Daily\ Inflow}$ (cu ft/day)
Developed Sectors	8,702.8	1,163.5	3,324.2
Undeveloped Sector	8,225.8	1,099.7	3,142.0

Total sump volume:

$$V_{TOT} = 1/3\left(A_1 + A_2 + \sqrt{(A_1 \cdot A_2)}\right)h$$ (Ref. 4, page 17)

Where:

A_1 = Area of bottom of sump
A_2 = Area of top of sump
h = Depth of sump



Y = Slope of sump side walls
$A_1 = X_1 * X_2$
$A_2 = (X_1 + 2(h*Y))*(X_2 + 2(h*Y))$

	X_1 (ft)	X_2 (ft)	Y (ft)	h (ft)	A_1 (ft^2)	A_2 (ft^2)	V_{TOT} (ft^3)
Developed Sectors							
-Sector 1	20	23	3	3	460	1,558	2,865
-Sectors 2, 3, 4, 5, and 6	27	27	3	3	729	2,025	3,969
-Sectors 7 and 8	21	21	3	3	441	1,521	2,781
-Sector 9	28.5	28.5	3	3	812	2,162	4,300
-Sector 10	29.67	29.67	3	3	880	2,272	4,567
Undeveloped Sectors	27	27	3	3	729	2,025	3,969
Sector 12	27	27	3	3	729	2,025	3,969
Sector 13	27	27	3	3	729	2,025	3,969
Sector 14	27	27	3	3	729	2,025	3,969

Compute the number of days storage provided for the following:

$$\text{STORAGE (Detention Time)} = \frac{V_{TOT}}{V_{\text{Daily Inflow}}}$$

1. Active

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	3,414.1	2,781	0.8
Undeveloped Sector	3,059.7	3,969	1.3

2. Inactive with Intermediate Cover

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	4,529.7	2,781	0.6
Undeveloped Sector	3,839.3	3,969	1.0

3. Closed

	$V_{\text{Daily Inflow}}$ (cu ft/day)	V_{TOT} (cu ft)*	Storage (days)
Developed Sectors	3,324.2	2,781	0.8
Undeveloped Sector	3,142.0	3,969	1.3

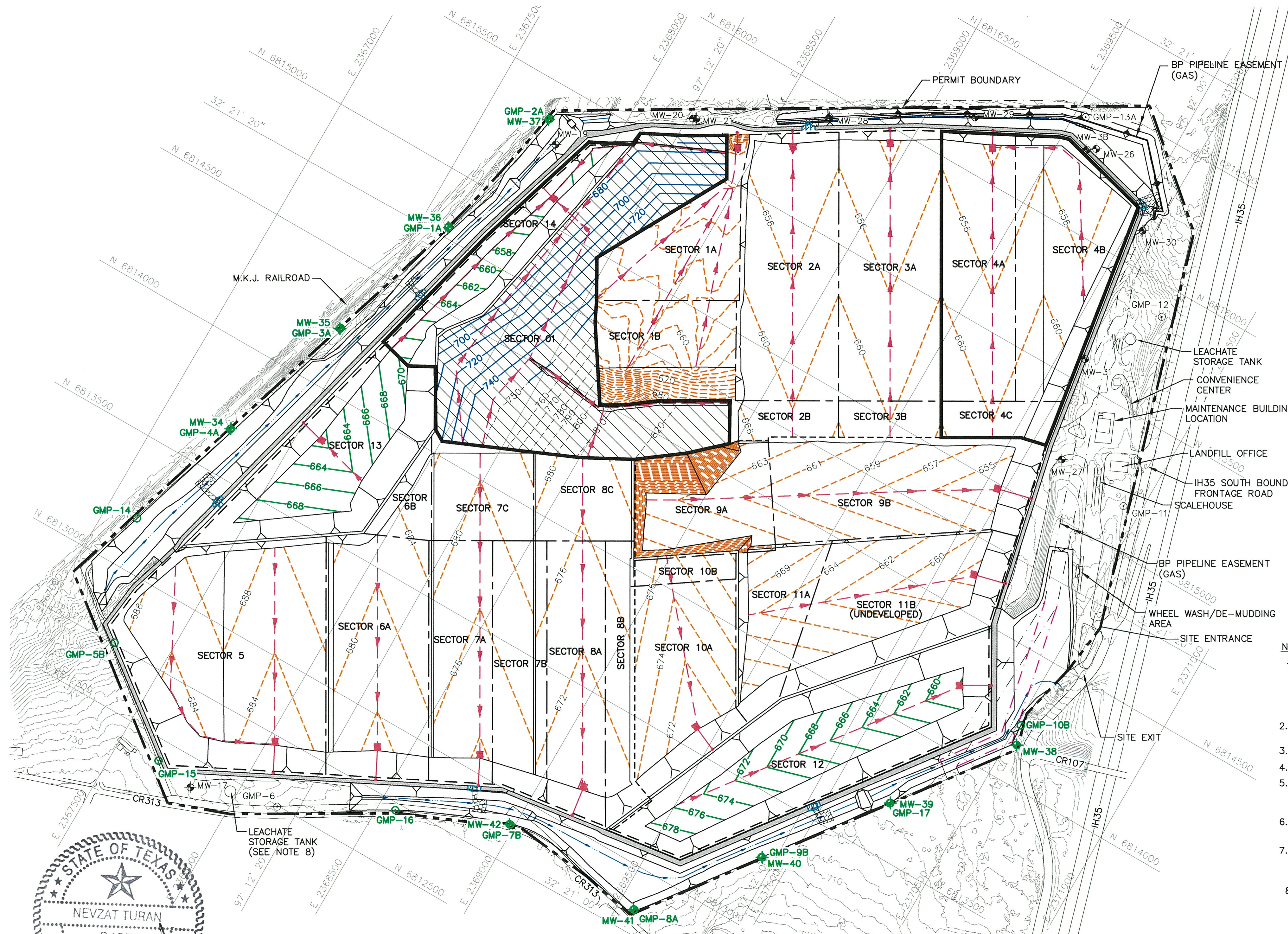
* The smallest V_{TOT} of the developed sectors' sumps is used to be conservative.

C. Estimated rate of leachate removal.

Submersible pump capacity = 15 gpm

	Production	Average Pump Time	
	(gpd)	(min/day)	(hr/day)
Developed Sectors			
-Active	8,938.1	595.9	9.9
-Inactive with Interm. Cover	11,858.8	790.6	13.2
-Closed	8,702.8	580.2	9.7
Undeveloped Sector			
-Active	8,010.2	534.0	8.9
-Inactive with Interm. Cover	10,051.3	670.1	11.2
-Closed	8,225.8	548.4	9.1

Average pump time is less than 24 hours per day, therefore the design is acceptable. A pump with less capacity may also be used if it can be determined that the actual leachate generation is less than the design flow. Prior authorization from TCEQ will be obtained with a permit modification.



LEGEND

- PERMIT BOUNDARY
- LIMITS OF WASTE
- LIMIT OF CLASS 1 WASTE DISPOSAL AREA
- 750 — EXISTING CONTOUR
- N 6816000 — STATE PLANE COORDINATE
- 32' 21' 20" — GEODETIC COORDINATE
- EASEMENT
- RELOCATED EASEMENT
- SECTOR BOUNDARY
- 800 — OVERLINER CONTOUR
- 670 — PERMITTED/EXISTING TOP OF LINER CONTOUR
- 662 — PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
- PERMITTED/UNDEVELOPED LEACHATE LINE
- LEACHATE COLLECTION SUMP
- MW-7 — EXISTING GROUNDWATER MONITORING WELL
- GMP-12 — EXISTING GAS MONITORING PROBE
- MW-7 — PROPOSED GROUNDWATER MONITORING WELL
- GMP-17 — PROPOSED GAS MONITORING PROBE
- PRE SUBTITLE D AREA
- DRAINAGE AREA BOUNDARY

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. EXCAVATION SLOPES AND SLOPES OUTSIDE THE LIMIT OF WASTE (e.g., CHANNELS) ARE TYPICALLY 3H:1V.
3. REFER TO APPENDIX IIIC FOR LEACHATE STORAGE INFORMATION.
4. MINIMUM EXCAVATION ELEVATION AT LCS SUMP IS 648 FT-MSL.
5. SUBTITLE D AREA LCS PIPES SLOPE WITH A MINIMUM OF 0.8% TO SUMPS. OVERLINER LCS PIPES SLOPE WITH A MINIMUM 1.0% TO SUMPS.
6. SEQUENCE OF SITE DEVELOPMENT IS PROVIDED IN PARTS I/II, APPENDIX I/IIA DRAWINGS I/IIA.5 THROUGH I/IIA.7.
7. CLASS 1 NON HAZARDOUS INDUSTRIAL WASTE (NOT CLASSIFIED AS SUCH DUE TO ASBESTOS CONTENT) WILL BE DISPOSED OF ONLY IN SECTORS 9A, 9B, 10A, 10B, 11, 11A, 11B, AND 12.
8. THIS LEACHATE STORAGE TANK WILL BE RELOCATED FROM AROUND SECTOR 8A RISER AREA TO THE LOCATION SHOWN ON THIS DRAWING FOR THE DEVELOPMENT OF SECTOR 12 AND/OR PERIMETER DRAINAGE STRUCTURES.

SUMP DRAINAGE AREAS

SECTOR	AREA (ACRES)
DEVELOPED SECTOR 4	16.4
UNDEVELOPED SECTOR 14 (INCLUDES OVERLINER AREA)	20.2

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: IIIC-B-62 SUMP PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
SUMP DRAINAGE AREA

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

WWW.WCGRP.COM

SHEET IIIC-B-62

O:\0771\368\EXPANSION 2021\PART III\IIIC\IIIC-B-62 SUMP DRAINAGE.dwg, rarrington, 1:2

GEOTEXTILE DESIGN

REQUIRED: Determine geotextile properties for the following:

A. Geotextile "A" around the chimney drain granular drainage material. This is applicable to the liner and overliner systems.

B. Geotextile "B" used as top component of drainage geocomposite. This is applicable to the liner and overliner systems.

METHOD: Design geotextiles and determine material property requirements.

REFERENCES:

1. MIRAFI, *Geotextile Filter Design, Application, and Product Selection Guide*, 1991, http://www.tcmirafi.com/pdf/brochures/ef_guidelines.pdf.
2. Koerner, R.M., *Designing With Geosynthetics*, Fifth Edition, 2005.
3. AASHTO Designation: M288-17.
4. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

SOLUTION:

A. Geotextile "A" Around the Chimney Drain Granular Drainage Material.

The design calculations assume the waste located above the chimney drain will have a hydraulic conductivity of 1.0×10^{-3} cm/s and the protective cover soil will consist of soils with a hydraulic conductivity less than 1.2×10^{-4} cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the protective cover material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate the adequacy of the material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIC-B-70, the apparent opening size (O_{95}) may be determined.

$$O_{95} < 0.21 \text{ mm}$$

Permeability:

The required permeability is determined by comparing the permeability of the overlying waste material (1.0×10^{-3} cm/s) and the protective cover (1.2×10^{-4} cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} =	Reduction factor for soil clogging and blinding	2.0
RF_{CR} =	Reduction factor for creep reduction of void space	2.0
RF_{IN} =	Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} =	Reduction factor for chemical clogging	1.5
RF_{BC} =	Reduction factor for biological clogging	2.0
	Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 4.

$$k_{allow} = k_{ult} / ORF = (0.2 \text{ cm/s}) / 14.4$$

$$\boxed{k_{allow} = 1.4E-02 \text{ cm/s}}$$

$k_{allow} >> k_{waste}$ (1.0×10^{-3} cm/s) or $k_{protective\ cover}$ (1.2×10^{-4} cm/s).

Specification: Chimney drain geotextile permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Geotextile properties should be selected considering Class 2 survivability (page IIIC-B-69).

Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile "A" (around the chimney drain granular drainage material):

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	309	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

B. Geotextile "B" Used as Top Component of Drainage Geocomposite.

The design calculations assume the protective cover soil will consist of soils with a hydraulic conductivity less than 1.2×10^{-4} cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the protective cover material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate adequacy of material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIC-B-80, the apparent opening size (O_{95}) may be determined.

$O_{95} <$ 0.21 mm

Permeability:

The required permeability is determined by comparing the permeability of the protective cover (1.2×10^{-4} cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 2 - Reduction Factors[1]

RF_{SCB} =	Reduction factor for soil clogging and blinding	2.0
RF_{CR} =	Reduction factor for creep reduction of void space	2.0
RF_{IN} =	Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} =	Reduction factor for chemical clogging	1.5
RF_{BC} =	Reduction factor for biological clogging	2.0
	Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 4.

$k_{allow} = k_{ult}$ / ORF = (0.2 cm/s) / 14.4

k_{allow} = 1.4E-02 cm/s

$k_{allow} >> k_{protective\ cover}$ (1.2×10^{-4} cm/s).

Specification: Geotextile component of geocomposite permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Geotextile properties should be selected considering Class 2 survivability (page IIIC-B-70).

Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile "B" (top component of drainage geocomposite):

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lbs
Elongation	>=	50	%
Puncture strength	>	309	lbs
Trapezoid tear	>	56	lbs
Permeability	>=	0.2	cm/s

Table 1—Geotextile Strength Property Requirements

			Geotextile Class[a,b]						
			Class 1A	Class 1		Class 2		Class 3	
	Test Methods	Units	Elongation <50%	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]
Grab strength	ASTM D4632/ D4632M	N	[e]	1400	900	1100	700	800	500
Sewn seam strength[d]	ASTM D4632/ D4632M	N	[e]	1260	810	990	630	720	450
Tear strength	ASTM D4533/ D4533M	N	[e]	500	350	400[f]	250	300	180
Puncture strength	ASTM D6241	N	[e]	2750	1925	2200	1375	1650	990
Permittivity	ASTM D4491	sec⁻¹	Refer to Table 6.	Minimum property values for permittivity, AOS, and UV stability are based on geotextile application. Refer to Table 2 for subsurface drainage, Table 3 and Table 4 for separation, Table 5 for stabilization, and Table 7 for permanent erosion control.					
Apparent opening size	ASTM D4751	mm	Refer to Table 6.						
Ultraviolet stability (retained strength)	ASTM D4355/ D4355M	%	Refer to Table 6.	T					

[a] Required geotextile class is designated in Table 2, 3, 4, 5, 6, or 7 for the indicated application. The severity of installation conditions for the application generally dictates the required geotextile class. Class 1A and Class 1 are specified for more severe or harsh installation conditions where there is a greater potential for geotextile damage, and Classes 2 and 3 are specified for less severe conditions.

[b] All numeric values represent MARV in the weaker principal direction. (See Section 8.1.2.)

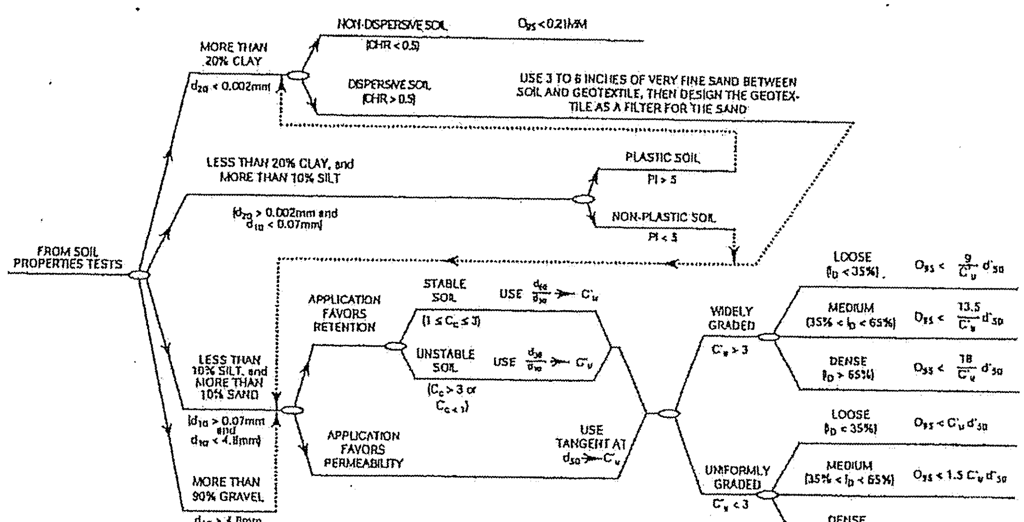
[c] As measured in accordance with ASTM D4632/D4632M.

[d] When sewn seams are required. Refer to Appendix X1 for overlap seam requirements.

[e] Property requirement not applicable to Class 1A. Refer to Table 6 for enhancement for wide width tensile property requirement.

[f] The required MARV tear strength for woven monofilament geotextiles is 250 N.

Chart 1. Soil Retention Criteria of Steady-State Flow Conditions



Stable soil: USE $\frac{d_{60}}{d_{30}} \rightarrow C'_u$

Unstable soil: USE $\frac{d_{30}}{d_{10}} \rightarrow C'_u$

Widely graded, loose: $O_{95} < \frac{9}{C'_u} d'_{50}$

Widely graded, medium: $O_{95} < \frac{13.5}{C'_u} d'_{50}$

Widely graded, dense: $O_{95} < \frac{18}{C'_u} d'_{50}$

NOTES:

d_x = particle diameter of which size x percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

CHIMNEY DRAIN CALCULATIONS

TURKEY CREEK LANDFILL
0771-368-11
SUBTITLE D LEACHATE COLLECTION SYSTEM
CHIMNEY DRAIN CALCULATIONS

Required: Evaluate the adequacy of the chimney drain design along the leachate collection pipe for the maximum leachate impingement rate.

Method:

1. Determine the maximum leachate inflow rate into the chimney drain.
2. Determine the minimum drainage capacity of the chimney drain.
3. Compare the allowable flow rate to the required flow rate.

References:

1. GSE Nonwoven Geotextile (6 oz/sy).
2. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.
3. HELP results from Appendix IIIC, Appendix IIIC-A.

Solution:

1. Determine the maximum leachate inflow rate into the chimney drain.

A comparison of the developed MSW area, developed Class 1 area, and undeveloped area, was developed to determine the worst case scenario (i.e., which scenario generates the maximum leachate inflow rate). The peak daily generation rate is from HELP model analyses in Appendix IIIC, Appendix IIIC-A.

Sectors	Peak Daily Generation Rate, q (cf/ac/day)	Peak Daily Generation Rate, q (cfs/sf)	Maximum Drainage Length, L[1] (ft)	Inflow Rate, Q_{req} (cfs)
Developed MSW Areas	220.4	5.86E-08	460	2.69E-05
Undeveloped MSW Areas	200.6	5.33E-08	570	3.04E-05
Developed Class 1 Areas	220.8	5.87E-08	610	3.58E-05
Undeveloped Class 1 Areas	202.9	5.39E-08	710	3.83E-05

[1] The maximum drainage length as shown takes in to account both sides draining to the chimney drain.

Maximum leachate inflow rate to the chimney drain per unit length (1 ft) is calculated using the following equation:

$$Q_{req} = L * 1 * q$$

where:

Q_{req} = Maximum leachate inflow rate into chimney drain, cfs
L = Maximum length draining to chimney drain from both sides
q = Peak daily leachate generation rate from HELP model listed above, cfs/sf

Maximum Leachate Generation Rate from above table:

Q_{req} = 3.83E-05 cfs

2. Determine the minimum drainage capacity of the chimney drain.

Minimum drainage capacity of the chimney drain per unit length (1 ft):

$$Q_{ult} = k * i * w * 1$$

where:

Q_{ult} = Ultimate flow rate
k = Minimum permeability of the geotextile wrap
i = Hydraulic gradient = 1 under free drainage
w = Width of the chimney drain keyed into the waste layer, measured at the top of protective layer, min. 3 ft, as shown in Appendix IIIA-A, Drawing A.4

k = 0.2 cm/s = 6.56E-03 fps (Ref. 1)
i = 1
w = 3 ft

Q_{ult} = 1.97E-02 cfs

To determine the allowable drainage capacity of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 2.

$$Q_{allow} = Q_{ult} / ORF$$

where:

Q_{allow} = Allowable flow rate
Q_{ult} = Ultimate flow rate
ORF = Overall reduction factor from Table 1

Q_{allow} = 1.37E-03 cfs

Q_{allow} = 1.37E-03 cfs >> Q_{req} = 3.83E-05 cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

OVERLINER CHIMNEY DRAIN CALCULATIONS

Required: Evaluate the adequacy of the overliner chimney drain design for the maximum leachate impingement rate.

Method:

1. Determine the maximum leachate inflow rate into the chimney drain.
2. Determine the minimum drainage capacity of the chimney drain.
3. Compare the allowable flow rate to the required flow rate.

References:

1. GSE Nonwoven Geotextile (6 oz/sy)
2. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

Solution:

1. Determine the maximum leachate inflow rate into the chimney drain.

Note: The maximum leachate impingement rate is from HELP model analyses for the overliner in Appendix IIIC-A.

Peak daily leachate generation rate, q = 150.4 cf/acre/day
= 4.00E-08 cfs/sf

Maximum leachate inflow rate to the chimney drain per unit length (1 ft):

$$Q_{req} = L * 1 * q$$

where:

Q_{req} = Maximum leachate inflow rate into chimney drain, cfs
L = Maximum length draining to chimney drain
= 300 ft
q = Peak daily leachate generation rate from HELP model listed above, cfs/sf

Q_{req} =	1.20E-05	cfs

2. Determine the minimum drainage capacity of the chimney drain.

Minimum drainage capacity of the chimney drain per unit length (1 ft):

$$Q_{ult} = k * i * w * 1$$

where:

Q_{ult} = Ultimate flow rate
k = Minimum permeability of the geotextile wrap
i = Hydraulic gradient = 1 under free drainage
w = Width of the chimney drain keyed into the waste layer, measured at the top of protective layer, min. 4 ft, as shown in Appendix IIIA-A, Drawing A.12.

k =	0.2	cm/s	=	6.56E-03	fps	(Ref. 1)
i =	1					
w =	4	ft				

Q_{ult} =	2.62E-02	cfs

To determine the allowable drainage capacity of the geotextile, the following reduction factors are used:

Table 1 - Reduction Factors[1]

RF_{SCB} = Reduction factor for soil clogging and blinding	2.0
RF_{CR} = Reduction factor for creep reduction of void space	2.0
RF_{IN} = Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} = Reduction factor for chemical clogging	1.5
RF_{BC} = Reduction factor for biological clogging	2.0
Overall Reduction Factor (ORF) =	14.4

[1] Reduction factors obtained from Ref. 2.

$$Q_{allow} = Q_{ult} / ORF$$

where:
Q_{allow} = Allowable flow rate
Q_{ult} = Ultimate flow rate
ORF = Overall reduction factor from Table 1

Q_{allow} =	1.82E-03	cfs

3. Compare the allowable flow rate to the required flow rate.

Q_{allow} =	1.82E-03	cfs	>>	Q_{req} =	1.20E-05	cfs

The predicted flow does not exceed the capacity of the chimney drain geotextile. The chimney drain design is adequate to convey the generated leachate to the leachate collection pipe.

GROUNDWATER INFLOW CALCULATIONS

TURKEY CREEK LANDFILL
0771-368-11
LEACHATE COLLECTION SYSTEM
GROUNDWATER INFLOW RATE CALCULATION

REQUIRED: Determine the maximum groundwater inflow rate into the leachate collection system, consistent with §330.337(d).

METHOD:

1. Determine the permeability of the materials surrounding the liner system, the potentiometri conditions of the groundwater, and the geomembrane hole size and spacing.

2. Calculate the maximum groundwater inflow rate into the leachate collection system.

REFERENCES:

1. Rowe, R. Kerry et al. *Barrier Systems for Waste Disposal Facilities,* 2nd Edition, Spon Press, 2004

SOLUTION:

1. **Determine the permeability of the materials surrounding the liner system, the potentiometric conditions of the groundwater, and the geomembrane hole size and spacing.**

The maximum groundwater unit flow rate can be defined with the following equation:

q_o=ki, where
- q_o= Unit groundwater flow rate below the liner system
- k= Hydraulic conductivity of the soil below the liner system
- i= Hydraulic gradient of the soil below the liner system

The excavation is founded partially in the Upper Sand Unit, the Bounding Shale Unit, and the Lower Sand Unit. The greatest hydraulic conducitivty of these units will be used for this demonstration. Table 4-2 in Appendix IIIG lists a maximum hydraulic conducticity of 3.00×10^{-4} cm/s (Upper Sand Unit). Additionally, the hydraulic gradient of the Upper Sand Unit is 0.0012 ft/ft.

Therefore, the unit groundwater flow rate below the liner system is q_o=ki.

k=	3.00E-04	cm/s
i=	0.0012	ft/ft
q_o=	3.60E-07	cm/s

2. **Calculate the maximum groundwater inflow rate into the leachate collection system.**

To calculate the groundwater inflow to the liner system, the following equation is used:

$$h_w = \left\{ \frac{r_0^2 q_0}{2k_{om}} + \frac{Q}{2\pi k_{om}} \left[\ln\left(\frac{Q}{\pi r_0^2 q_0}\right) - 1 \right] + \frac{1}{4g^2} \left(\frac{Q}{1.88 r_0^2}\right)^4 \right\}^{0.5}$$

where

- h_w= Groundwater head on the liner
- r_o= Radius of the geomembrane defect
- q_o= Unit groundwater flow rate below the liner system
- Q= Inflow rate through the geomembrane into the leachate collection system
- k_{om}= Hydraulic conductivity of the layer upgradient (below) the geomembrane liner system
- g= Acceleration due to gravity

TURKEY CREEK LANDFILL
0771-368-11
LEACHATE COLLECTION SYSTEM
GROUNDWATER INFLOW RATE CALCULATION

The groundwater head on the liner (h_w) is taken from the location where the potentiometric levels are the most critical. Figure IIIG-D-3 in Appendix IIIG-D shows the highest measured groundwater map. Based on this map, the most critical area of the leachate collection systen liner occurs in Sector 6. The potentiometric level of the groundwater is at approximately 702 ft-msl, while the elevation of the bottom liner is 677 ft-msl. Therefore, the overall groundwater head at Sector 6 is estimated to be 25 ft.

To be conservative, the pinhole density is assumed to be 4 holes per acre and the geomembrane installation defects is assumed to be 4 holes per acre.

The area of 1 hole of geomembrane installation defect equals 1 cm^2 and 1 pinhole has a diameter of 1mm.

The radius of the geomembrane defect (r_o) based on the pinhole density and geomembrane installation defect equals 0.03717 ft.

In order to calculate the inflow rate through the geomembrane into the leachate collection system (Q), the following calculated values are used.

h_w=	25.0	ft (equal to the overall groundwater head)
r_o=	0.03717	ft
q_o=	3.60E-07	cm/s or
	1.18E-08	ft/s
g=	32.2	ft/s^2
k_{om}=	1.00E-07	cm/s or
	3.28E-09	ft/s
Q=	1.40E-06	cf/s per acre or
	0.12	cf/day per acre or
	0.012	in/yr

Conclusion: The Developed MSW Sectors interim 320 ft Case HELP run (which has the highe peak daily head on liner) was rerun by adding 0.012 in/yr of groundwater inflow based on the above calculations. The HELP runs are attached to this calculation (Sheets IIIC-B-83 through IIIC-B-91). Based on the results, it can be seen that there is an insignificant increase in average annual flow rate and peak daily flow rate (38,381.5 cf/year vs 38,520.3 cf/year and 220.4 cf/day vs 220.5 cf/day). There was no change in the annual and peak head on liner. Therefore it can be concluded that the design and capacity of leachate collectioı system is not significantly affected by groundwater inflow.

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:     C:\TC\CB\I320\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\CB\I320\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\TC\CB\I320\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\CB\I320\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\TC\CB\I320\DATA10.D10
OUTPUT DATA FILE:            C:\TC\CB\I320\OUTPUT1.OUT
```

TIME: 12:49   DATE: 11/ 5/2021

```
******************************************************************************

     TITLE:  TURKEY CREEK - GROUNDWATER FLOW MSW DEV - INTERIM 320 FT

******************************************************************************
```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
WERE SPECIFIED BY THE USER.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 11

THICKNESS   =   12.00   INCHES

```
   POROSITY                        =      0.4640 VOL/VOL
   FIELD CAPACITY                  =      0.3100 VOL/VOL
   WILTING POINT                   =      0.1870 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3100 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.639999998000E-04 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =   1500.00   INCHES
   POROSITY                        =      0.6174 VOL/VOL
   FIELD CAPACITY                  =      0.5174 VOL/VOL
   WILTING POINT                   =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.100000005000E-02 CM/SEC
NOTE:   10.00 PERCENT OF THE DRAINAGE COLLECTED FROM LAYER # 5
         IS RECIRCULATED INTO THIS LAYER.


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =   2340.00   INCHES
   POROSITY                        =      0.4852 VOL/VOL
   FIELD CAPACITY                  =      0.4751 VOL/VOL
   WILTING POINT                   =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.3800 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.999999975000E-04 CM/SEC


                         LAYER  4
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  10
   THICKNESS                       =     24.00   INCHES
   POROSITY                        =      0.3980 VOL/VOL
```

```
FIELD CAPACITY             =      0.2440 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2440 VOL/VOL
EFFECTIVE SAT. HYD. COND.  = 0.119999997000E-03 CM/SEC
```

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                  =      0.13   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.  =   2.56999993000      CM/SEC
SLOPE                      =      1.80   PERCENT
DRAINAGE LENGTH            =    230.0    FEET
SUBSURFACE INFLOW          =      0.01   INCHES/YR
NOTE:  10.00 PERCENT OF THE DRAINAGE COLLECTED FROM THIS
          LAYER IS RECIRCULATED INTO LAYER #  2.
```

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        =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      0.00   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 #11 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	87.10	
FRACTION OF AREA ALLOWING RUNOFF	=	80.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.640	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.870	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1479.025	INCHES
TOTAL INITIAL WATER	=	1479.025	INCHES
TOTAL SUBSURFACE INFLOW	=	0.01	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM DALLAS TEXAS

STATION LATITUDE	=	32.85 DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 21 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.60	2.36	3.23	3.25	3.57	3.62
	4.86	2.05	5.05	3.72	2.88	4.03
STD. DEVIATIONS	1.73	1.11	1.36	1.21	1.98	2.38

```
                         3.78     1.50     2.11     3.47     1.89     2.05

RUNOFF
------
  TOTALS                 0.098    0.117    0.104    0.091    0.177    0.332
                         0.637    0.124    0.429    0.623    0.086    0.248

  STD. DEVIATIONS        0.100    0.218    0.125    0.113    0.186    0.379
                         0.881    0.189    0.369    1.286    0.146    0.312

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.899    1.877    2.445    2.983    2.984    2.462
                         3.333    1.827    3.048    2.255    1.305    1.801

  STD. DEVIATIONS        0.278    0.703    0.634    1.203    1.092    1.614
                         1.476    1.228    1.207    1.319    0.687    0.561

LATERAL DRAINAGE RECIRCULATED INTO LAYER  2
-------------------------------------------
  TOTALS                 0.0869   0.0843   0.0912   0.0902   0.0895   0.0911
                         0.0903   0.0893   0.0847   0.0899   0.0857   0.0880

  STD. DEVIATIONS        0.0158   0.0164   0.0198   0.0186   0.0169   0.0190
                         0.0190   0.0176   0.0162   0.0154   0.0158   0.0151

SUBSURFACE INFLOW INTO LAYER  5
-------------------------------
  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

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.7822   0.7583   0.8210   0.8119   0.8058   0.8199
                         0.8129   0.8041   0.7621   0.8087   0.7715   0.7922

  STD. DEVIATIONS        0.1426   0.1478   0.1786   0.1673   0.1525   0.1714
                         0.1707   0.1586   0.1462   0.1385   0.1421   0.1357

LATERAL DRAINAGE RECIRCULATED FROM LAYER  5
-------------------------------------------
  TOTALS                 0.0869   0.0843   0.0912   0.0902   0.0895   0.0911
                         0.0903   0.0893   0.0847   0.0899   0.0857   0.0880

  STD. DEVIATIONS        0.0158   0.0164   0.0198   0.0186   0.0169   0.0190
                         0.0190   0.0176   0.0162   0.0154   0.0158   0.0151

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 6

AVERAGES	0.0246	0.0262	0.0258	0.0264	0.0253	0.0266
	0.0256	0.0253	0.0248	0.0254	0.0251	0.0249
STD. DEVIATIONS	0.0045	0.0052	0.0056	0.0054	0.0048	0.0056
	0.0054	0.0050	0.0048	0.0044	0.0046	0.0043

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 21 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	41.23	(5.000)	149664.9	100.00
RUNOFF	3.066	(1.2950)	11127.99	7.435
EVAPOTRANSPIRATION	28.219	(2.9081)	102435.06	68.443
DRAINAGE RECIRCULATED INTO LAYER 2	1.06117	(0.19471)	3852.033	2.57377
SUBSURFACE INFLOW INTO LAYER 5	0.00000		0.000	0.00000
LATERAL DRAINAGE COLLECTED FROM LAYER 5	9.55050	(1.75241)	34668.305	23.16395
DRAINAGE RECIRCULATED FROM LAYER 5	1.06117	(0.19471)	3852.033	2.57377
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.009	0.00001

```
AVERAGE HEAD ON TOP                0.026 (    0.005)
  OF LAYER  6

CHANGE IN WATER STORAGE            0.407    (  3.5708)       1478.10      0.988

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


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

               PEAK DAILY VALUES FOR YEARS    21 THROUGH   30
   ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------   -------------
     PRECIPITATION                                  5.13        18621.900

     RUNOFF                                         2.308        8376.4365

     DRAINAGE RECIRCULATED INTO LAYER  2            0.00607        22.05156

     DRAINAGE COLLECTED FROM LAYER  5               0.05467       198.46402

     DRAINAGE RECIRCULATED FROM LAYER  5            0.00607        22.05156

     PERCOLATION/LEAKAGE THROUGH LAYER  7           0.000000        0.00002

     AVERAGE HEAD ON TOP OF LAYER  6                0.053

     MAXIMUM HEAD ON TOP OF LAYER  6                0.105

     LOCATION OF MAXIMUM HEAD IN LAYER  5
           (DISTANCE FROM DRAIN)                    2.5 FEET

     SNOW WATER                                     1.31         4756.4434


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.4640

     MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.1870

      ***  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.
```

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	2.5981	0.2165
2	650.4070	0.4336
3	813.2241	0.3475
4	6.6034	0.2751
5	0.0163	0.1285
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

****
****

MAXIMUM HEAD CALCULATION FOR SECTORS 2A, 3A, 4A4B, AND 6A

Required: Determine the head on the tire chips in Sectors 2A, 3A, 4A/4B, and 6A and show that the flow is within the tire chips.

Background: Sectors 2A, 3A, 4A/4B, and 6A were constructed with the following alternate liner system (from top to bottom).

- 12-inch-thick Tire Chip Leachate Collection System
- 12-inch-thick General Fill Layer
- 60-mil HDPE Geomembrane
- 2-foot-thick Compacted Clay Liner (CCL)

The material requirements for the tire chip layer are listed below:

- Tire Chip Layer - The 12-inch-thick tire chip layer consists of pieces of scrap tires that have a basic geometrical shape and a nominal size of 2 to 4 inches.

The alternate liner design was completed assuming a leachate based on the liner system of 24 inches (e.g., the design assumed the 12-inch-thick general fill layer and the 12-inch-thick tire chip layer were saturated).

Method:

1. Use the maximum peak flow from the HELP Model analysis in Appendix IIIC-A as the flow into the tire chips.
2. Determine the head on liner.
3. Conclusion.

References:

1. Dana N.Humphrey, *Civil Engineering Application of Tire Shreds*, Presented at the Tire Industry Conference, Hilton Head, South Carolina, March 3, 1999.
2. Giroud, J.P. et al., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers*, Geosynthetics International, Vol 7, 2000.
3. D.B. Narejo and M. Shettima, *Use of Recycled Automobile Tires to Design Landfill Components*, Geosynthetics International, Vol 2, No 3, 1995.

Solution:

1. Determine the flow into the tire chips:

The maximum peak leachate generation rate from the HELP model analysis for the Developed Subtitle D area was used as the flow into the tire chips.

Flow into tire chips, q_h = 220.4 cf/ac/day, generated by HELP Model (Appendix IIIC-A, page IIIC-A-30)

2. Determine the head on the tire chips:

The head on tire chips is determined using the following formula:

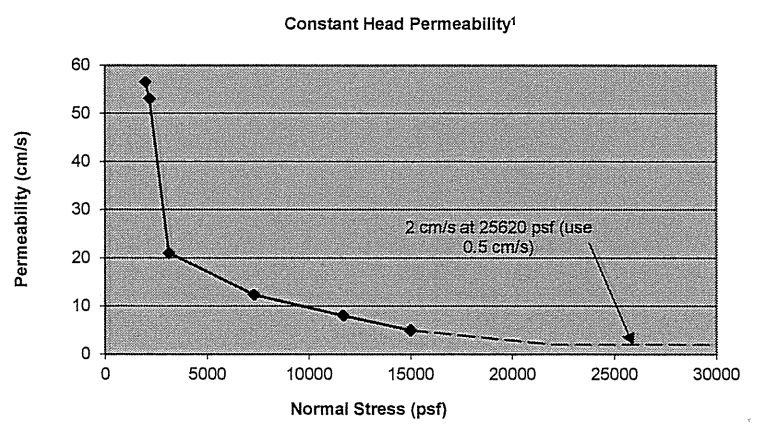
$$T_{\max} = \frac{\sqrt{(\tan^2\beta + \frac{4q_h}{k_1})} - \tan\beta}{2\cos\beta} * L$$

where,

T_{max}= maximum head on tire chips, ft
β= slope, deg
q_h= inflow rate, in/s
k_1= hydraulic conductivity of tire chips, in/s
L= slope length, ft

β= 1.232 °
$\tan\beta$= 0.0215
$\tan^2\beta$= 4.62E-04
$\cos\beta$= 1.00

k_1 is hydraulic conductivity and is obtained from Ref 3. The permeability was established from the following graph:



[1] Chart was reproduced from Figure 3 in Ref. 3. The dotted line represents an extrapolation of the published graph.

k_1 =	0.5	cm/s
=	0.19685	in/s
q_h=	220.40	cf/ac/day
=	6.07E-02	in/day
=	7.03E-07	in/s
L=	220	ft
T_{max}=	0.036	ft
=	0.435	in

5. Conclusion:

T_{max} (0.435 inches) is less than the thickness of the tire chips (12 inches). Therefore, the flow will be within the tire chips, which is consistent with the original approval to use tire chips.

APPENDIX IIIC-C

CONTAINMENT BERM AND DIVERSION BERM CALCULATIONS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-C-1 through IIIC-C-8

REQUIRED:

1. Determine the height of the contaminated water berm required at the working face.
2. Determine the height of the diversion berm required for run-on control of the working face.

PROCEDURE: **Containment Berm Calculations**

1. Determine the 25-year, 24-hour rainfall.
2. Calculate the volume of water captured behind the containment berm for 25-year, 24-hour rainfall event.
3. Calculate the height of the containment berm required to hold the volume of water calculated in step 2.

Diversion Berm Calculations

1. Determine the 25-year frequency runoff flow rates for the diversion berm run-on drainage areas by the Rational Method.
2. Calculate the capacity of the diversion berm swales at various slopes.
3. Calculate the height of the diversion berm required for the flow rate of run-on surface water.

REFERENCES:

1. NOAA Atlas 14 - Precipitation-Frequency Atlas of the United States, Volume 11, Version 2.0: Texas (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Weather Service, 2018)
2. Texas Department of Highways and Public Transportation, Bridge Division Hydraulic Manual, 3rd Ed, December 1985.
3. Dodson and Associates, Inc., *ProHec-1 Program Documentation*, 1993.

SOLUTION: **Containment Berm Calculations**

1. Based on Reference 1, the 25-year, 24-hour rainfall depth for Johnson County is:

$R \approx$ 7.33 in

2. Determine the volume of storage required, V_R.

$V_R = CAR$

Where:

C =	Runoff coefficient	=	0.5	
A =	Drainage area	=	varies	ac
R =	25-year, 24-hour rainfall depth =		7.33	in

The storage volume required for varying drainage areas are shown on the attached table.

3. Determine the height of the containment berm for a non-sloping water storage area.

$$H = \frac{V_R}{A_{stor}}$$

Where: A_{stor} = Storage area (sf)

Values for height of the containment berm (H) are listed on Sheet IIIC-C-8 for several storage areas.

4. Determine the height of the berm for a sloping water storage area.

The volume contained by the berm is equal to the cross-sectional storage area multiplied by the width of the berm. The computed volume must be greater than the volume found in step 2.

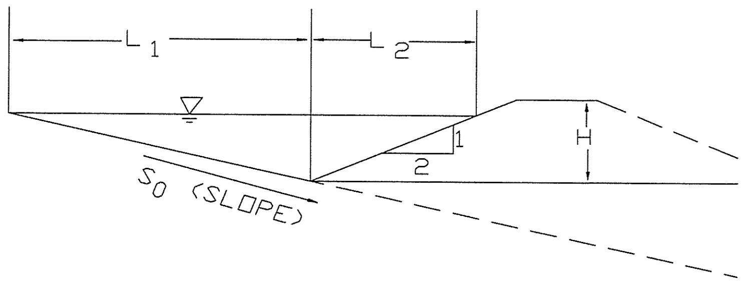
$V_C = A_s W$

Where:

A_s = Cross-sectional storage area (sf)
W = Width (ft)

The minimum width of the downstream berm is 100 feet.

Figure 1. Cross Section of Berm and Storage Area



$$A_s = \frac{(L_1 + L_2)H}{2}$$

Where:

$$L_1 = \frac{H}{S_o} \text{ (ft)}$$

$L_2 =$ 2H (ft)

$S_o =$ Slope of active cell (ft/ft)

Example calculations:

1. Non-sloping water storage area:

Variables:	$S_o =$	0.00	%	R =	7.3	in
	$A_{stor} =$	0.25	ac	C =	0.5	
	A =	0.50	ac	W =	100	ft
Volume:	$V_R =$	6,652	cf			
Height:	H =	0.611	ft			

2. Sloping water storage area:

Variables:

S_o =	1.00	%	R =	7.3	in
A_{stor} =	0.25	ac	C =	0.5	
A =	0.50	ac	W =	100	ft

Height: An iterative process is used to determine the height of the berm required to meet the storage volume requirement for a non-sloping storage area.

H = 1.2 ft

Check to ensure that the above berm height is adequate:

L_1 =	120.00	ft
L_2 =	2.40	ft
A_s =	73.44	sf
V_C =	7,344	cf

V_C is larger than V_R; berm has adequate height. See Sheet IIIC-C-5 and page IIIC-C-8 for summary.

3. Sloping water storage area:

Variables:

S_o =	2.00	%	R =	7.3	in
A_{stor} =	0.25	ac	C =	0.5	
A =	0.50	ac	W =	100	ft

Height: An iterative process is used to determine the height of the berm required to meet the storage volume requirement for a non-sloping storage area.

H = 1.7 ft

Check to ensure that the above berm height is adequate:

L_1 =	85.00	ft
L_2 =	3.40	ft
A_s =	75.14	sf
V_C =	7,514	cf

V_C is larger than V_R; berm has adequate height. See Sheet IIIC-C-5 and page IIIC-C-8 for summary.

Prep By: BPY
Date: 2/22/2022

TURKEY CREEK LANDFILL
0771-368-11
CONTAINMENT BERM
CALCULATIONS SUMMARY

Chkd By: NT
Date: 2/22/2022

Drainage Area	Storage Area	Volume Required	Slope	Berm Height	Required Berm Height	Cross Sectional Area	Width	Water Surface Area	Volume Provided	L_1[1]	L_2[1]
(ac)	(ac)	(cf)	(%)	(ft)	(ft)	(sf)	(ft)	(ac)	(cf)	(ft)	(ft)
0.5	0.25	6,652	0	0.61	1.61						
			1	1.18	2.18	71.01	100	0.276	7,101	118.0	2.4
			2	1.64	2.64	69.93	100	0.196	6,993	82.0	3.3
1.0	0.50	13,304	0	0.61	1.61						
			1	1.66	2.66	140.54	100	0.389	14,054	166.0	3.3
			2	2.32	3.32	139.94	100	0.277	13,994	116.0	4.6
2.0	1.00	26,608	0	0.61	1.61						
			1	2.35	3.35	281.65	100	0.550	28,165	235.0	4.7
			2	3.28	4.28	279.72	100	0.392	27,972	164.0	6.6
4.0	2.00	53,216	0	0.61	1.61						
			1	3.32	4.32	562.14	100	0.777	56,214	332.0	6.6
			2	4.64	5.64	559.77	100	0.554	55,977	232.0	9.3

[1] L_1 and L_2 are shown on Sheet IIIC-C-2.

Diversion Berm Calculations

- As shown on Sheet IIIC-C-8, several swales were analyzed to determine the adequacy of the swale configuration.
- Hydraulic calculations are summarized on page IIIC-C-8.

The swales were analyzed by the Rational Method.

From Reference 2 for Johnson County:

$$Q = C\,I\,A$$

C = 0.5 (intermediate cover)
I = 7.94 intensity, in/hr (see calculation below)
A = varies drainage area, ac

$$I = \frac{b}{(t_c + d)^e}$$

b = 83.01
d = 10.65
e = 0.775

t_c is assumed to be 10 min. for all cases

I = 7.94 in/hr

<u>Diversion Berm Flow Rate Summary</u>

Area(ac)	Flow Rate (cfs)
0.5	2.0
1	4.0
1.5	6.0
2	7.9
2.5	9.9
3	11.9

Prep By: BPY
Date: 2/22/2022

Chkd By: NT
Date: 2/22/2022

TURKEY CREEK LANDFILL
0771-368-11
DIVERSION BERM
CALCULATION SUMMARY

For 33H:1V Diversion Berm Area Slope

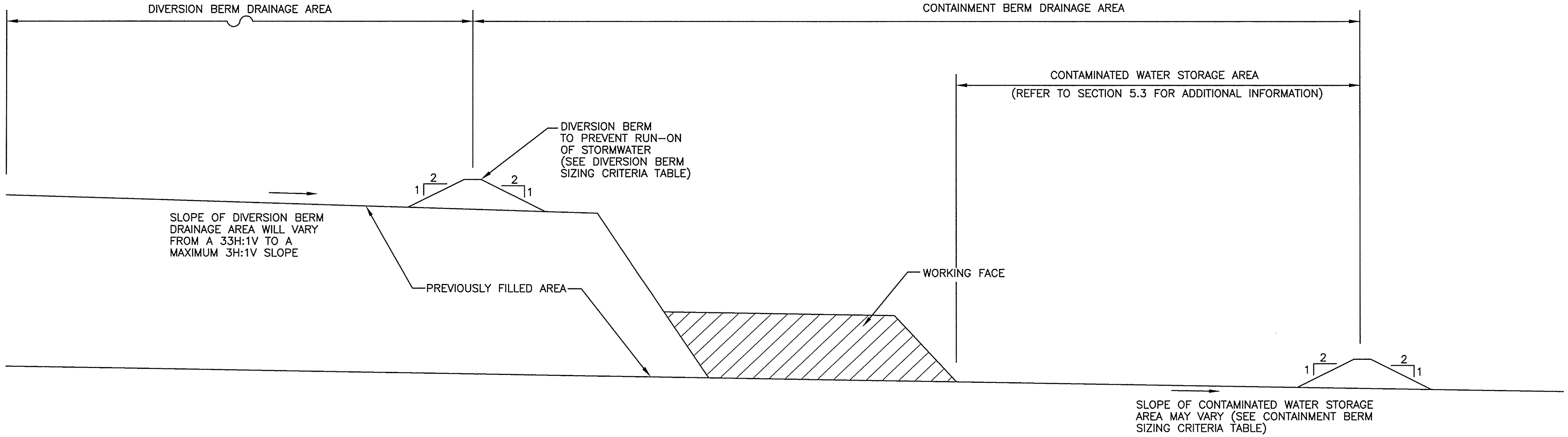
Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.0	0.01	0.03	2	33.0	0	0.29	1.37	0.634	0.03	0.32	1.46	10.12
1	4.0	0.01	0.03	2	33.0	0	0.38	1.62	0.661	0.04	0.42	2.46	13.13
1.5	6.0	0.01	0.03	2	33.0	0	0.44	1.80	0.678	0.05	0.49	3.34	15.29
2	7.9	0.01	0.03	2	33.0	0	0.49	1.93	0.690	0.06	0.54	4.15	17.03
2.5	9.9	0.01	0.03	2	33.0	0	0.53	2.03	0.699	0.06	0.59	0.49	18.46
3	11.9	0.01	0.03	2	33.0	0	0.57	2.13	0.706	0.07	0.64	0.56	19.78

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates (Version 1.2a, 1996).

For 3H:1V Diversion Berm Area Slope

Drainage Area	Flow Rate (cfs)	Bottom Slope(ft/ft)	Manning's n	Side Slope (left)	Side Slope (right)	Bottom Width(ft)	Normal Depth(ft)	Flow Vel. (fps)	Froude Number	Velocity Head(ft)	Energy Head(ft)	Flow Area (sf)	Flow Top Width(ft)
0.5	2.0	0.01	0.03	2	3	0	0.61	2.14	6.830	0.07	0.68	0.93	3.06
1	4.0	0.01	0.03	2	3	0	0.79	2.54	0.712	0.10	0.89	1.57	3.97
1.5	6.0	0.01	0.03	2	3	0	0.92	2.81	0.728	0.12	1.05	2.14	4.62
2	7.9	0.01	0.03	2	3	0	1.03	3.02	0.742	0.14	1.17	2.65	5.15
2.5	9.9	0.01	0.03	2	3	0	1.11	3.19	0.754	0.16	1.27	3.10	5.57
3	11.9	0.01	0.03	2	3	0	1.19	3.33	0.761	0.17	1.37	3.57	5.97

Note: Calculations were performed using the HYDROCALC Hydraulics for Windows developed by Dodson and Associates (Version 1.2a, 1996).



DIVERSION BERM SIZING CRITERIA *

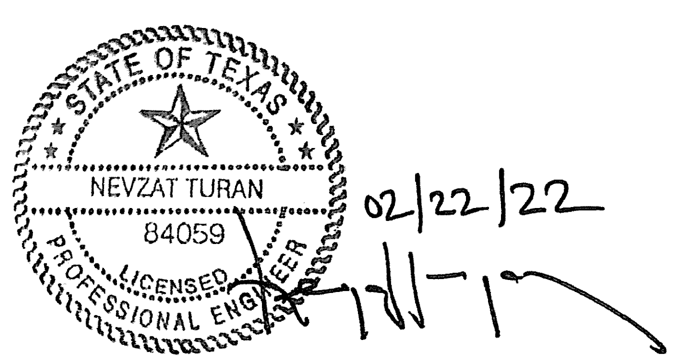
DIVERSION BERM DRAINAGE AREA (ACRES)	MINIMUM 3% FLOW RATE (CFS)	MINIMUM 3% FLOW DEPTH (FT)	MINIMUM 3% REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)	MAXIMUM 33% FLOW RATE (CFS)	MAXIMUM 33% FLOW DEPTH (FT)	MAXIMUM 33% REQUIRED MINIMUM DIVERSION BERM HEIGHT (FT)
0.5	2.0	0.29	1.29	2.0	0.61	1.61
1	4.0	0.38	1.38	4.0	0.79	1.79
1.5	6.0	0.44	1.44	6.0	0.92	1.92
2	7.9	0.49	1.49	7.9	1.03	2.03
2.5	9.9	0.53	1.53	9.9	1.11	2.11
3	11.9	0.57	1.57	11.9	1.19	2.19

* DIVERSION BERM WILL BE SIZED USING THE ABOVE TABLE AS A GUIDELINE TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. SUPPORTING CALCULATIONS ARE INCLUDED ON PAGES IIIC-C-6 THROUGH IIIC-C-7.

CONTAINMENT BERM SIZING CRITERIA *

CONTAINMENT BERM DRAINAGE AREA (ACRES)	CONTAMINATED WATER STORAGE AREA (ACRES)	FLOOR SLOPE OF CONTAMINATED WATER STORAGE AREA	CALCULATED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)	REQUIRED MINIMUM HEIGHT OF CONTAINMENT BERM (FT)
0.5	0.25	0 % 1 % 2 %	0.642 1.18 1.64	1.64 2.18 2.64
1.0	0.50	0 % 1 % 2 %	0.642 1.66 2.32	1.64 2.66 3.32
2.0	1.00	0 % 1 % 2 %	0.642 2.35 3.28	1.64 3.35 4.28
4.0	2.00	0 % 1 % 2 %	0.642 3.32 4.64	1.64 4.32 5.64

* CONTAINMENT BERM WILL BE SIZED USING THE ABOVE TABLE AS A GUIDLINE TO CONTAIN STORMWATER FROM THE 25 YEAR, 24 HOUR STORM EVENT. SUPPORTING CALCULATIONS ARE INCLUDED ON PAGES IIIC-C-2 THROUGH IIIC-C-5. NOTE THAT THE CRITERIA SET FORTH IN THE ABOVE TABLE IS BASED ON A MINIMUM DOWNSLOPE CONTAINMENT BERM LENGTH OF 100 FEET.



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☒ FOR PERMITTING PURPOSES ONLY
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DATE: 02/2022
FILE: 0771-368-11
CAD: C-8-LEACHATE STORAGE TANK.DWG
DRAWN BY: JDW
DESIGN BY: DEP
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE AND CONTAMINATED WATER PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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SHEET IIIC-C-8

O:\0771\368\EXPANSION 2021\PART III\IIIC\IIIC-C-8 CONTAMINATED WATER PLAN.dwg, jwilson, 1:2

APPENDIX IIIC-D

STORAGE TANK AND FORCEMAIN CAPACITY CALCULATIONS

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER

02/22/22

Includes pages IIIC-D-1 through IIIC-D-16

Required: Determine the required leachate storage capacity for the site using HELP model results.

Method:
1. Determine the leachate volume using predicted leachate generation values from the HELP model.
2. Design the secondary containment area for the leachate storage tank.

Note: The site will have two 100,000-gallon leachate storage tanks. The following demonstration shows that a minimum of 100,000 gallons of leachate for each tank is sufficient to meet the leachate production needs of the site. A larger tank size may be used.

Solution: 1. **Determine the leachate volume using predicted leachate generation values from the HELP model.**

Results from the HELP model in Appendix IIIC-A.

Developed Sectors:

Condition	Average[1,2] cfy/ac	Average gpd/ac
Interim, 50' Waste	6,315.2	129.4
Interim, 100' Waste	28,617.0	586.5
Interim, 200' Waste	24,311.4	498.2
Interim, 300' Waste	35,284.7	723.1
Interim, 320'/330' Waste	40,226.3	824.4
Closed, 320'/330' Waste	25,894.3	530.7

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.
[2]For each fill condition the highest leachate generation rate from the developed MSW and Class 1 HELP runs was used to be conservative.

Undeveloped Sectors:

Condition	Average[1] cfy/ac	Average gpd/ac
Active, 10' Waste	3,004.4	61.6
Interim, 50' Waste	7,453.0	152.7
Interim, 100' Waste	28,510.1	584.3
Interim, 200' Waste	24,280.7	497.6
Interim, 270' Waste	31,099.8	637.3
Closed, 270' Waste	19,871.0	407.2

[1]The leachate value is the sum of the leachate recirculated and the leachate collected for each condition, if applicable.
[2]For each fill condition the highest leachate generation rate from the developed MSW and Class 1 HELP runs was used to be conservative.

Overliner Area:

Condition	Average cfy/ac	Average gpd/ac
Active, 10' Waste	3,049.5	62.5
Interim, 50' Waste	5,813.2	119.1
Interim, 100' Waste	24,696.4	506.1
Interim, 170' Waste	21,837.4	447.5
Closed, 170' Waste	12,826.6	262.9

Assume the following fill scenarios:

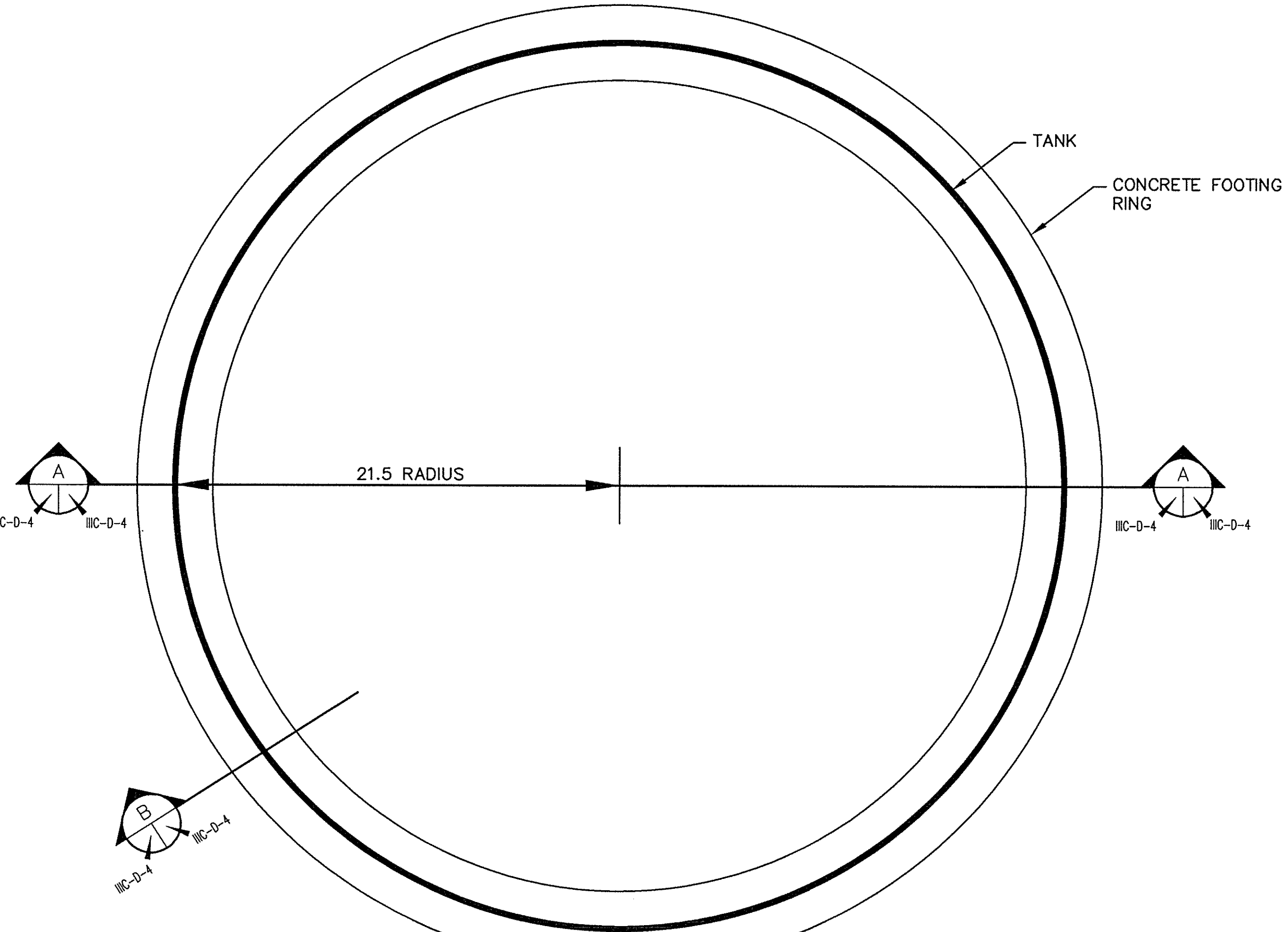
	East Storage Tank						South Storage Tank	
Condition	Developed Sectors 1-4 and 9 (62.0 acres)		Undeveloped Sectors 11 - 14 (37.6 acres)		Overliner Area (15.5 acres)		Developed Sectors 5-8 and 10 (57.1 acres)	
	(ac)	(gpd)	(ac)	(gpd)	(ac)	(gpd)	(ac)	(gpd)
Active, 10' Waste			5.2	320	2.5	156		
Interim, 50 Waste	9.6	1,242	6.2	947	2.7	322	8.0	1,035
Interim, 100' Waste	10.4	6,099	6.5	3,798	3.3	1,670	9.2	5,395
Interim, 170' Waste					4.8	2,148		
Interim, 200' Waste	12.2	6,078	7.5	3,732			12.5	6,228
Interim, 270' Waste			8.2	5,226				
Interim, 300' Waste	14.0	10,123					13.2	9,545
Interim, 320'/330' Waste	10.8	8,903					9.2	7,584
Closed	5.0	2,653	4.0	1,629	2.2	578	5.0	2,653
Total:	62.0	35,099	37.6	15,652	15.5	4,874	57.1	32,441
Total for Each Tank:					55,626	gpd	32,441	gpd

Leachate Storage Tank Management Plan

Phase of Development	Tank Location and Size	Leachate Generation, gallons per day	Management Plan
Sectors 1-4, 9, 11 and Overliner Sector 01	East - 100,000 gallons (minimum)	55,626	Over 40,000 gallons of one 100,000 gallon storage tank will remain empty and available to store leachate during emergency situations.
Sectors 5-8 and 10	South - 100,000 gallons (minimum)	32,441	Over 40,000 gallons of one 100,000 gallon storage tank will remain empty and available to store leachate during emergency situations.

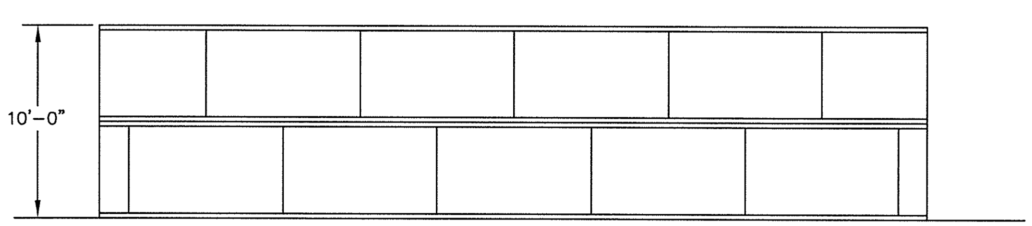
2. **Design the secondary containment area for the leachate storage tank.**

The existing 100,000-gallon storage tanks locations are shown on Figure 4-1 in Appendix IIIC. Each 100,000-gallon storage tank is a double-walled steel tank that contains an inner tank ("storage vessel") consisting of a geomembrane liner. The secondary geomembrane liner, attached to the inner surface of the steel tank, collects any leachate that may infiltrate through the primary geomembrane liner. Therefore, the 100,000-gallon storage tank design provides secondary containment as shown on Sheet IIIC-D-4.



MODULAR TANK
PLAN
NTS

0 5 10
SCALE IN FEET



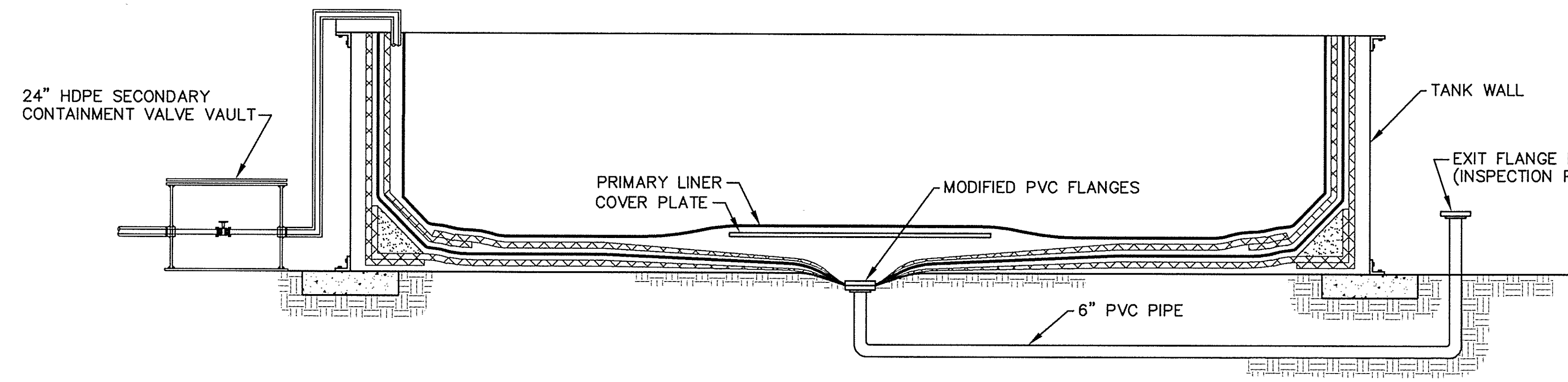
MODULAR TANK
ELEVATION
NTS

0 5 10
SCALE IN FEET

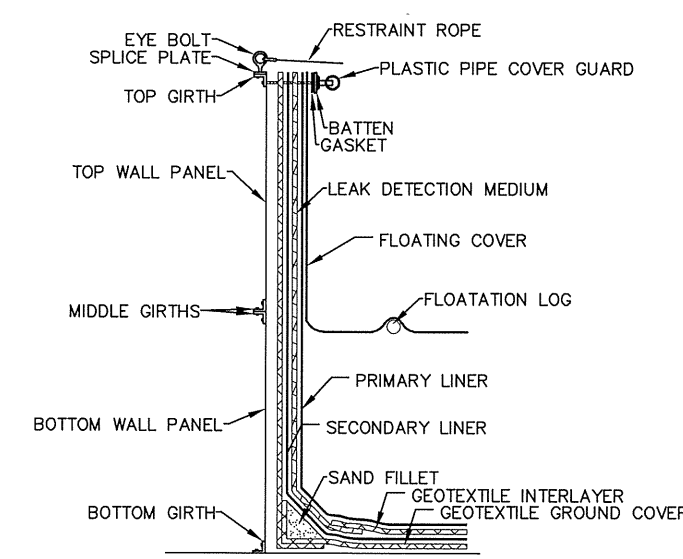
TANK VOLUME GALLONS	TANK DIMENSIONS
100,000	43' DIA X 10'

NOTE:

1. 100,000 GALLON MODULAR TANK HAS A DOUBLE LINER, LEAK DETECTION SUMP, AND A FLOATING COVER.
2. BACK FLOW PREVENTION VALVES WILL BE INSTALLED, AS NEEDED.



A TYPICAL SECTION AT LEAK DETECTION SUMP
NTS
IIIC-D-4 IIIC-D-4



B TYPICAL SECTION
NTS
IIIC-D-4 IIIC-D-4

STATE OF TEXAS
NEVZAT TURAN
84059
LICENSED
PROFESSIONAL ENGINEER
02/22/22

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☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022 DRAWN BY: JDW
FILE: 0771-368-11 DESIGN BY: CAM
CAD: D-4-LEACHATE STORAGE TANK.DWG REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LEACHATE STORAGE TANK DETAILS

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

WWW.WCGRP.COM SHEET IIIC-D-4

O:\0771\368\EXPANSION 2021\PART III\IIIC\IIIC-D-4 TANK DETAILS.dwg, rarrington, 1:2

TURKEY CREEK LANDFILL
0771-368-11
LEACHATE FORCEMAIN CAPACITY CALCULATIONS
EAST STORAGE TANK

REQUIRED: Size the leachate forcemain collection pipe.

METHOD:

A. Use leachate production rates provided in Appendix IIIC-A (based on the HELP model analysis) to determine the required capacity of the leachate collection forcemain pipes

B. Determine the capacity of the leachate collection system forcemain pipe.

C. Calculate the maximum pressure experienced by the forcemain pipe.

D. Evaluate the flow velocity in the forcemain pipe.

E. Conclusion.

REFERENCES:

1. Driscopipe Systems Design, Phillips 66. 1992 Phillips Driscopipe, Inc. 1235-91 A 01

SOLUTION:

A. Use leachate production rates provided in Appendix IIIC-A to determine the required capacity of the leachate collection forcemain pipe.

CONDITION	AREA[1]	AVERAGE ANNUAL FLOW		TOTAL FLOW	FLOW
	ac	cfy[2]	gpd/ac	gpd	cfs
10' to 50' Waste	15	7,453	153	2,291	0.0035
50' to 100' Waste	26	28,617	586	15,248	0.0236
100' to 200' Waste	27	24,311	498	13,452	0.0208
200' to 300' Waste	32	35,285	723	23,139	0.0358
300' to 330' Waste	15	40,226	824	12,365	0.0191
Total =	115				0.1029

[1]Total limits of the Subtitle D and overliner area (approximately 115 acres) directed to the East Storage Tank is represented with different waste column thicknesses for demonstration purposes.

[2]The average annual flows in cubic feet per year (cfy) have been obtained from the HELP Model summary tables included on pages IIIC-A-22 and IIIC-A-25. The highest values for a given waste thickness have been used for demonstration purposes.

Total maximum leachate production = Q = 0.1029 cubic feet per second (cfs)
Q = 46 gallons per minute (gpm)
Q = 66,495 gallons per day (gpd)

Required capacity of leachate forcemain pipe =	66,495	gpd

B. Determine the capacity of the leachate collection system forcemain pipe.

Capacity of the forcemain is calculated by using the following formula from Ref. 1.

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}} \qquad \text{Eq. 1}$$

where:

ΔP_{100} = Friction pressure loss, pounds per square inch per 100 feet of pipe
Q = Rate of flow, gallons per minute
C = Pipe coefficient, See Chart 4 on Page IIIC-D-11
D = Pipe internal diameter, inches

Rearrange Equation 1 to solve for Q.

$$Q = \left(\frac{\Delta P_{100} * C^{1.85} * D^{4.86}}{452}\right)^{(1/1.85)} \qquad \text{Eq. 2}$$

Calculate ΔP_{100}:

$$\Delta P_{100} = (P - \Delta h) / (L/100)$$

where:

P = Pipe strength, psi
Δh = Geometric head difference, psi
L = Pipe length, ft

P = 160 psi (refer to page IIIC-D-10 for SDR11 pipe)

Calculate Δh:

Elevation at the low point of forcemain =	684	ft-msl
Elevation at the high point of forcemain =	695	ft-msl
Δh =	11	ft

Convert units from feet to psi:

Note: 1 psi is equal to 2.31 feet of water column.

Δh (psi) = Δh (ft) / (2.31 ft/psi)

Δh = 4.77 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 155.23 psi

L= 5,687 ft

(Note: Forcemain length is assumed to be the total length of the forcemain serving the East Storage Tank (refer to Figure 4-1 in Appendix IIIC for location). This is a conservative assumption given that it is assumed that the design pipe flow travels the maximum distance for estimating the total head loss.)

$$\Delta P_{100} = (160 - 15.60)/(3{,}782/100)$$

$$\Delta P_{100} = 2.73 \text{ psi}$$

Calculate maximum capacity of the 2-inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-11)
D = 1.943 inches, internal diameter of forcemain (refer to page IIIC-D-10)

$$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$$

$$Q = [(3.82*155^{1.85}*2.864^{4.86})/452]^{(1/1.85)}$$

Q =	56	gpm
Q =	80,733	gpd

The above calculated value reflects the maximum capacity of the pipe, which is greater than the required capacity (i.e., 80,733 gpd > 66,495 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 2-inch diameter forcemain using the following equation from Ref. 1:

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}}$$

Q =	46	gpm (from Step A)
C =	155	From Chart 4 on Page IIIC-D-11
D =	1.943	inches, diameter of discharge pipe contained in a 6-inch diameter containment pipe

ΔP_{100} = 1.91 psi

Total head loss ($\Sigma\Delta P$) = ΔP_{100} * (L/100) = 01.91 psi x (5687/100)

$\Sigma\Delta P$= 108.42 psi

To account for local head losses (elbows, etc.) multiply the calculated total head loss with a factor of safety of 1.2.

F.S.= 1.2
$\Sigma\Delta P$ * F.S.= 130.10 psi

Calculate total head at the pump:

$P_{tot} = \Delta h + \Sigma\Delta P$

where:

P_{tot} = Total head at pump, psi
Δh = Geometric head (from Step B)
$\Sigma\Delta P$= Total head loss, psi

P_{tot} = 130.10 psi + 4.77 psi

P=	134.87	psi

D. Evaluate the flow velocity in the forcemain pipe.

$$V = 0.408 * (Q/D^2)$$ (Ref. 1)

where:

Q = Rate of flow, gpm
D = Pipe internal diameter, inches

Q =	46	gpm (from Step A)
D =	1.943	inches
V=	**4.99**	**fps**

E. Conclusion.

The pipe capacity (56 gpm) is not exceeded by the expected flow of 46 gpm.

The forcemain can withstand 160 psi, and the maximum pressure calculated as 134.87 psi; therefore, the pipe strength is acceptable.

The calculated velocity of the 2-inch forcemain for 30 gpm of flow is well within acceptable flow velocity range.

Throughout the life of the site, the flow rate in the forcemain will range from 0 to 46 gpm. Excessive sediment accumulation in the forcemain will be prevented by the system operation. For example, the pump will operate on a periodic basis. When the pump activates, flow in the forcemain will surge and the velocity will increase periodically which will transport sediment to the discharge point. This variation in Q will functionally minimize the sediment build-up potential in the pipe.

3/4" (1.050 OD)

SDR 11	160 psi	0.12 lbs./ft.	0.860 ID	.095 wall

1" (1.315 OD)

SDR 11	160 psi	0.19 lbs./ft.	1.075 ID	.120 wall

1-1/4" (1.660 OD)

SDR 11	160 psi	0.31 lbs./ft.	1.358 ID	.151 wall

1-1/2" (1.900 OD)

SDR 11	160 psi	0.41 lbs./ft.	1.554 ID	.173 wall

2" (2.375 OD)

SDR 7	267 psi	0.94 lbs/ft	1.697 ID	.339 wall
SDR 9	200 psi	0.76	1.847	.264
SDR 11 •	160 psi	0.64	1.943	.216
SDR 13.5	128 psi	0.53	2.023	.176
SDR 15.5	110 psi	0.47	2.069	.153
SDR 17	100 psi	0.43	2.095	.140

3" (3.500 OD)

SDR 7	267 psi	2.05 lbs/ft.	2.500 ID	.500 wall
SDR 9	200 psi	1.66	2.722	.389
SDR 11 •	160 psi	1.39	2.864	.318
SDR 13.5	128 psi	1.15	2.982	.259
SDR 15.5	110 psi	1.02	3.048	.226
SDR 17 •	100 psi	0.93	3.088	.206
SDR 19	89 psi	0.84	3.132	.184
SDR 21	80 psi	0.77	3.166	.167
SDR 26	64 psi	0.62	3.230	.135
SDR 32.5	51 psi	0.50	3.284	.108

4" (4.500 OD)

SDR 7	267 psi	3.39 lbs/ft.	3.214 ID	.643 wall
SDR 9	200 psi	2.74	3.500	.500
SDR 11 •	160 psi	2.29	3.682	.409
SDR 13.3	128 psi	1.90	3.834	.333
SDR 15.5 •	110 psi	1.68	3.020	.290
SDR 17 •	100 psi	1.54	3.970	.265
SDR 19	89 psi	1.39	4.026	.237
SDR 21	80 psi	1.26	4.072	.214
SDR 26 •	64 psi	1.03	4.154	.173
SDR 32.5	51 psi	0.83	4.224	.138

5-3/8" (5.375 OD)

SDR 17	100 psi	2.20 lbs/ft.	4.743 ID	.316 wall
SDR 21	80 psi	1.80	4.863	.256
SDR 26	64 psi	1.47	4.961	.207
SDR 32.5	51 psi	1.18	5.045	.165

5" (5.563 OD)

SDR 7	267 psi	5.17 lbs/ft.	3.973 ID	.795 wall
SDR 9	200 psi	4.18	4.327	.618
SDR 11	160 psi	3.51	4.551	.506
SDR 13.5	128 psi	2.91	4.739	.412
SDR 15.5	110 psi	2.57	4.845	.359
SDR 17	100 psi	2.35	4.909	.327
SDR 19	89 psi	2.12	4.977	.293
SDR 21	80 psi	1.93	5.033	.265
SDR 26	64 psi	1.57	5.135	.214
SDR 32.5	51 psi	1.27	5.221	.171

6" (6.625 OD)

SDR 7	267 psi	7.33 lbs./ft.	4.733 ID	.946 wall
SDR 9	200 psi	5.93	5.153	.736
SDR 11 •	160 psi	4.97	5.421	.602
SDR 13.5	128 psi	4.13	5.643	.491
SDR 15.5	110 psi	3.63	5.771	.427
SDR 17 •	100 psi	3.34	5.845	.390
SDR 19	89 psi	3.01	5.927	.349
SDR 21 •	80 psi	2.73	5.995	.315
SDR 26 •	64 psi	2.23	6.115	.255
SDR 32.5 •	51 psi	1.80	6.217	.204

7" (7.125 OD)

SDR 7	267 psi	8.49 lbs./ft.	5.089 ID	1.018 wall
SDR 9	200 psi	6.86	5.541	.792
SDR 11	160 psi	5.75	5.829	.648
SDR 13.5	128 psi	4.78	6.069	.528
SDR 15.5	110 psi	4.21	6.205	.460
SDR 17	100 psi	3.86	6.287	.419
SDR 19	89 psi	3.48	6.375	.375
SDR 21	80 psi	3.16	6.445	.340
SDR 26 •	64 psi	2.58	6.577	.274
SDR 32.5	51 psi	2.08	6.685	.220

8" (8.625 OD)

SDR 7	267 psi	12.43 lbs.ft.	6.161 ID	1.232 wall
SDR 9	200 psi	10.05	6.709	.958
SDR 11 •	160 psi	8.42	7.057	.784
SDR 13.5	128 psi	7.00	7.347	.639
SDR 15.5	110 psi	6.16	7.513	.556
SDR 17 •	100 psi	5.65	7.611	.507
SDR 19	89 psi	5.10	7.717	.454
SDR 21 •	80 psi	4.64	7.803	.411
SDR 26 •	64 psi	3.79	7.961	.332
SDR 32.5 •	51 psi	3.05	8.095	.265

• denotes standard sizes

Chart 4

Table of "C" Values for "Hazen and Williams Formula"

Constant	Type of Pipe
155	Driscopipe
140	New steel pipe or tubing Glass tubing Asbestos cement
130	Copper tubing Ordinary brass pipe Cast iron—new Cast iron—tar coated but new Cast iron—fully cement lined
125	Steel pipe—old
120	Wood stave pipe Concrete pipe New wrought iron pipe Four to six years old cast iron pipe
110	Ten to twelve years old cast iron pipe Vitrified pipe Spiral riveted steel, flow with lap Galvanized steel
100	Spiral riveted steel, flow against lap Thirteen to twenty years old cast iron pipe Galvanized steel—over 5 years old Cast iron—tar coated over 10 years old
90	Twenty-six to thirty-year old cast iron pipe
60	Corrugated steel pipe

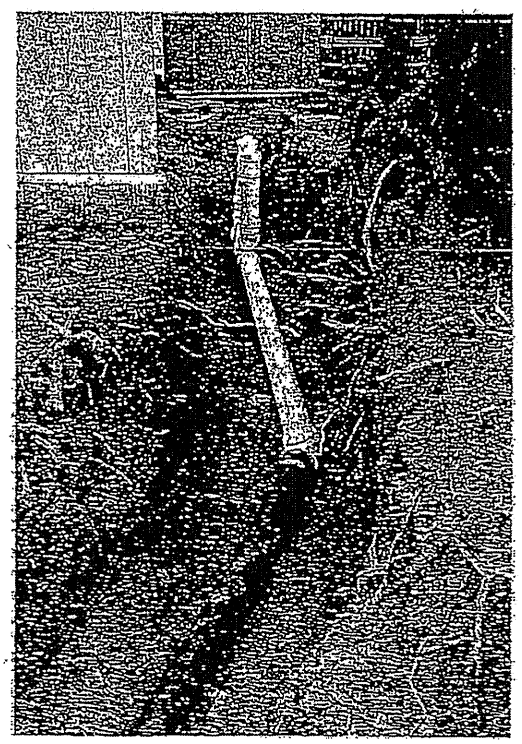
Fitting Pressure Drop: Listed below in Chart 5 are various common piping system components and the associated pressure loss through the fitting expressed as an equivalent length of straight pipe in terms of diameters. The inside diameter (in feet) multiplied by the equivalent length diameters gives the equivalent length (in feet) of pipe. This equivalent length of pipe is added to the total footage of the piping system when calculating the total system pressure drop.

These equivalent lengths should be considered an approximation suitable for most installations.

Chart 5

Fabricated Fitting	Equiv. Length
Running Tee	20 D
Branch Tee	50 D
90° Fab. Ell	30 D
60° Fab. Ell	25 D
45° Fab. Ell	18 D
45° Fab. Wye	60 D
Conventional Globe Valve (Full Open)	350 D
Conventional Angle Valve (Full Open)	180 D
Conventional Wedge Gate Valve (Full Open)	15 D
Butterfly Valve (Full Open)	40 D
Conventional Swing Check Valve	100D

(See Appendix for further data on resistance of valves and fittings to flow).



TURKEY CREEK LANDFILL
0771-368-11
LEACHATE FORCEMAIN CAPACITY CALCULATIONS
SOUTH STORAGE TANK

REQUIRED: Size the leachate forcemain collection pipe.

METHOD:

A. Use leachate production rates provided in Appendix IIIC-A (based on the HELP model analysis) to determine the required capacity of the leachate collection forcemain pipes

B. Determine the capacity of the leachate collection system forcemain pipe.

C. Calculate the maximum pressure experienced by the forcemain pipe.

D. Evaluate the flow velocity in the forcemain pipe.

E. Conclusion.

REFERENCES:

1. Driscopipe Systems Design, Phillips 66. 1992 Phillips Driscopipe, Inc. 1235-91 A 01

SOLUTION:

A. Use leachate production rates provided in Appendix IIIC-A to determine the required capacity of the leachate collection forcemain pipe.

CONDITION	AREA[1]	AVERAGE ANNUAL FLOW		TOTAL FLOW	FLOW
	ac	cfy[2]	gpd/ac	gpd	cfs
10' to 50' Waste	9	7,608	156	1,403	0.0022
50' to 100' Waste	8	29,607	607	4,854	0.0075
100' to 200' Waste	13	27,187	557	6,964	0.0108
200' to 300' Waste	15	27,187	557	8,357	0.0129
300' to 330' Waste	12	35,632	730	8,762	0.0136
Total =	57				0.0469

[1]Total limits of the Subtitle D and overliner area (approximately 57 acres) directed to the South Storage Tank is represented with different waste column thicknesses for demonstration purposes.

[2]The average annual flows in cubic feet per year (cfy) have been obtained from the HELP Model summary tables included on pages IIIC-A-22 through IIIC-A-25. The highest values for a given waste thickness have been used for demonstration purposes.

Total maximum leachate production = Q = 0.0469 cubic feet per second (cfs)
Q = 21 gallons per minute (gpm)
Q = 30,341 gallons per day (gpd)

Required capacity of leachate forcemain pipe =	30,341	gpd

B. Determine the capacity of the leachate collection system forcemain pipe.

Capacity of the forcemain is calculated by using the following formula from Ref. 1.

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}} \qquad \text{Eq. 1}$$

where:

ΔP_{100} = Friction pressure loss, pounds per square inch per 100 feet of pipe
Q = Rate of flow, gallons per minute
C = Pipe coefficient, See Chart 4 on Page IIIC-D-11
D = Pipe internal diameter, inches

Rearrange Equation 1 to solve for Q.

$$Q = \left(\frac{\Delta P_{100} * C^{1.85} * D^{4.86}}{452}\right)^{(1/1.85)} \qquad \text{Eq. 2}$$

Calculate ΔP_{100}:

$$\Delta P_{100} = (P - \Delta h) / (L/100)$$

where:

P = Pipe strength, psi
Δh = Geometric head difference, psi
L = Pipe length, ft

P = 160 psi (refer to page IIIC-D-10 for SDR11 pipe)

Calculate Δh:

Elevation at the low point of forcemain =	692	ft-msl
Elevation at the high point of forcemain =	790	ft-msl
Δh =	98	ft

Convert units from feet to psi:

Note: 1 psi is equal to 2.31 feet of water column.

Δh (psi) = Δh (ft) / (2.31 ft/psi)

Δh = 42.47 psi

Pipe Strength Available for Friction Loss = P - Δh

Pipe Strength for Friction Loss = 117.53 psi

L= 2,037 ft

(Note: Forcemain length is assumed to be the total length of the forcemain serving the South Storage Tank (refer to Figure 4-1 in Appendix IIIC for location). This is a conservative assumption given that it is assumed that the design pipe flow travels the maximum distance for estimating the total head loss.)

$$\Delta P_{100} = (160 - 9.53)/(1{,}122/100)$$

$$\Delta P_{100} = 5.77 \text{ psi}$$

Calculate maximum capacity of the 2-inch pipe by using Equation 2 above:

C = 155 (refer to page IIIC-D-11)
D = 1.943 inches, internal diameter of forcemain (refer to page IIIC-D-10)

$$Q = [(\Delta P_{100} C^{1.85} D^{4.86})/452]^{(1/1.85)}$$

$$Q = [(13.41*155^{1.85}*2.864^{4.86})/452]^{(1/1.85)}$$

Q =	84	gpm
Q =	120,980	gpd

The above calculated value reflects the maximum capacity of the pipe, which is greater than the required capacity (i.e., 80,733 gpd > 31,341 gpd).

C. Calculate the maximum pressure experienced by the forcemain pipe.

Calculate head loss in the 2-inch diameter forcemain using the following equation from Ref. 1:

$$\Delta P_{100} = \frac{452 * Q^{1.85}}{C^{1.85} * D^{4.86}}$$

Q =	21	gpm (from Step A)
C =	155	From Chart 4 on Page IIIC-D-11
D =	1.943	inches, diameter of discharge pipe contained in a 6-inch diameter containment pipe

$\Delta P_{100} =$ 0.45 psi

Total head loss $(\Sigma\Delta P) = \Delta P_{100} * (L/100) =$ 0.45 psi x (2037/100)

$\Sigma\Delta P =$ 9.10 psi

To account for local head losses (elbows, etc.) multiply the calculated total head loss with a factor of safety of 1.2.

F.S.=	1.2	
$\Sigma\Delta P$ * F.S.=	10.92	psi

Calculate total head at the pump:

$$P_{tot} = \Delta h + \Sigma\Delta P$$

where:

P_{tot} = Total head at pump, psi
Δh = Geometric head (from Step B)
$\Sigma\Delta P$= Total head loss, psi

P_{tot} = 10.92 psi + 42.47 psi

P=	53.38	psi

D. Evaluate the flow velocity in the forcemain pipe.

$V = 0.408 * (Q/D^2)$ (Ref. 1)

where:

Q = Rate of flow, gpm
D = Pipe internal diameter, inches

Q =	21	gpm (from Step A)
D =	1.943	inches

V=	2.28	fps

E. Conclusion.

The pipe capacity (84 gpm) is not exceeded by the expected flow of 21 gpm.

The forcemain can withstand 160 psi, and the maximum pressure calculated as 53.38 psi; therefore, the pipe strength is acceptable.

The calculated velocity of the 3-inch forcemain for 21 gpm of flow is well within acceptable flow velocity range.

Throughout the life of the site, the flow rate in the forcemain will range from 0 to 21 gpm. Excessive sediment accumulation in the forcemain will be prevented by the system operation. For example, the pump will operate on a periodic basis. When the pump activates, flow in the forcemain will surge and the velocity will increase periodically which will transport sediment to the discharge point. This variation in Q will functionally minimize the sediment build-up potential in the pipe.

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIID
LINER QUALITY CONTROL PLAN

Prepared for

Texas Regional Landfill Company, LP

February 2022

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This document is intended for permitting purposes only.

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1 INTRODUCTION

1.1 Purpose

This appendix addresses §330.63(d)(4)(G), §330.337, §330.339, and §330.341.

This Liner Quality Control Plan (LQCP) has been prepared to provide the Operator, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Rules (MSWR). More specifically, the LQCP addresses the soil and geosynthetic components of the liner system and the overliner system. The provisions of this LQCP were developed based on the latest technical guidelines of the TCEQ, including quality control of construction, testing frequencies and procedures, and quality assurance of sampling and testing procedures.

This LQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Earthwork and Drainage Aggregates
- Section 3 – Construction Quality Assurance for Geosynthetics
- Section 4 – Construction Quality Assurance for Geosynthetic Clay Liner
- Section 5 – Construction Quality Assurance for Piping
- Section 6 – Liners Constructed Below the Highest Groundwater Level
- Section 7 – Geotechnical Strength Testing Requirements
- Section 8 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

This means the American Society for Testing and Materials.

Ballast Evaluation Report (BER)

Certification report for the constructed ballast, prepared and sealed by the POR and submitted to TCEQ.

Construction Quality Assurance (CQA)

A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance that confirms that the facility was constructed in accordance with plans and specifications approved by the permitting agency. The POR must be registered as a Professional Engineer in Texas and experienced in geotechnical testing and interpretation. Experience and education must include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, and quality control testing, and hydrogeology. POR or his designated representative will be on-site during all liner system construction. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The POR or his designated representative will be on-site during all liner system construction. The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during liner system construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing will be NICET-certified in geotechnical engineering technology at Level 2 or higher for soils testing; certified through the Geosynthetic Certification Institute's Inspectors Certification Program (GCI-ICP) for geosynthetics; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) on behalf of the POR. Additional CQA monitors may be employed under the supervision of the qualified CQA monitor, who is required to be at the site during liner system construction.

Contract Documents

These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator, and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction specifications and Section 2 of this plan.

Film Tear Bond (FTB)

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Geomembrane Liner (GM)

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM. A 60-mil-thick high density polyethylene (HDPE) geomembrane is used for the bottom liner and a 40-mil-thick linear low density polyethylene (LLDPE) geomembrane is used for the overliner. Textured and smooth geomembrane used for the bottom liner and overliner are described in Sections 3.3 and 3.4, respectively.

Geomembrane Liner Evaluation Report (GLER)

Certification report for the geomembrane liner, prepared and sealed by the POR that is submitted to the TCEQ for approval. Also referred to as flexible membrane liner evaluation report (GLER).

Geosynthetic Clay Liner (GCL)

This is a synthetic lining material, which in the most basic form consists of bentonite sandwiched between two geotextiles. Also referred as prefabricated bentonite blankets, mats or panels, or clay blankets, mats or panels.

Geosynthetic Clay Liner Evaluation Report (GCLER)

Certification report for the geosynthetic clay liner, prepared and sealed by POR, which is submitted to TCEQ for approval.

Geosynthetics Contractor

This individual is also referred to as the "contractor" or "installer," and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or geotextile, even if not his primary function.

Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the liner system or the manufacturer of the liner system products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit (Texas Regional Landfill Company, LP).

Organic Matter

Organic matter is material that may be capable of decay (e.g., plant material), the product of decay, or both.

Permittee's Representative

This is the person that is an official representative of the permittee responsible for planning, organizing, and controlling the design and construction activities.

Panel

This is a unit area of the FML, which will be seamed in the field.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor.

Soil Liner Evaluation Report (SLER)

Construction report for the soil liner prepared and sealed by the POR and submitted to the TCEQ.

Tire Chips

Pieces of scrap tires that have a basic geometrical shape and a nominal size of 2 to 4 inches. The tire chips typically include a high tensile steel wire cord used in the steel belts. The high tensile steel wire cord will have a maximum length of 6 inches. Additionally, the tire chips will be free of foreign objects.

2 CONSTRUCTION QUALITY ASSURANCE EARTHWORK AND DRAINAGE AGGREGATES

2.1 Introduction

This section of the LQCP addresses the construction of the soil and drainage components of the liner system and the overliner system and outlines the LQCP program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements, and treatment of problems.

The scope of earthwork and related construction quality assurance includes the following elements:

- Subgrade preparation
- Soil liner stockpile
- Soil liner placement
- General fill
- Drainage aggregates
- Anchor trench backfill
- Excavation dewatering

2.2 Composite Liner

The landfill is designed to include a Subtitle D composite liner (MSW and Class 1) for the undeveloped sectors. Class 1 waste sectors will be constructed with a 3-foot-thick compacted clay liner overlain by a 60-mil-thick high density polyethylene (HDPE) flexible membrane liner (FML). The Class 1 sectors will also require additional subgrade preparation as discussed in Section 2.3.1. MSW sectors will be constructed with a 2-foot-thick compacted clay liner overlain by a 60-mil-thick HDPE FML.

In addition, the landfill design also includes an overliner system for the pre-Subtitle D area. The overliner is placed on 2-foot of compacted clay and consists of a 40-mil linear low-density polyethylene (LLDPE) FML which is textured on both sides. As an alternate to the 2 feet of constructed clay liner, a geosynthetic clay liner (GCL) can be used in place of the clay liner. The alternate overliner is placed on a 12-inch soil subgrade and consists of a GCL overlain by a 40-mil LLDPE FML which is textured on both sides.

These liner systems are detailed in Appendix IIIA – Landfill Unit Design Information. A structural stability analysis for the liner systems, including calculations for anchor trench runout lengths, stress on the liner components, and an infinite slope stability analysis, is included in Appendix IIIM – Geotechnical Report.

2.3 Earthwork Construction

The following paragraphs describe general construction procedures to be used for various earthwork components within the landfill. The earthwork construction specifications will be developed based on the material and construction procedures outlined in this section of the LQCP for each specific liner construction. The earthwork construction specifications will include details for compaction of soils, cross sections showing typical slopes, widths, and thicknesses for compacted lifts.

2.3.1 Subgrade

Subgrade refers to a surface which is exposed after stripping topsoil or excavating to establish the grade directly beneath the composite liner. The prepared subgrade for unconstructed sectors must conform to the Excavation Plan included in Appendix IIIA – Landfill Unit Design Information.

Prior to beginning liner construction, the subgrade area will be stripped to a depth sufficient to remove all loose surface soils or soft zones within the exposed excavation. The liner subgrade area will be proof-rolled with heavy, rubber-tired construction equipment to detect unstable areas. Unstable areas will be undercut to firm material and refilled with suitable compacted general fill. Soil used for backfill will meet the same material requirements as the soil liner and will be installed in accordance with the soil liner installation procedures. The fill will be free of organic matter, foreign objects, and other deleterious matter, compacted sufficiently to provide a firm base for composite liner placement. The subgrade will also be scarified prior to placement of the first lift of clay liner. The subgrade preparation specifications for each liner construction event will be developed in accordance with this section. Construction project specifications and construction plans will be developed for each cell construction event in accordance with this LQCP consistent with the Excavation Plan (Drawing A.1) included in Appendix IIIA – Landfill Design Unit Information and the sector design as contained in the approved Site Development Plan.

Subgrade voids and cracks are expected to be minor. However, the subgrade will be re-worked as necessary to provide a foundation suitable for soil liner placement.

Visual examination of the subgrade preparation by the CQA monitor will generally be sufficient to evaluate its suitability as a foundation for the subgrade. The CQA monitor may find that physical testing is necessary to evaluate the prepared subgrade or fill placed in large voids.

The POR will approve the prepared subgrade prior to the placement of the underdrain, soil liner, or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the subgrade preparation. Additionally, during the subgrade acceptance, the POR will verify that the underlying material is consistent with the geotechnical design assumptions included in Appendix IIIM – Geotechnical Report.

Surveying will be performed to verify that the finished subgrade is to the lines and grades specified in design with a vertical tolerance of -0.2 feet to +0.0 feet to ensure that the clay liner will achieve the required minimum thickness.

2.3.1.1 Class 1 Liner Subgrade Preparation on Sector Excavation Sideslopes

TAC Title 30 TAC §335.584(b)(2) requires that the base of a containment structure be separated from the underlying Regional Aquifer by a minimum of 10 feet of material not exceeding $1x10^{-7}$ cm/s towards the aquifer. The Turkey Creek Landfill containment structures (bottom liner systems) are separated from the underlying Regional Aquifer by a thickness of approximately 70 feet, most with permeabilities less than $1x10^{-7}$ cm/s, as discussed in Appendix G, Section 4.4.2 of this application. Therefore, this requirement does not affect the design and construction of containment structures (disposal cells) at the Turkey Creek Landfill.

Title 30 TAC §335.584(b)(1) requires that containment structures have a minimum of 5 feet of separation from sands and gravels, sandy or gravely soils, or soils with a permeability greater than $1x10^{-5}$ cm/s. This requirement is being met in areas the bottom liner excavations encounter the Upper Sand unit by the installation of a 5-foot-thick compacted clay separation layer between the base of the bottom liner system and the underlying Upper Sand unit. The 5-foot-thick separation layer will be installed with a permeability of not greater than $1x10^{-5}$ cm/s. The area requiring a reconstructed separation layer will be installed on the sector sideslope extending from an elevation 2 feet below the Upper Sand unit, to an elevation above the seasonal high water table elevation, as determined from groundwater monitoring. The reconstructed separation layer will be a minimum 5 feet in thickness (measured perpendicular to the sideslope) and have a permeability of $1x10^{-5}$ cm/s or less. The liner system will be constructed above the separation layer. A site plan presenting the proposed locations of the separation layer in Sectors 11 and 12 is included as Figure IIID-3 in this appendix. The 5-foot reconstructed layer, combined with the 3-foot-thick compacted clay liner, and the 2 feet of protective cover will provide for 10-feet of separation between the Upper Sand unit and waste.

The separation layer material below the liner subgrade will be placed in 6-inch loose lifts and compacted to 95 percent of the maximum dry density at a moisture content between optimum moisture content and up to 5 percent above optimum as determined by the Standard Proctor Compaction Test (ASTM D 698). This material will exhibit a hydraulic conductivity of $1x10^{-5}$ cm/s or less.

Testing of the separation layer soil will be performed at the same frequency for soil liners as indicated in Table 2-2. A licensed land surveyor will be retained to verify thickness of the reconstructed separation layer by surveying methods, prior to subsequent soil liner construction. The separation layer thickness will be determined on a grid not exceeding 5,000 ft^2 with a minimum of two grid points required for verification of an area. Documentation of any Class 1 separation layer construction will be included in the SLER.

2.3.2 Soil Liner

The soil liner will consist of a minimum 2-foot-thick (or 3-foot-thick for Class 1 area) compacted clay liner (measured perpendicular to the subgrade surface) that will extend along the floor and side slopes of the landfill. The soil liner will be constructed in continuous, single, compacted lifts (6 inches thick) parallel to the floor and sideslope subgrades. Details depicting the liner system are included in Appendix IIIA – Landfill Unit Design Information. Soil Liner material shall comply with the requirements of Table 2-1 below, and Section 3.2.2 of this LQCP.

2.3.2.1 Soil Liner Borrow Material

Adequate soil liner material will be available from proposed landfill excavations onsite or offsite borrow sources. The liner soil will be free of debris, rock greater than 1 inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Laboratory tests will verify that materials are adequate to meet the compacted clay liner requirements listed in Title 30 TAC §330.339(c)(5) prior to liner construction. As necessary, an off-site borrow source can be used for soil liner and protective cover construction.

Soils used in soil liners will have the following minimum values verified by testing in a soil laboratory prior to liner construction.

Table 2-1
Required Properties for Soil Liner

Test[1]	Specification	Standard	Frequency
Moisture/Density Relationship	Determine moisture/density curve using a minimum of four data points	ASTM D698	One per soil type
Coefficient of Permeability (Remolded Sample)[2]	1.0×10^{-7} cm/s or less	CoE EM1110-2-1906	
Plasticity Index	15 minimum	ASTM D4318	
Liquid Limit, percent	30 minimum	ASTM D4318	
Percent Passing No. 200 Mesh Sieve	30 minimum	ASTM D1140	
Percent Passing 1-inch Sieve	100	ASTM D448	
Unified Soil Classification	Reported in moisture/density test for soils meeting liquid limit, elastic limit, and percent passing -200	ASTM D2487	

1 Testing will be performed in accordance with the test methods included in Section 2.4.
2 The coefficient of permeability for remolded sample is run at a minimum of 95% of the maximum dry density (determined using Moisture/density test) at or above the optimum moisture content.

Representative preliminary sampling and testing will be performed on soils (on or offsite) to be used as liner material. Prior to construction of each liner construction event, conformance tests that include USCS classification, liquid limit, plastic limit, percent passing the No. 200 sieve, Standard Proctor (ASTM D 698) compaction test and coefficient of permeability test will be performed for each material proposed for each individual liner construction. The coefficient of permeability test specimens for the liner will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor maximum dry density. One Standard Proctor moisture-density relationship and remolded coefficient of permeability test will be required for each different material. The soil is considered as a separate soil borrow source if the liquid limit or plasticity index is determined to vary by more than 10 points. Additional conformance tests will be conducted if there are visual changes (color, texture, etc.) in borrow material or as determined necessary by the POR. The liquid limit and plastic limit testing will be performed on the separate borrow source as an initial determination. If the liquid limit or plasticity index varies by more than 10 points then all other testing listed in Table 2-1 will be performed on the separate borrow source.

The CQA monitor, Earthwork Contractor, and/or Operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required. The liquid limit and plastic limit testing will be performed on the separate borrow source as an initial determination. If the liquid limit or plasticity index varies by more than 10 points then all other testing listed in Table 2-1 will be performed on the separate borrow source.

The physical characteristics of the liner materials will be evaluated through visual observation before and during construction. To adjust moisture to the material properly, any clod sizes will first be crushed into manageable sizes of 4 inches in diameter or less. Rocks and clods within the compacted liner must be less than 1 inch in diameter. Soil clod size will be reduced to the smallest size necessary to achieve the coefficient of permeability reported by the testing laboratory. Additionally, the rock content of the soil liner will not be more than 10 percent by weight. Water used for the soil liner moisture adjustment must be clean and not contaminated by waste or any objectionable material. Stormwater collected onsite may be used if it has not come into contact with solid waste.

2.3.2.2 Liner Construction

This LQCP has been developed in accordance with the TCEQ MSWR. The requirements for testing and evaluation of the soil liner during construction are included in this LQCP. The construction methods and test procedures documented in the SLER will be consistent with this LQCP and TCEQ regulations.

The soil liner material will be placed in maximum 8-inch-thick loose lifts to produce a compacted lift thickness of approximately 6 inches. The soil liner will have elevations, slopes, thickness, and widths as depicted on Drawing A.1 – Excavation Plan, and Drawings A.4 and A.5 – Liner System Details in Appendix IIIA – Landfill Unit Design Information.

The liner material will be compacted to a minimum of 95 percent of the maximum dry density at or above the optimum moisture content as determined by Standard Proctor (ASTM D 698). The compaction of the clay liner will be verified by a third party independent laboratory to result in a coefficient of permeability of $1x10^{-7}$ cm/s or less.

The soil liner must be compacted with a pad/tamping-foot or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. Use of pad/tamping-foot or prong-foot rollers will provide sufficient roughening of liner lifts surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds, and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (1 direction) of the compactor, not just an axle, over a given area. The recommended minimum of five passes is for a vehicle with front and rear drums. The Caterpillar 815B and 825C are examples of equipment typically used to achieve satisfactory results.

The soil liner will not be compacted solely with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller.

During the construction of continuous liners, the new liner segment will not be constructed by "butting" the entire thickness of the new liner directly against the edge of the old liner. The tie-in will be constructed by a sloped transition (typical 5 horizontal to 1 vertical) as shown in Appendix IIIA – Landfill Unit Design Information. The length of the tie-in must be at least 5 feet per foot of liner thickness. The tie-in will be scarified prior to placement of the next lift.

CQA testing of the soil liner will be performed as the liner is being constructed. Testing of the soil liner is addressed in Section 2.4. Sections of compacted soil liner which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density and moisture content test results will be incorporated into the SLER.

Hydraulic conductivity samples will be obtained by pushing a sampler through each lift of the constructed clay liner prior to construction of the next lift. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/clay liner soil material mixture consisting of at least 20 percent bentonite and compacted by hand tamping.

If the integrity of the "A" sample appears to have been compromised during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the maximum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample, the ASTM D 5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned.

The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the SLER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or sample "A" fails in such a way that there is not an option to use the "B sample), the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location). Additional tests may be taken to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section.

Furthermore, if it is determined that the "B" sample may not be used to replace the "A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed liner lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test, and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each lift, given that the reconstructed liner area is not larger than 100,000 square feet (i.e., four hydraulic conductivity tests per 100,000 square feet of reconstructed liner area for 2-foot-thick clay liner or six hydraulic conductivity tests per 100,000 square feet of reconstructed liner for 3-foot-thick clay liner). The reconstructed liner area will be tied into the currently constructed liner with a 5H:1V transition slope according to the tie-in detail included in Appendix IIIA – Landfill Unit Design Information. Reconstructed liner area is also subject to field density and moisture content testing per Table 2-2 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed).

Each lift of the reconstructed liner area will be tested for hydraulic conductivity. Reconstruction activities, including additional testing and surveying, will be incorporated into the SLER.

Soil liner construction and testing will be conducted in a systematic and timely fashion on each lift. Delays will be avoided in liner construction. Construction and testing of the soil liner will generally not exceed 60 working days from beginning of liner installation to completion. The TCEQ will be notified during construction if delays in excess of 60 days are anticipated. Reasons for liner construction taking more than 60 days to complete will be fully explained in the SLER submittal.

The finished surface of the final lift of soil liner must be rolled with a smooth, steel-drum roller to obtain a hard, uniform, and smooth surface. The surface of the final lift of soil liner will then be inspected by the CQA monitor. All undesired materials will be removed from the liner surface, and any voids created by removing undesired materials will be backfilled with liner material to the density specifications outlined for liner construction and tested at the discretion of the CQA monitor.

Surveying will be performed to verify that the finished top of liner grade is to the lines and grades specified in construction plans for a particular cell. Top of soil liner surveying will be performed within a tolerance of -0.0 feet to +0.2 feet. The surface slope of the top layer will conform to the slope requirements of the leachate collection layer. Survey frequency is included in Table 2-2.

The POR will submit to the TCEQ a SLER for approval of each soil liner area.

The soil liner will be prevented from losing moisture during the SLER approval process. Preserving the moisture content of the installed soil liner will be dependent on the earthwork contractors means and methods, and is subject to POR approval.

Upon approval of a SLER by TCEQ and prior to waste placement, SLER markers will be installed to clearly indicate the limits of constructed and approved liner areas in accordance with Section 4.7 – Landfill Markers and Benchmark of the approved Site Operating Plan. SLER markers will be located so that they are not destroyed during operations. Any damaged SLER marker will be replaced and/or re-installed immediately.

2.3.3 Overliner Construction

The soil component of the overliner will be compacted clay or GCL. The compacted clay placed on prepared subgrade soil will have a minimum of 24 inches finished thickness and will be placed in accordance with Section 2.3.2. The top of liner will have elevations, slopes, thickness, and widths as depicted on Drawing A.1 – Excavation Plan and Drawings A.12 through A.14 – Overliner System Details in Appendix IIIA – Landfill Unit Design Information.

The GCL alternative, installed as a substitute to the clay liner described above, will be placed in accordance with Section 4 of the LQCP.

The overliner construction and testing will be conducted in a systematic and timely fashion. Delays will be avoided in overliner construction. Construction and testing of the overliner will generally not exceed 60 working days from beginning of overliner installation to completion of placement of protective cover. The TCEQ will be notified during construction if delays in excess of 60 days are anticipated. Reasons for overliner construction taking more than 60 days to complete will be fully explained in the GLER submittal.

The existing soil final cover, where it exists, will be stripped to leave at least 24 inches of soil liner. The finished surface of the subgrade must be rolled with a smooth, steel-drum roller to obtain a firm, uniform, and smooth surface. The surface of the constructed soil liner will then be inspected by the POR and subgrade acceptance will be signed by the owner, CQA (or CQA monitor), Engineer, and geosynthetic installer. Surveying will be performed to verify that the finished soil liner has been constructed to a minimum thickness of 24 inches. Thickness verification may be performed by using settlement plates. A typical settlement plate diagram is shown on Figure IIID-1. The location of the settlement plates will be established by a Texas registered surveyor on a 100-foot grid. The shaft extending upward from the base will be marked to indicate the minimum required thickness of the soil liner. The soil liner will be constructed to the minimum thickness marked on the shaft of the settlement plate. The POR and CQA monitor will verify that the subgrade is placed uniformly between each settlement plate.

A compacted clay liner thickness drawing at each of the survey measurement grid points will be provided in the SLER. Coordinates defining the perimeter of the overliner will be called out on one of the final drawings. The compacted clay thickness drawing will be sealed by a Texas registered surveyor. After the construction of the compacted clay liner is complete, the Texas registered surveyor will survey the final elevation of the installed liner. The certification drawings will be included in the SLER. In addition, the elevations obtained for the top of the compacted clay liner will be used to verify that the as-built slopes are consistent with the approved top of overliner plan (Drawing A.2 in Appendix IIIA). A statement that confirms that the as-built slopes are consistent with the approved top of overliner plan will be included in the SLER.

Once the survey is complete, the settlement plate shaft will be removed and the resulting hole will be backfilled with bentonite or a bentonite/soil mixture consisting of at least 20 percent bentonite and compacted by hand tamping.

Settlement plate monitoring of settlement of the overliner will not be required for the GCL alternative, as demonstration of thickness of the installed GCL is not necessary (beyond the manufacturer's CQA certification).

The POR will incorporate the subgrade-related information into the SLER.

2.3.4 General Fill/Structural Fill

General fill/structural fill material will be comprised of uncontaminated earthen material. General fill material placed below the liner (e.g., over-excavated areas within the liner construction area) will be placed in uniform lifts which do not exceed 8 inches in loose thickness similar to compacted clay liner that will be placed over the backfilled area. General structural fill (e.g., perimeter berm construction) will be placed in uniform lifts which do not exceed 12 inches in loose thickness and will be compacted to at least 90 percent of Standard Proctor maximum dry density (ASTM D 698). The fill placed below the liner will be compacted to at least 95 percent of Standard Proctor maximum dry density (ASTM D 698) at a moisture content range at or above the optimum moisture content when it is used as fill for below liner grades.

When tire chips are used in the leachate collection layer, general fill will be placed on the composite liner to separate the HDPE geomembrane liner and tire chip layer. This layer will be placed using low ground pressure equipment as outlined in Section 3.7 (no compaction requirements) and will be placed by spreading in front of the spreading equipment with a minimum of 12 inches of soil between the spreading equipment and the installed geosynthetics. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics.

This layer will be free of organics, angular rocks, and foreign objects larger than 3/8 inch.

2.3.5 Drainage Aggregate Around Pipes

The coarse aggregate (i.e., filter material) selected for placement around the leachate collection pipes used in the LCS for the composite liner and overliner will consist of normal (e.g., typical unit weight of 90 to 110 pcf) or lightweight (e.g., unit weight not to exceed 70 pcf) materials that comply with the following criteria. The leachate collection system (LCS) aggregate will have a calcium carbonate content less than 15 percent. Either the J&L Testing method or the ASTM D 3042 method, modified to use a solution of hydrochloric acid having a pH of 5, can be used to determine calcium carbonate content. The drainage aggregate will meet the gradation for ASTM D 448, size number 467 or Grade 57 (nominal aggregate size 1.5 inches to No. 4). However, if approved by the POR, coarse aggregates not complying with the size number 467 gradation may also be used if demonstrated to have a hydraulic conductivity of at least 1.0×10^{-2} cm/s and meet the filter gradation requirements given below (in no case will the maximum rock size be more than 2 inches) for the specific leachate collection pipe perforation design:

For circular holes in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter}} > 1.7$$

For slots in the leachate collection pipe:

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Slot Width}} > 2.0$$

Note that "85 Percent Size of Filter Material" corresponds to the d_{85} of the coarse aggregate surrounding the leachate collection pipe (i.e., the particle size for which 85 percent of the filter material particles are smaller than). The coarse aggregate will be tested for gradation (ASTM D 448) at the supply source or from the on-site stockpile prior to acceptance. Gradation testing will be conducted at a minimum frequency of 1 test per 3,000 cubic yards of coarse aggregate or per liner construction event if less than 3,000 cubic yards of coarse aggregate is required for the specific construction. The aggregate will be free of organic matter, angular rocks, foreign objects, or other deleterious materials. The physical characteristics of the aggregate will be evaluated through visual observation and laboratory classification testing before construction and visual observation during construction. The coarse aggregate may be tested during construction at the discretion of the CQA monitor. The test results for the coarse aggregate will be included in the GLER.

2.3.6 Protective Cover

Protective cover will be placed over the drainage layer in accordance with this section and approved Excavation Plan (Appendix IIIA-A, Drawing A.1) for each liner and overliner construction. The geosynthetics of the composite liner and overliner systems will be covered with a minimum of 2 feet of protective cover (including drainage aggregate and tire chips where applicable). The protective cover will consist of soil materials that have not previously come in contact with solid waste and do not contain materials detrimental to the underlying geosynthetics. The protective cover will be free of organics, foreign objects, or other deleterious materials. The physical characteristics of the protective cover will be evaluated through visual observation (and laboratory testing if the POR deems it necessary) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the CQA monitor. The protective cover will be installed with passageways (i.e., chimney drains) to allow moisture to drain to the leachate collection system.

The protective cover layer will be placed using any low ground pressure equipment as outlined in Section 3.7. The protective cover will be placed by spreading in front of the spreading equipment with a minimum of 12 inches of soil between the spreading equipment and the installed geosynthetics. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics.

The thickness of the protective cover layer placed over the composite liner and overliner will be verified with surveying procedures at a minimum of 1 survey point per 5,000 square feet of constructed area by a licensed Texas land surveyor with a minimum of 2 reference points. The survey results for the protective cover will be included in the GLER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Verify that the cover soil for sideslopes is pushed from the toe up the slope.
- Monitor haul road thickness over geosynthetic installations and verify that equipment hauling and materials placement meet equipment specifications (see Section 3.7).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the protective cover materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey.

2.3.7 Anchor Trench Backfill

The anchor trench backfill material for geosynthetic anchoring will be uncontaminated earthen material and will be placed in uniform lifts which do not exceed 12 inches in loose thickness and will be compacted to at least 90 percent of Standard Proctor maximum dry density (ASTM D 698). In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the GLER.

2.3.8 Surface Water Removal

The excavation may encounter water from storm events. Soil liner will not be placed in standing water or over soft or pumping subgrade. The excavation area will therefore have a temporary sump area to collect water entering the excavation and will be graded to allow drainage at planned areas. Portable pumps will be on site to dewater the sumps. Temporary earthen berms will be constructed to divert surface flow away from the excavation. Surface water that accumulates on the constructed liner or geosynthetics surface will be removed promptly after the end of a rainfall event. The POR will inspect and approve the constructed area that received rainfall prior to placement of overlying liner system component. The criteria for approval of the finished surface of the soil liner for geomembrane placement will follow the requirements of Sections 3.3.3 and 3.4.5 and for geocomposite placement on top of geomembrane will follow the requirements of Section 3.6.3. Surface water from the site will be discharged per the site's TPDES permit requirement.

2.3.9 Excavations Below Groundwater

As shown in Appendix IIID-B (previous Attachment 10, Appendix 10B) (Figure IIID-B-1), the landfill excavation extends below the highest measured groundwater levels (potentiometric surface) in the southern portions of the site. An updated (2021) highest measured groundwater elevation map is provided as Drawing IIID-B-1.

The potential short-term hydrostatic pressures for the south area will be mitigated by the implementation of a temporary dewatering system as discussed below. In order to mitigate potential short-term hydrostatic uplift pressures on the sidewall due to the groundwater in the Upper Sand (See Drawings IIID-B-1 and 10C2), a sidewall underdrain will be constructed below the liner system. The sidewall underdrain will be constructed at the contact of the Upper Sand and the underlying Bounding Shale with a minimum trench depth of three feet. This underdrain will extend a minimum of two feet below the Upper Sand unit, as is shown on Figure 10C2 in Appendix 10C, and will be graded a minimum of 0.5 percent to the nearest open excavation or to a sump or sideslope riser. To facilitate drainage of groundwater to the open excavation, a 4-inch-diameter perforated pipe enveloped with gravel and geotextile will be placed into this underdrain trench. Also, a geocomposite drainage layer will be placed on the sideslope above the seasonal high water table elevation to maintain drawdown of the groundwater within the Upper Sand unit. The geocomposite will be anchored into the sideslope at a minimum of two feet and will extend one foot into the underdrain trench. Temporary sumps may be constructed to maintain positive drainage within the underdrain trench. The temporary sumps will consist of drainage stone enveloped in geotextile with an 18-inch-diameter HDPE riser pipe for groundwater removal.

Liner areas that extend below the highest measured potentiometric surface will be designed and constructed to provide protection against long-term uplift from hydrostatic forces by the use of ballast in accordance with Title 30 TAC §330.203. Ballast, if required, will be designed, installed, and verified as described in Section 8.3. Example ballast calculations are provided in Appendix IIID-B.

2.3.10 Liner Tie-In Construction

Newly constructed liners will be tied-in with any adjoining existing liners. Additionally, terminations will be constructed for future tie-ins along edges where the liner will be extended in the future. The tie-ins with existing clay liners will be constructed utilizing a sloped transition a minimum of 10-foot-wide for the 2-foot-thick clay liner and 15 feet wide for the 3-foot-thick clay liner. Terminations for future tie-ins will be constructed by extending the clay liner approximately 10 feet past the limits for the cell under construction. The liner tie-in details are shown in Appendix IIIA – Landfill Unit Design Information. Waste and intermediate cover will not be deposited closer than 10 feet to the edge of any cell or 20 feet from the leading edge of a constructed clay liner (whichever is greater) where a future tie-in will be constructed. Red-colored markers (i.e., SLER markers) will be placed along the limits of the cells with constructed clay liners and tied to the site grid system in accordance with Title 30 TAC §330.143(b)(1).

2.4 Construction Testing

2.4.1 Standard Operating Procedures

CQA monitors with qualified professional experience in geotechnical engineering and/or engineering geology will perform field and laboratory tests in accordance with applicable standards specified in this LQCP. All quality control testing and evaluation of soil liners will be performed during construction of the liner and must be complete before placement of the leachate collection system, except for the testing required for the final constructed lift, verification of liner thickness, or cover material thickness. Standard operating and test procedures will be utilized per the POR's direction. Sampling from the constructed soil liner lifts will be performed in accordance with ASTM D 1587. The sampling holes (e.g., samples for coefficient of permeability test) will be backfilled with bentonite or bentonite/liner soil material mixture. The standard operating procedure will be prepared or modified by the POR during construction, as necessary, to address site specific construction issues. Prior written approval will be obtained from the TCEQ if any changes to material requirements or procedures set forth in this LQCP will be made.

The following test standards apply as called out in this LQCP and in the technical specifications provided in this LQCP.

Standard Test Method	Test Description
ASTM D 698	Laboratory compaction characteristics of soil using standard effort
ASTM D 422	Particle size analysis of soils
ASTM D 1587	Thin-walled tube sampling of soils for geotechnical purposes
ASTM D 2167	Density and unit weight of a soil in place by the rubber balloon method
ASTM D 6938	In-place density and water content of soil and soil-aggregate by nuclear methods (shallow depth)
ASTM D 2216	Laboratory determination of water (moisture) content of soil and rock by mass
ASTM D 2434	Method of test for permeability of porous granular material
ASTM D 5084	Method of test for permeability of fine-grained soils
ASTM D 4318	Atterberg limits
ASTM D 1140	Amount of material in soils finer than the No. 200 sieve
ASTM D 2487	Classification of soils for engineering purposes
ASTM D 2488	Description and identification of soils (visual-manual procedure)
EM 1110-2-1906	U.S. Army Corps of Engineers permeability test
ASTM D 448	Standard classification for sizes of aggregate for road and bridge construction
ASTM D 3042	Test method for insoluble residue in carbonate aggregates

2.4.2 Test Frequencies

This LQCP establishes the minimum test frequencies for the soil liner construction quality assurance. The test frequencies for soil liner are listed in Table 2-2. Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Additional testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

The composite liner system may require general fill (e.g., establish excavation grades by means of backfilling as necessary as discussed in Section 2.3.1 - Subgrade) and structural fill (e.g., berms around the excavation perimeter). Testing will be limited to one moisture density relationship (ASTM D 698) per borrow source (as defined in Section 2.3.2.1) per project.

2.4.3 Material Strength Requirements

The geotechnical analysis is included in Appendix IIIM – Geotechnical Report and includes slope stability, foundation heave, and settlement analyses for the proposed excavation of remaining undeveloped sectors (Sectors 11, 12, 13, and 14), interim slopes, overliners, and final landfill slopes. Soil parameters used in the geotechnical analysis were obtained from subsurface investigations and geotechnical reports, geotechnical testing performed on soil samples recovered at the site and assumptions based on professional experience with similar materials.

The POR will verify that the proposed liner material meets the minimum soil properties used in the geotechnical analysis included in Appendix IIIM prior to liner construction, as applicable. These soil properties include unit weight, moisture content, cohesion, friction angle, and consolidation strength parameters used in the slope stability and settlement analyses. Additionally, shear strength conformation testing as described in Appendix IIIM-A-5 will be conducted. The POR will verify that the underlying material below the liner is consistent with design assumptions. If the POR determines that the underlying material or borrow material is not consistent with design assumptions, the appropriate geotechnical analysis (e.g., slope stability) will be updated consistent with the procedures in Appendix IIIM. The updated analysis will be incorporated into the SLER.

2.5 Reporting

The POR will submit to the TCEQ a SLER for approval of each soil liner area. Section 8 describes the documentation requirements.

Table 2-2
Required Tests and Observations on Compacted Clay Liner[6]

Parameter	Frequency	Test Method	Passing Criteria
Field Density and Moisture	1 each 8,000 SF per 6-inch parallel lift	ASTM D 6938 and ASTM D 2216[4]	95% Maximum Standard Proctor Dry Density. Standard Proctor optimum moisture content or greater determined during preconstruction testing
Sieve Analysis (passing no. 200)	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 1140	30 percent minimum
Atterberg Limits (liquid and plastic limit)	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 4318	PI = 15 percent minimum LL = 30 percent minimum
Coefficient Permeability (Hydraulic Conductivity)[3]	1 test per 100,000 square feet per 6-inch parallel lift, with a minimum of 1 test per 6-inch lift	ASTM D 5084 (Falling head, flex wall) Corps of Engineers EM 1110-2-1906 (Falling head permeameter)	$1.0x10^{-7}$ cm/s or less
Thickness Verification[1,2,5]	1 each 5,000 square feet with a minimum of 2 reference points by a licensed Texas land surveyor	Survey subgrade and top of clay liner and protective cover layer	2 feet minimum (MSW area) or 3 feet minimum (Class 1 area) compacted clay liner thickness and 2 feet minimum protective cover thickness

[1] Thickness verification for the overliner will be 2 feet minimum protective cover thickness and 2 feet compacted clay liner thickness.
[2] If the option to use settlement plates to verify thickness of the overliner is utilized, the procedure outlined in Section 2.3.3 will be followed.
[3] Field permeability testing in accordance with Title 30 TAC §330.339(c)(7) may be performed to augment this testing program if a permit modification is submitted and approved by the TCEQ.
[4] This method is not applicable if the field nuclear gauge reads both density and moisture.
[5] The thickness of the reconstructed separation layer will be 5.0 feet minimum.
[6] The liner will be constructed in parallel lifts and not horizontal lifts for sidewalls.

3 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

3.1 Introduction

Section 3 describes CQA procedures for the installation of geosynthetic components.

The scope of geosynthetic related construction quality assurance includes the following elements:

- Bottom Liner Geomembrane
  - 60-mil HDPE – smooth on slopes less than 7H:1V and textured on both sides for slopes greater than or equal to 7H:1V
- Overliner Geomembrane
  - 40-mil LLDPE – textured on both sides regardless of slope
- Geotextiles
- Drainage Layer
  - 250-mil single-sided drainage geocomposite (on bottom liner slopes less than 7H:1V)
  - Double-sided drainage geocomposite (250-mil bottom liner sideslopes (greater than 7H:1V) and 300-mil on all overliner slopes)

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this LQCP, and that the project is built in accordance with the project construction drawings and technical specifications that will be developed in accordance with this LQCP for each liner construction. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. A construction report and GLER, prepared after project completion, will document that the constructed facility meets design intent and specifications outlined in this LQCP.

3.2 Geosynthetics Quality Assurance

3.2.1 General

The composite liner system provides the primary means for preventing leachate infiltration into groundwater. A geomembrane is a component of both the bottom liner and the overliner. Proper geomembrane installation is a crucial work element, which greatly affects the performance of the composite liner system. Construction quality control for the geomembrane installation will be performed by the geomembrane installation contractor. Construction quality assurance for the geomembrane installation will be performed by the POR to assure the geomembrane is constructed as specified in the design. Construction must be conducted in accordance with the procedures outlined in this LQCP. To monitor compliance, a quality assurance program will include the following:

- A review of the manufacturer's quality control testing
- Material conformance testing by an independent third party laboratory
- Field and construction testing
- Construction monitoring

The manufacturer's quality control testing will include resin and geomembrane testing. The required tests for material properties are included in Sections 3.3 (bottom liner) and 3.4 (overliner).

Conformance testing refers to material testing performed by an independent third party laboratory that takes place prior to material installation. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this LQCP. Field testing will be observed by the CQA monitor. Documentation must meet the requirements of this LQCP.

3.2.2 Overliner and Bottom Liner Interface Shear Strength Conformance Testing

Prior to each construction event, conformance testing will be required for the specific geosynthetic and soil liner components to be incorporated into the project. The required interface shear strength conformance testing requirements have been established for the project based on stability analyses performed for the expansion. The description of the interface shear strength conformance testing requirements and supporting stability analyses is presented in Appendix IIIM-A-5. As discussed in the appendix, the conformance testing requirements are applicable to both laboratory stack testing and single interface testing results and will be incorporated into the Geosynthetic Liner Evaluation Report (GLER) prepared for the respective construction event.

3.3 Bottom Liner Geomembrane

The bottom liner geomembrane will consist of a 60-mil HDPE geomembrane. The geomembrane will be smooth on both sides on slopes less than 7H:1V and textured on both sides on slopes greater than or equal to 7H:1V for the bottom system. Required testing for the bottom liner geomembrane is included in Table 3-1 and required material properties for the bottom liner geomembrane are included in Table 3-2.

3.3.1 Delivery

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

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the manufacturer's specifications and stacked not more than 5 rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Manufacturing documentation required by the specifications outlined in this LQCP has been received and reviewed for compliance. This documentation will be included in the GLER.
- The geosynthetics receipt log form has been completed for all materials received.

Damaged geomembrane will be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until all documentation has been received, reviewed, and accepted.

3.3.2 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5199 for smooth FML and ASTM D 5994 for textured FML)
- Tensile properties (ASTM D 638/Type IV), ASTM D 6693 may be used upon approval by POR

Table 3-1
Required Testing for 60-mil-thick Smooth and Textured (Both Sides) HDPE Geomembrane[1]

Test	Type of Test	Standard Test Method	Frequency of Testing (Minimum)
Resin	Specific Gravity/Density	ASTM D 792, Method A or ASTM D 1505	Per 200,000 pounds and every resin lot
	Melt Flow Index	ASTM D 1238	Per 100,000 SF and every resin lot
Manufacturer's Quality Control	Thickness	ASTM D 5199 (smooth) and ASTM D 5994 (textured)	Per roll of geomembrane
	Specific Gravity/Density	ASTM D 1505/D 792	Per 200,000 pounds
	Carbon Black Content	ASTM D 1603	Per 20,000 pounds
	Carbon Black Dispersion	ASTM D 5596	Per 45,000 pounds
	Tensile Properties	ASTM D 638 / Type IV (ASTM D 6693 may be used as an alternative upon POR's approval)	Per 20,000 pounds
	Tear	ASTM D 1004	Per 45,000 pounds
	Puncture	ASTM D 4833	Per 45,000 pounds
	Stress Crack Resistance	ASTM D 5397	Per GRI-GM 10
	Oxidative Induction Time	ASTM D 8117 or ASTM D 5885	Per 200,000 pounds
	Oven Aging @ 85°C	ASTM D 5721	Per each formulation
	Oven Aging @ 85°C Standard OIT (min. avg.) - % retained after 90 days	ASTM D 3895	Per each formulation
	UV Resistance[2] High Pressure OIT (min. avg.) - % retained after 1,600 hours	ASTM D 7238 ASTM D 5885	Per each formulation
	Asperity Height	ASTM D 7466	Every second roll[3]

[1] All tests will conform to the minimum requirements set forth by GRI testing standard GM13. Required values for the parameters are listed in Table 3-2. Refer to GRI testing standard GM13 for additional information.

[2] 20 hours of UV cycle at 75°C followed by 4 hours condensation at 60°C.

[3] Measurement side will be alternated for double-sided textured sheet. This testing is specified for textured geomembrane only.

Table 3-2
Minimum Required Properties of 60-mil-thick Smooth and Textured (Both Sides) HDPE Geomembranes

Property	Test Method	Minimum Required Property	
		Smooth	Textured
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199, ASTM D 5994 for textured	 60 54 NA	 57 51 54
Density, g/cc	ASTM D 1505/D 792	0.94	0.94
Asperity Height, mils	ASTM D 7466	N/A	16
Tensile Properties[1] 1. Yield Strength, lb/in 2. Break Strength, lb/in 3. Yield Elongation, % 4. Break Elongation, %	ASTM D 638 (Type IV Specimen @ 2 in/min) (ASTM D 6693 may be used as an alternative upon approval by POR)	 126 228 12 700	 126 90 12 100
Tear Resistance, lb	ASTM D 1004	42	42
Puncture Resistance, lb	ASTM D 4833	108	90
Stress Crack Resistance[2], hrs	ASTM D 5397	500	500
Carbon Black Content[3], %	ASTM D 1603	2.0 – 3.0	2.0 – 3.0
Carbon Black Dispersion[4], Category	ASTM D 5596	1 or 2 and 3	1 or 2 and 3
Oxidative Induction Time (OIT)[7] (Minimum Average) Standard OIT, minutes High Pressure OIT, minutes	 ASTM D 3895 ASTM D 5885	 100 400	 100 400
Oven Aging at 85ºC Standard OIT - % retained after 90 days High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	 55 80	 55 80
UV Resistance[5] High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 7238 ASTM D 5885	 50	 50
Seam Properties (4 out of 5 specimens, 5th specimen can be as low as 80% per GRI-GM19) 1. Shear Strength, lb/in 2. Peel Strength, lb/in	 ASTM D 6392	 120 91 & FTB (78, Extrusion Weld)	 120 91 & FTB (78, Extrusion Weld)

[1] Machine direction (MD) and cross machine direction (XMD) average values will be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; break elongation is calculated using a gauge length of 2.0 inches.
[2] The yield stress used to calculate the applied load for the Single Point Notched Constant Tensile Load (SP-NCTL) test will be the mean value via MQC testing.
[3] Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
[4] Carbon black dispersion for 10 different views; 9 in Categories 1 and 2 and 1 in Category 3.
[5] The condition of the test will be 20 hr UV cycle at 75ºC followed by 4 hr. condensation at 60ºC.
[6] UV resistance is based on percent retained value regardless of the original HP-OIT value.
[7] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
[8] Required properties are reproduced from GRI GM13, except for the seam properties which are based on GRI GM19. At the time of each liner construction event, an updated GM-13 will be used if available.

The density of the geomembrane must be greater than 0.94 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures, and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. For smooth geomembranes, no single measurement will be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 60-mil geomembrane a minimum thickness of 54 mils is required) and the average must be at least 60 mils. Refer to Table 3-2 for a complete listing of the material requirements for both smooth and textured geomembranes that will be used for the composite Subtitle D bottom liner.

Sampling Procedure. Samples will be taken across the entire roll width. Unless otherwise specified, samples will be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

3.3.3 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the installed soil liner surface will be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- All lines and grades for the soil liner have been verified by the surveyor and accepted by the contractor for geosynthetic installation. The POR or his representative, the owner, and geomembrane installer will certify and accept in writing the finished final lift of the soil liner.
- The soil liner has been prepared in accordance with the earthwork construction plans and specifications as outlined in Section 2.
- The soil liner surface is free of surface irregularities and protrusions. The soil liner will be rolled and compacted to ensure a clean surface.
- The soil liner surface does not contain stones or other objects that could damage the geomembrane and underlying soil liner. The surface of the soil liner will be smooth and free of foreign and organic material, sharp objects, exposed soil or aggregate particles greater than 3/8 inches (or less if recommended by the geosynthetic manufacturer), or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.

- There are no excessively soft areas in the soil liner that could result in geomembrane damage.
- The geomembrane will not be placed over soil liner during inclement weather such as rain or high winds.
- The soil liner is not saturated, and no standing water is present above the soil liner.
- The soil liner has not desiccated (e.g., areas with desiccation cracks).
- All construction stakes and hubs have been removed and the resultant holes have been backfilled. There are no rocks, debris, or any other objects on the soil liner surface.
- The geosynthetics contractor has certified in writing that the soil liner surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that geomembrane is placed in direct and uniform contact with the underlying compacted clay soil liner.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record all panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. All repairs must be made in accordance with the specifications as outlined in Section 3.3.5 and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.7 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no angular stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.

- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation will not be performed when the air temperature is less than 41°F or greater than 104°F, or when standing water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.
- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles will be walked-out or removed at the discretion of the CQA monitor.
- 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 the textured material extends a minimum of approximately 5 feet out past the toe of the slope where textured geomembrane is used.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels will be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welders), must be tested, at a minimum, at daily start-up and at midday break, and/or any break that the seaming machine is stopped more than 30 minutes to determine if the equipment is functioning properly. The GLER will include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.3.4 – Construction Testing. The CQA monitor must observe all welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 and GRI-GM19:

Hot Wedge: AD and AD-Brk>25%

Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there will be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or the percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (30° Fahrenheit), humidity, or wind speed, the test weld will be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a welded area fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval and the failed area will be patched. Patching will performed by placing additional geomembrane over the failed area or removing the failed area geomembrane weld and patching it with additional geomembrane per POR's direction. Welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.

- The extrusion welder is purged prior to beginning a weld until all the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41° and 104° Fahrenheit, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels will be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specifications that will be developed in accordance with this section for each future liner construction. Seams will be oriented parallel to the line of maximum slope with no horizontal seams on side slopes. In corners and odd-shaped geometric locations, the number of field seams will be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, all unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.3.4 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing was performed in compliance with this section and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section, which has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel will be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi or ½ psi per mil of geomembrane thickness, whichever is greater. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications outlined in this section.
- Observe that the entire length of each seam is tested in accordance with the specifications outlined in this section.
- Observe all continuity testing and record results on the appropriate log.
- Observe that all testing is completed in accordance with the project specifications outlined in this section.

- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that all repairs are completed and tested in accordance with the project specifications outlined in this section and Section 3.3.5.
- Record all completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test per 500 linear feet of seam length. Destructive testing will also be performed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements outlined in this section. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 4437. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one random test within each 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.

- Sample locations will not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number, which contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is Film Tear Bond (FTB) and the seam strength meets the required strength values for peel and shear given previously for trial seams under field seaming and below for third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples will be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the operator to archive. The laboratory sample will be shipped to the third party laboratory for over-night deliver and next day testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. All seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third-Party Laboratory Testing. Destructive samples must be shipped to the third-party laboratory for seam testing. Testing for each sample will include 5 bonded seam shear strength tests and 5 peel adhesion tests (10 for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear must meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, 4 out of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results within 24 hours, in writing or via telephone, to the CQA monitor. Certified test results are to be provided within 5 days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM19 for geomembrane seams. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5^{th} specimen can be as low as 80 percent of the listed values). Elongation measurements will be omitted for field testing.

- Shear strength (lb/in) 120
- Shear elongation at break (%) 50

- Peel strength (lb/in) 91 (78, Extrusion Weld) & FTB
- Peel separation (%) 25

A passing extrusion or fusion welded seam will be achieved in peel when:

- Yield strength for 4 of 5 specimens (10 tests for dual-track welds) is not less than the above minimum peel strength value and the average of all 5 specimens is not less than the minimum value.
- No greater than 25 percent of the seam width peels (separates) at any point for 4 of 5 specimens (both inner and outer welds for dual-track welds).

A passing extrusion or fusion weld will be achieved in shear when:

- Yield strength for 4 of 5 specimens is not less than the above minimum shear strength value and the average for all 5 specimens is not less than the minimum value.
- Yield strain for 4 out of 5 specimens is at least 25 percent.
- Break strain for 4 out of 5 specimens is at least 50 percent.

3.3.5 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive, or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specific liner construction specifications and consistent with all the applicable parts (e.g., material requirement, installation, testing, etc.) of this section. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching - used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion - used to repair small defects in the panels and seams. In general, this procedure will be used for defects less than ⅜-inch in the largest dimension.
- Capping - used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal - used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

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.
- Testing of repaired seams consistent with Section 3.3.4 – Construction Testing.

3.3.6 Wrinkles

During placement of cover materials over the geomembrane, temperature changes or creep can cause wrinkles to develop in the geomembrane. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane, which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.3.7 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll, which are due to manufacturing process, are acceptable.

3.3.8 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane will be accounted for during the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench will be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.3.9 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of all seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the GLER by TCEQ.

3.3.10 Bridging

Bridging must be removed.

3.4 Overliner Geomembrane

3.4.1 General

This section describes material types, handling, installation, and testing of overliner geomembrane. LLDPE geomembrane that is textured on both sides will be used for the overliner. The required tests for 40-mil LLDPE are summarized in Table 3-3. Required material properties for 40-mil LLDPE are included in Table 3-4.

3.4.2 Delivery

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

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the manufacturer's specifications and stacked not more than five rolls high. The

geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.

- Manufacturing documentation required by the specifications outlined in this LQCP has been received and reviewed for compliance. This documentation will be included in the GLER.
- The geosynthetics receipt log form has been completed for all materials received.

Damaged geomembrane will be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until all documentation has been received, reviewed, and accepted.

3.4.3 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5994 for textured geomembrane)
- Tensile properties (ASTM D 638/Type IV Specimen)

The density of the geomembrane must be greater than 0.94 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures, and will inform the third-party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel.

Refer to Table 3-3 for a complete listing of the material requirements for textured geomembranes that will be used for the overliner.

Table 3-3
Required Testing for 40-mil-thick Textured (Both Sides) LLDPE Geomembrane

Test	Type of Test	Standard Test Method	Frequency of Testing
Resin	Density	ASTM D 1505	Per 200,000 pounds and every resin lot
	Melt Flow Index	ASTM D 1238 (90/2.16 and 190/21.6)	
Resin/Compound Evaluation	Per manufacturer's quality control specifications	Per manufacturer's quality control specifications	Per manufacturer's quality control specifications
Manufacturer's Quality Control[1]	Testing per GRI Standard, GRI Test Method GM17 for 40 mil LLDPE textured on both sides		
Conformance Testing by 3rd Party Independent Laboratory	Thickness[2]	ASTM D 5994 (textured LLDPE)	Per 100,000 ft^2 and every resin lot
	Specific Gravity/Density	ASTM D 1505/D 792	
	Carbon Black Content	ASTM D 1603	
	Carbon Black Dispersion	ASTM D 5596	
	Tensile Properties	ASTM D 6693, Type IV	
Destructive Seam Field Testing[3]	Shear & Peel	ASTM D 6392	Various for field, lab, and archive
Non-Destructive Seam Field Testing	Air Pressure	ASTM D 5820	All dual-track fusion weld seams
	Vacuum	ASTM D 4437	All non-air pressure tested seams when possible
	Other		Concurrence of TCEQ

1 UV Resistance testing not required for geomembrane, which is to be immediately covered.
2 Field thickness measurements for each panel must be conducted. Use ASTM D 5994 and perform 1 series of measurements along the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than 15% below the required nominal thickness in order for the panel to be acceptable. As an alternative to field thickness measurements, the conformance thickness testing will be performed in a third party laboratory and the test frequency will be doubled.
3 Passing criteria for the geomembrane materials are listed in Table 3-4.
4 Required properties are reproduced from GRI GM-13, except for the seam properties which are based on GRI GM-19. At the time of each liner construction event, an updated GM-13 will be used if available.

Table 3-4
Minimum Required Properties of 40-mil-thick Textured (Both Sides) LLDPE Geomembrane

Property	Test Method	Minimum Required Property[7]
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5994	 38 34 36
Density, g/cc (maximum)	ASTM D 1505/D 792	0.939
Asperity Height, mils	ASTM D 7466	16
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	 60 250
Tear Resistance, lb	ASTM D 1004	22
Puncture Resistance, lb	ASTM D 4833	44
Break Resistance Strain, % (min)	ASTM D 5617	30
Carbon Black Content[2], %	ASTM D 1603	2.0 – 3.0
Carbon Black Dispersion[3], Category	ASTM D 5596	1 or 2 and 3
Oxidative Induction Time (OIT),[6] minimum average Standard OIT, minutes or High Pressure OIT, minutes	 ASTM D 3895 ASTM D 5885	 100 400
Oven Aging at 85ºC Standard OIT - % retained after 90 days or High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	 35 60
UV Resistance[4] High Pressure OIT[5] - % retained after 1600 hrs	ASTM D 7238 ASTM D 5885	 35
Seam Properties (4 out of 5 specimens, 5th specimen can be as low as 80% per GRI-GM19) Shear Strength, lb/in Peel Strength, lb/in	ASTM D 6392	60 50 (44, Extrusion Weld) & FTB

1 Machine direction (MD) and cross machine direction (XMD) average values will be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views; 9 in Categories 1 or 2 and 1 in Category 3.
4 The condition of the test will be 20 hr UV cycle at 75ºC followed by 4 hr. condensation at 60ºC.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.
6 The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
7 Required properties are reproduced from GRI GM-13, except for the seam properties which are based on GRI GM-19. At the time of each liner construction event, an updated GM-13 will be used if available.

3.4.4 Anchor Trench Backfill

General fill material placed in anchor trenches will be uncontaminated earthen material and will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted to at least 90 percent of Standard Proctor maximum dry density (ASTM D 698). In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the GLER. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of the liner system.

3.4.5 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the subgrade on which the geomembrane will be placed will be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- When placing the geomembrane on the overliner subgrade (i.e., top of 2-foot-thick clay liner), construction placement equipment should not be permitted to ride directly on the geomembrane. Overliner geomembrane will be moved by hand or by using small pneumatic-tire lifting units. Other techniques, such as use of block and tackles, have also been used.
- All-terrain vehicles (ATVs) or equipment with smooth, oversized tires of maximum ground contact pressure of 28 to 41 kPa (4-6 psi) can be used; however, the following restrictions will be imposed:
  - There should be no sudden stops or starts.
  - There should be no spinning of tires or sliding at any time.
  - Vehicle tires must be smooth and clean of mud, dirt, and debris that could potentially puncture or damage the underlying geomembrane.
  - All entering and exiting on the geomembrane should be done at 90-degree angles to the material.
  - There should be no excessive turning while driving on the geomembrane. Movement should be primarily forward and backward while deploying, and turning should be minimized to the greatest extent possible.
  - There should be no driving over wrinkles in geosynthetics.
  - There should be no more than one person riding on vehicle.
  - Vehicles should not be used on slopes.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.

- The geomembrane will not be placed during inclement weather such as rain or high winds.
- The geosynthetics contractor has certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying subgrade.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications as outlined in Section 3.4.7 and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.7 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no angular stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation will not be performed when the air temperature is less than 41°F or greater than 104°F,

or when standing water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.

- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles will be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that seams on slopes (slopes steeper than or equal to 7H:1V) are oriented parallel to the slip direction, and the textured material extends a minimum of approximately 5 feet out past the side slope.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels will be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welders) must be tested, at a minimum, at daily start-up and at midday break, and/or anytime the machine is turned off for more than 30 minutes to determine if the equipment is functioning properly. The GLER will include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.4.6 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392 and GRI GM19:

Hot Wedge: AD and AD-Brk>25%

Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there will be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or the percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld will be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR's direction. Welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).

- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41°F and 104°F, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels will be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specifications that will be developed in accordance with this section for each liner construction. Seams will be oriented parallel to the line of maximum slope with no horizontal seams on side slopes. In corners and odd-shaped geometric locations, the number of field seams will be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.4.6 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing was performed in compliance with this section and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel will be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications outlined in this section.
- Observe that the entire length of each seam is tested in accordance with the specifications outlined in this section.
- Observe all continuity testing and record results on the appropriate log.
- Observe that all testing is completed in accordance with the project specifications outlined in this section.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that repairs are completed and tested in accordance with the project specifications outlined in this section and Section 3.4.7.

- Record completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements outlined in this section. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 4437. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one random test within each 500 feet of seam length. This is an average frequency for the entire installation; individual samples may be taken at greater or lesser intervals.
- Sample locations will not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed

samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is Film Tear Bond (FTB) and the seam strength meets the required strength values for peel and shear given previously for trial seams under field seaming and below for third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples will be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the operator to archive. The laboratory sample will be shipped to the third party laboratory for over-night delivery and next-day testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. Seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third-Party Laboratory Testing. Destructive samples must be shipped to the third-party laboratory for seam testing. Testing for each sample will include 5 bonded seam shear strength tests and 5 peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least 4 of the 5 specimens tested in peel and shear must meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the passing criteria listed below. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM-19 for geomembrane seams. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 40-mil textured LLDPE. Elongation measurements will be omitted for field testing.

- Shear strength (lb/in) 60
- Shear elongation at break (%) 50
- Peel strength (lb/in) 50 (44, Extrusion Weld) & FTB
- Peel separation (%) 25

A passing extrusion or fusion welded seam will be achieved in peel when:

- Yield strength for 4 of 5 specimens (10 tests for dual-track welds) is not less than the above minimum peel strength value and the average of all 5 specimens is not less than the minimum value.
- No greater than 25 percent of the seam width peels (separates) at any point for 4 of 5 specimens (both inner and outer welds for dual-track welds).

A passing extrusion or fusion weld will be achieved in shear when:

- Yield strength for 4 of 5 specimens is not less than the above minimum shear strength value and the average for all 5 specimens is not less than the minimum value.
- Yield strain for 4 out of 5 specimens is at least 25 percent.
- Break strain for 4 out of 5 specimens is at least 50 percent.

3.4.7 Repairs

Any portion of the geomembrane with a detected flaw, which fails a nondestructive or destructive test, where destructive tests were cut, or where nondestructive tests left cuts or holes must be repaired in accordance with the specifications developed for each phase of overliner construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 3.4 of this LQCP. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure will be used for defects less than 3/8-inch in the largest dimension.
- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

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 surfaces at the time of repair.

- Extend patches or caps at least 6 inches beyond the edge of the defect, and round 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.
- Perform testing on repair seams consistent with Section 3.4.6 – Construction Testing.

3.4.8 Wrinkles

Wrinkles must be walked-out or removed as much as possible prior to field seaming. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.4.9 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll which are due to manufacturing process are acceptable.

3.4.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane will be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench will be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.4.11 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- All seams have been inspected and verified to be acceptable.
- All required laboratory and field tests have been completed and reviewed.
- All required contractor-supplied documentation has been received and reviewed.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the GLER by TCEQ.

3.4.12 Bridging

Bridging must be removed.

3.5 Geotextiles

Geotextiles will be used to prevent clogging of drainage materials. Main usage of geotextiles will be enveloping drainage stone used for chimney drains in the leachate collection system (LCS). Geotextiles for LCS will meet the design requirements set forth in Appendix IIIC – Leachate and Contaminated Water Management Plan.

3.5.1 Delivery

During delivery the CQA monitor must observe the following:

- Equipment used to unload the rolls will not damage the geotextile.
- Rolls are wrapped in impermeable and opaque protection covers.
- Care is used when unloading the rolls.
- All documentation required by this LQCP and the specifications has been received and reviewed for compliance with this LQCP.
- Each roll is marked or tagged with the manufacturer's name, project identification, lot number, roll number, and roll dimensions.
- Materials are stored in a location that will protect the rolls from precipitation, mud, dirt, dust, puncture, cutting, or any other damaging or deleterious conditions.

Any damaged rolls must be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation must also be stored at a separate location until all documentation has been received and approved.

3.5.2 Testing

The geotextile manufacturer will conduct manufacturer quality control (MQC) testing and certify that the materials delivered to the site comply with project specifications outlined in this LQCP. The material certification will be reviewed by the POR and approved for the project prior to acceptance of any of the material. The MQC testing will include the following tests with at least one test for each 100,000 square feet of geotextile delivered:

- Grab tensile strength/elongation (ASTM D 4632)
- Mass per unit area (ASTM D 5261)
- Thickness (ASTM D 5199)
- Puncture resistance (ASTM D 4833)
- Trapezoidal Tear Strength (ASTM D 4533)
- Hydraulic tests (ASTM D 4491)
- Apparent opening size (ASTM D 4751)

Where optional procedures are noted in the test method, the specification requirements of this LQCP prevail. The POR will review all test results and report any nonconformance.

3.5.3 Geotextile Installation

Surface Preparation. Prior to geotextile installation, the CQA monitor must observe the following:

- All lines and grades have been verified by the surveyor.
- The supporting surface does not contain stones that could damage the geotextile or the underlying geomembrane.
- There are no excessively soft areas that could result in damage to the geotextile, or other components of the liner system.
- Construction stakes and hubs have been removed.

Geotextile Placement. During geotextile placement, the CQA monitor must:

- Observe the geotextile as it is deployed, and record all defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications outlined in Section 3.5.4.

- Observe that equipment used does not damage the geotextile by handling, equipment transit, leakage of hydrocarbons, or other means.
- Observe that people working on the geotextile do not smoke, wear shoes that could damage the geotextile, or engage in activities that could damage the geotextile.
- Observe that the geotextile is securely anchored in an anchor trench.
- Observe that the geotextiles are anchored to prevent movement by the wind.
- Observe that the panels are overlapped a minimum of six inches.
- Examine the geotextile after installation to ensure that no potentially harmful foreign objects are present.
- Observe that seams (where required) are continuously sewn or thermal bonded in accordance with the manufacturer's recommendations and the project specifications outlined in this LQCP.

The CQA monitor must inform both the contractor and POR if the above conditions are not met.

3.5.4 Repairs

Repair procedures include:

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

Holes, tears, and defects must be repaired in the following manner. Soil or other material which may have penetrated the defect must be removed completely prior to repair. If located on a slope, the defect must be patched using the same type of geotextile and double-seamed into place. Should any tear, hole, or defect exceed 30 percent of the width of the roll, the roll will be cut off and the defect removed or the roll removed and replaced. If the defect is not located on a slope, the patch must be made using the same type of material seamed into place with a minimum of 24 inches overlap in all directions. Seams will be either thermal bonded or sewn in accordance with the manufacturer's recommendations.

3.6 Drainage Geocomposite – Geonet and Geotextile

Drainage geocomposite will be used for the LCS. Drainage geocomposite used for the construction will meet the requirements set forth in Appendix – Geotechnical Report and Appendix IIIC – Leachate and Contaminated Water Management Plan of the Site Development Plan along with this LQCP. Manufacturer's testing for geotextile and drainage geocomposite are listed in Table 3-5. The drainage geocomposite will also meet the requirements listed in Table 3-5.

3.6.1 Delivery

Upon delivery the CQA monitor must observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation will also be stored at a separate location until all documentation has been received and approved. Geonet and geotextile may be used as an alternative to single-sided geocomposite on bottom liners. The references herein to geocomposite also apply to geonet and geotextile as applicable.

3.6.2 Testing

The drainage geocomposite manufacturer (or supplier) will conduct quality control testing and certify that all materials delivered to the site comply with the specifications listed in Table 3-5. The minimum testing frequency will be one test sample per 100,000 square feet of geocomposite (or geonet/geotextile). See footnotes 2 and 3 of Table 3-5 for testing frequency for transmissivity. The material certifications will be reviewed by the POR to verify that the geocomposite meets the values given in Table 3-5.

Geonet will be tested by the manufacturer for thickness, tensile strength, and carbon black content. Geotextile will be tested for mass per unit area, grab tensile strength, and AOS. The finished geocomposite will be tested for peel adhesion and transmissivity (note that the geocomposite transmissivity tests need to be conducted by a third party laboratory only under the specific conditions listed in Table 3-5, footnotes 2 and 3). Additionally, material strength parameters used for geotechnical analysis in Appendix IIIM – Geotechnical Report will be verified prior to construction, and the slope stability analysis will be updated as necessary based on site-specific material data.

Where optional procedures are noted in the test method, the specification requirements of this LQCP will prevail. The CQA monitor will review all test results and will report any nonconformance to the POR and to the contractor.

Table 3-5
Geotextile and Drainage Geocomposite Required Testing and Properties[1]

Responsible Party	Material	Test	Standard	Required Bottom Liner Property[4]	Required Overliner Property[4]
Manufacturer	Geotextile (before lamination)	Unit Weight	ASTM D 5261	8 oz/sy	6 oz/sy
		Apparent Opening Size	ASTM D 4751	0.180 mm	0.25 mm
		Grab Strength	ASTM D 4632	220 lb	157 lb
		Grab Elongation	ASTM D 4632	50%	50%
		Tear Strength	ASTM D 4533	95 lb	55 lb
		Puncture Strength	ASTM D 6241	575 lb	310 lb
		Permeability	ASTM D 4491	1.3 cm^{-1}	0.2 cm/s
		UV Stability	ASTM D 4355	70%	50%
Manufacturer	HDPE Geonet (before lamination)	Density	ASTM D 1505	0.94 g/cm^3	0.94 g/cm^3
		Thickness	ASTM D 5199	0.25 inch	0.30 inch
		Carbon Black Content	ASTM D 1603	2%	2%
		Tensile Strength	ASTM D 7179	55 lb/in	75 lb/in
		Compressive Strength	ASTM D 6364		120 lb/in^2
		Transmissivity	ASTM D 4716	14.49 gpm/ft	9.0 gpm/ft
Third Party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Note 2	See Notes 2 and 3
		Strength	ASTM D 5321	See Table 6-1	See Table 6-1
Manufacturer		Ply Adhesion	ASTM D 7005	1.0 lb/in	1.0 lb/in

1 The minimum testing frequency will be one test sample per 100,000 square feet. The drainage geocomposite is single-sided for the floor grades of the bottom liner. The drainage geocomposite will be double-sided for the sideslopes of the bottom liner and all overliner areas.

2 As noted in Appendix IIIC, Appendices IIIC-A and IIIC-B, the transmissivity of the bottom liner single-sided geocomposite will be measured at a gradient of 0.015 under normal pressures of 1,000, 5,000 and 11,850 psf (or higher) boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours will be run for the first 100,000 square feet of liner construction. For each additional 100,000 square feet of single-sided geocomposite placement area, one additional transmissivity test will be run under the maximum normal stress (i.e., 11,850 psf) with all the other assumptions the same as the first three tests. The minimum transmissivity will be $7.41 \times 10^{-4}\ m^2/s$. The transmissivity of the bottom sidewall liner double-sided geocomposite will be measured at a minimum gradient of 0.33 under normal pressures of 1,000, 5,000 and 11,850 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours. The minimum transmissivity will be $7.37 \times 10^{-5}\ m^2/s$. For each additional 100,000 square feet of double-sided geocomposite placement area, one additional transmissivity test will be run under the maximum normal stress (i.e., 11,850 psf) with all the other assumptions the same as the first three tests. As shown in Appendix IIIC-A, the HELP Model was developed for a 220-mil geocomposite. 220-mil geocomposite may be utilized as long as the required values (eg. transmissivity) are met.

3 As noted in Appendix IIIC, Appendices IIIC-A and IIIC-B, the transmissivity of the overliner double-sided 0.3 inch geocomposite will be measured at a minimum gradient of 0.01 under normal pressures of 1,000, 3,000 and 6,360 psf (or higher), boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The minimum transmissivity will be $5.16 \times 10^{-3}\ m^2/s$. For each additional 100,000 square feet of double-sided geocomposite placement area, one additional transmissivity test will be run under the maximum normal stress (i.e., 6.360 psf) with all the same assumptions as the first three tests.

4 Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendices IIIC-A and IIIC-B. The geonet properties are based on values specified by multiple manufacturers which are consistent with GRI-GM-4. In addition, each material will be tested prior to construction to verify that it meets the minimum required properties. At the time of each construction event, an updated GRI-GM-4 will be used if available.

3.6.3 Installation

Surface Preparation. Prior to drainage geocomposite installation, the CQA monitor must observe the following:

- All lines and grades have been verified by the surveyor (where required).
- The subgrade has been prepared in accordance with the earthwork specifications outlined in Section 2.
- When placed over a geomembrane, the geomembrane installation, including all required documentation, has been completed.
- The supporting surface does not contain angular stones that could damage the geocomposite or the geomembrane.

Drainage Geocomposite Placement. During placement, the CQA monitor must:

- Ensure single-sided geocomposite is placed on slopes less than 7H:1V and double-sided geocomposite is placed on slopes equal to or steeper than 7H:1V.
- Observe the drainage geocomposite as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications outlined in Section 3.6.4.
- Verify that equipment used does not damage the drainage geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that people working on the drainage geocomposite do not smoke, wear shoes that could damage the drainage geocomposite, or engage in activities that could damage the drainage geocomposite or underlying geomembrane.
- Verify that the drainage geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from windblown drainage geocomposite).
- Verify that the drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- Observe that the drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- Observe that on slopes the drainage geocomposite is secured in the liner anchor trench and then rolled down the slope.
- Observe that adjacent rolls of drainage geocomposite are overlapped a minimum of six inches, tied, and seamed in accordance with the manufacturer's recommendations.

- Observe that tying is with plastic fasteners in accordance with the manufacturer's recommendations. In the absence of other specifications the drainage geocomposite panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).
- Observe that geotextile component is overlapped and either heat bonded or sewn together.

3.6.4 Repairs

Repair procedures include:

- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed drainage geocomposite by tying every 6 inches.
- Where the hole or tear width across the roll is more than 50 percent of the roll width the damaged area will be cut out across the entire roll and the two portions of the drainage geocomposite will be jointed.

3.7 Equipment on Geosynthetic Materials

Construction equipment on the bottom liner and overliner systems will be minimized to reduce the potential for liner puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap liner material (rub sheets) above geosynthetic materials in the liner system. Aggregate drainage layers and/or protective cover will be placed using low ground pressure equipment. The CQA monitor will verify that the geosynthetics are not displaced while the soil layers are being placed.

Unless otherwise specified by the POR, all lifts of protective soil material placed over geosynthetics will conform with the following guidelines.

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in)
<5.0	12
5.1 – 8.0	18
8.1 – 16.0	24
>16.0	36

No equipment will be left running and unattended over the lined area.

3.8 Tire Chips

Tire chips may be used as a 12-inch thick leachate collection/protective cover layer. The leachate collection/protective cover layer consisting of tire chips will be placed over the general fill layer in accordance with the project plans and specifications. The tire chips will have a nominal size of 2 to 4 inches and will be free of foreign objects. The high tensile steel wire cord will have a maximum length of 6 inches. The physical characteristics of the tire chips will be evaluated through visual observation before and during construction.

The tire chips will be placed using low ground pressure equipment as outlined in Section 3.6. The tire chips will be placed by spreading in front of the spreading equipment with a minimum of 12 inches of soil between the spreading equipment and the installed geosynthetics. Under no circumstances will the construction equipment, or tire chips come in direct contact with the installed geosynthetics.

The thickness of the tire chips will be verified with surveying procedures of a minimum of one survey point per 5,000 square feet of constructed area by a registered Texas surveyor. A minimum of two survey points will be used for all constructed areas regardless of size. Surveying will verify that the finished tire chip layer minimum thickness is as specified in the specifications. The test results for the tire chip layer will be included in the GLER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Monitor haul road thickness over geosynthetic installations and verify that equipment hauling and materials placement meet equipment specifications (see Section 3.7).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the protective cover materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey.

3.9 Reporting

The POR will submit to the TCEQ a GLER for approval of the flexible membrane liner, leachate collection system and protective cover. Section 8 describes the documentation requirements.

4 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETIC CLAY LINER

4.1 Introduction

GCL will be used as an alternate liner design (reinforced GCL only). A geotechnical analysis of the overliner system with a GCL including slope stability analyses is included in Appendix IIIM – Geotechnical Report. Table 4-1 – Required Testing and Properties for GCL Materials includes the tests, testing methods, and frequencies. The GCL used for the overliner will meet the material properties listed in Table 4-1. The GCL will also comply with the conformance shear strength testing described in Section 3.2.2 of this LQCP.

4.2 Material Requirements

A reinforced GCL which consists of bentonite encapsulated between two geotextiles, one nonwoven and one woven, which are needle punched together will be used for the entire overliner area. The GCL materials and its components will be tested in accordance with Table 4-1 by the supplier/GCL manufacturer and a third party independent laboratory and will have the required values listed in Table 4-1. A certificate of analysis for each GCL panel will be submitted as part of the quality control documentation. The GCL permeability will be certified by the manufacturer and will be tested by an independent laboratory at frequencies included in Table 4-1 (the terms "hydraulic conductivity" and "permeability" are used interchangeably). The manufacturer will provide recommended seaming procedures and supporting test (flow box or other suitable device). The manufacturer will provide documentation showing the GCL seams are no more permeable than the GCL itself at a confining pressure anticipated in the field. The minimum shear strength of hydrated GCL (reinforced) will meet the requirements set forth in the geotechnical analysis provided in Appendix IIIM. The nonwoven side of the GCL will be in contact with the geomembrane. Table 4-1 includes further details for the GCL material.

The GCL will be shipped in rolls, which are wrapped individually in relatively impermeable and opaque protective covers. GCL rolls will be off-loaded with equipment that will not damage the GCL rolls. The rolls may be stacked only as allowed by manufacturer's recommendations. The GCL rolls must be stored above ground (i.e., wooden pallets) and covered with a waterproof tarpaulin.

GCL testing will be performed by the manufacturer and a third-party independent laboratory. The POR will review the manufacturer's certification (quality control certificate) and verify that the GCL meets the values given in the plan or specifications for those tests listed in Table 4-1. Required quality control documentation will be submitted to the POR a minimum of 7 days prior to deployment of any GCL. Requirements for GCL materials are listed in Table 4-1.

The POR will perform verification testing as required by additional detailed construction specifications or as required by the POR.

4.3 GCL Installation

Installation of GCL will have continuous on-site monitoring during construction by the POR or his designated representative. The installer will provide a panel layout plan, which will be reviewed by the POR prior to any material deployment. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

4.3.1 Surface Preparation

The surface of subgrade for the GCL installation will generally be intermediate soil cover and be stable. It will be smooth and free of foreign and organic material such as vegetation roots, sharp objects, exposed soil or aggregate particles greater than 3/4 inch (or less if recommended by the manufacturer), or other deleterious materials. Standing water or excessive water on the subgrade will not be allowed. If standing water is encountered it will be removed and soils with excessive moisture will be excavated and replaced with suitable borrowed soils to provide a firm, smooth-surfaced base for GCL placement. The POR will verify that the subgrade does not contain excessive moisture, and that soft soil is removed from the area. A firm, smooth-surfaced base grade will be established before GCL placement. The POR may require additional compaction and grading that will result in a smooth surface (e.g., proof rolling), as necessary.

Prior to GCL installation, the POR will verify the following:

- The grades below the GCL have been verified and accepted by the GCL contractor.
- Required documentation for constructed layers and subgrade preparation below the GCL have been completed and are acceptable.
- The supporting surface has been rolled to provide a smooth surface and does not contain materials, which could damage the GCL or adjacent layer. The subgrade will be rolled with a smooth-drum compactor. Protrusions extending more than 3/4 inches (or less if recommended by the

manufacturer) from the base grade surface will be either removed or pushed into the surface with a smooth-drum compactor.

4.3.2 Deployment

Equipment used to deploy GCL over soil must not cause excessive rutting of the GCL subgrade. Deployed GCL panels should contain no folds or excessive slack. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on GCL. Installation personnel must not smoke or wear damaging shoes when working on GCL.

GCL seams will be constructed overlapping their adjacent edges a minimum of 12 inches. GCL seams will be constructed per manufacturer's directions. Unless higher values are required by the manufacturer, 0.25 pounds per linear foot of bentonite will be applied 6 inches from the outside edge of the overlapping panel. The CQA monitor will verify that steps are taken to minimize the presence of loose soil or other debris within the overlap zone.

GCL on sideslopes must not be unrolled in a direction perpendicular to the direction of the slope. GCL should be anchored temporarily (e.g., sandbags) at the top of the slope and then unrolled working from the top of the slope so as to keep the material free of wrinkles and folds, and GCL should be anchored at the bottom of the slope.

Horizontal seams will only be allowed on the slopes under one of the following conditions:

- 2 feet of overlap with horizontal seams being staggered.
- 1 foot of overlap with the underlying panel having a 1-foot runout anchored with 6 inches of subgrade.

Manufacturer hydraulic conductivity testing of GCL seams must be performed by using a flow box or other suitable device per adjoining material and type. Hydraulic conductivity value must be equal to or less than the specified hydraulic conductivity value for the GCL ($5x10^{-9}$ cm/s).

The POR or his designated representative will observe the GCL as it is deployed for even bentonite distribution, thin spots, or other panel defects. Defects and the disposition of the defects (panel rejected, patch installed, etc.) will be recorded. Repairs are to be made in accordance with the specifications at the discretion of the POR. The POR will verify that only panels that can be covered on the same day with a FML are deployed and that the GCL panels are not placed during wet, rainy weather or impending rain. In accordance with the construction specifications, the POR will also verify the following:

- Proper GCL deployment techniques.

- Proper overlap during deployment.
- Seams between GCL panels are constructed per manufacturer's recommendations.
- The bentonite does not exceed the specified amount of hydration prior to covering.
- Defects are patched and overlapped properly.
- On sideslopes, the GCL is anchored at the top and then unrolled.
- Observe that no debris is trapped beneath or within the GCL.
- Observe that broken needle pieces do not exist within needle-punched GCL.
- Observe that wind speed is less than 40 miles per hour unless a lower wind speed is recommended by the manufacturer. At a minimum, a hand-held anemometer will be used, and readings will be taken at least once a day during GCL deployment to verify that the wind speed is less than 40 miles per hour.

The POR will observe the GCL for premature hydration visually and by walking over the GCL to locate soft spots. GCL that has prematurely hydrated according to the specifications will be removed and replaced with new GCL. These observations will be documented in the GCLER.

4.3.3 GCL Anchor Trench

The GCL anchor trench will be left open to allow installation of FML. Temporary anchoring will be provided until the placement of FML by using sand bags. Slightly rounded corners will be provided in anchor trenches where the GCL enters the trench so as to avoid sharp bends in the GCL. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of final cover system. Backfilling of soil will be in accordance with Section 2.3.4.

4.3.4 Patching

Torn or otherwise damaged GCL (with no loss of bentonite from the GCL) must be patched with the same type of GCL. The GCL patch must extend at least 12 inches beyond the damaged area and must be bonded to the main GCL to avoid shifting during backfilling. If the GCL damage includes loss of bentonite, the patch must consist of full GCL extending at least 12 inches beyond the damaged area. Lapping procedures must be the same as specified for original laps of GCL panels.

4.4 GCL Protection

Protection of GCL will be verified from production to deployment using the procedures discussed in this section. The manufacturer will provide inspection reports demonstrating that needle-punched nonwoven geotextile were inspected using metal detectors for the presence of broken needles and were found to be needle free. GCL must be rolled by the manufacturer in a fashion to prevent collapse during transit. Rolls will be labeled and bagged in a packaging that is resistant to water.

Visual inspection of each GCL roll will be made during unloading to identify any packaging that has been damaged. Rolls with damaged packaging will be marked and set aside for further inspection. The packaging will be repaired, for acceptable GCL rolls, prior to being placed in storage. If necessary, the party responsible for unloading the GCL will contact the manufacturer prior to shipment to ascertain the suitability of the proposed unloading methods and equipment.

The GCL installation contactor will be responsible for the storage of GCL material. A dedicated storage area will be selected at the job site or at an alternate offsite area per owner's direction. The selected area will be level, dry, and well drained. Rolls will be stored in a manner that prevents sliding or rolling from the stacks. Rolls should be stacked no higher than three rolls to protect the integrity of roll cores and ensure safe material handling. Stored GCL materials will be covered with a plastic sheet or tarpaulin until it is installed. The integrity and legibility of the labels will be preserved during storage.

Construction equipment (other than low contact pressure rubber-tired vehicles such as ATVs or golf carts) on the GCL will not be allowed. The CQA monitor will verify that small equipment such as generators is placed on scrap FML material (rub sheets). The protective cover will be placed (using low ground pressure equipment as discussed under Section 2.3.6) as soon as possible after installation of FML and drainage layer. Refer to Section 3.7 for equipment operating requirements over geosynthetic materials.

The CQA monitor will verify that GCL (or overlying geosynthetics) are not displaced or damaged while overlying materials are being placed.

4.5 Reporting

The POR will submit a GCLER to the TCEQ for approval of the GCL. Section 8 describes the documentation requirements.

Table 4-1
Required Testing and Properties for GCL Materials[1]

Tester	Test[11]	Property	Required Values	Standard Test Method	Frequency of Testing
Supplier or GCL Manufacturer	Bentonite[2]	Free Swell (ml/2g)	24 (min)	ASTM D 5890	Per 50 tons and every truck or railcar (minimum of 1 test for each construction event)
		Fluid Loss (ml)	18 (max)	ASTM D 5891	
	Geotextile	Mass Unit/Unit Area (oz/sy)	5.9 (min)	ASTM D 5261	Per 25,000 sy
		Tensile Strength at Break[3] (%)	65 (min)	ASTM D 6768	
GCL Manufacturer	GCL Product[9]	Bentonite Mass/Unit Area[4] (lb/sf)	0.75 (min)	ASTM D 5993	Per 5,000 sy
		Bentonite Moisture Content (%)	35 (max)	ASTM D 5993	
		Tensile Strength (lb/in)	23 (min)	ASTM D 6768	Per 25,000 sy
		Permeability[5] (cm/s)	$5x10^{-9}$ (max)	ASTM D 5887	Per 30,000 sy
		Lap Joint Permeability (cm/s)	$5x10^{-9}$ (max)	Flow box or other suitable device	Per GCL adjoining material and lap type[6]
Independent Laboratory (Conformance Testing)	GCL Product	Bentonite Mass/Unit Area (lb/sf)	0.75 (min)	ASTM D 5993	Per 100,000 ft^2
		Permeability[7] (cm/s)	$5x10^{-9}$ (max)	ASTM D 5887	
		Direct Shear[8]	Refer to Section 6 for required values.		One per GCL/adjoining material type

1 Tests and required values are developed using GRI-GCL3 – Test methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs).
2 Tests to be performed on bentonite before incorporation into GCL.
3 The geotextiles in their as-received condition are evaluated by incubation in a forced air oven set at 60° C for 50 days, per ASTM D 5721. If individual yarns are used in reinforcing GCLs, they must also meet this same endurance criterion.
4 Bentonite is measured after oven drying per the stated test method.
5 Report last 20 permeability values, ending on production date of supplied GCL.
6 May also be performed as conformance testing.
7 Test at confining/consolidating pressures simulating field conditions for ASTM D 5887.
8 Not applicable for slopes of less than 7H:1V. Testing must be on material in hydrated states and must use strain rates, confining pressures, and other parameters which simulate field conditions. Only reinforced GCL (bentonite encapsulated between two geotextiles, one nonwoven and one woven, which are needlepunched together) will be used for the overliner area. The nonwoven side of the GCL will be in contact with the geomembrane.
9 POR will verify that assembled GCL product has a minimum bentonite mass/unit area of 0.8 lb/ft^2.

5 QUALITY ASSURANCE FOR PIPING

5.1 Introduction

This section describes CQA procedures for the installation of HDPE pipe for the leachate collection system (LCS) used for the composite liner and overliner. This plan stresses careful documentation during the quality assurance process, from the selection of materials through installation.

The goal of the pipe quality assurance program is to assure that proper construction techniques and procedures are used, and that the project is built in accordance with the project construction drawings and specifications that will be developed in accordance with this LQCP for each future liner construction. All pipe designs will be prepared to provide adequate pipe size (diameter), strength (SDR value), and opening sizing (perforations or slots) to provide reliable, long-term performance of the pipe.

The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are corrected before construction is complete. A construction report, prepared after project completion, will document that the constructed facility meets design standards and specifications.

5.2 Pipe and Fittings

5.2.1 General

Construction must be conducted in accordance with the project construction drawings and specifications for each liner constructed. Piping design and specifications are provided in Appendix IIIC – Leachate and Contaminated Water Management Plan. To monitor compliance, a quality assurance program will be implemented that includes: (1) a review of the manufacturer's quality control testing, (2) material conformance testing, and (3) construction monitoring. Conformance testing refers to testing by an independent third party laboratory that will take place prior to material installation on materials delivered to the site.

5.2.2 Delivery

The CQA monitor will observe:

- That upon delivery, the pipe and pipe fittings are in compliance with the requirements of the construction specifications that will be developed in accordance with this LQCP for each liner construction.
- That a storage location is selected in which the pipe and pipe fittings are protected from excessive heat, cold, construction traffic, hazardous chemicals, and solvents. If the pipe and pipe fittings are stored at a location where other construction materials are present, the CQA monitor will assure that stacking or insertion of the other construction materials onto or into the pipe and pipe fitting is prohibited. The CQA monitor will periodically examine the storage area to observe that the pipe fittings are undamaged, and have been protected.
- That upon transporting pipe and fittings from the storage location to the construction site, the contractor will use pliable straps, slings, or rope to lift the pipe. Steel cables or chains will not be allowed to transport or lift the pipe.
- That the contractor will provide that a pipe greater than 20 feet in length will be lifted with at least two support points. The contractor will not drop, impact, or bump into the pipe, particularly at the pipe ends. Pipe and fitting ends must be cleaned of all dirt, debris, oil, or any other contaminant which may prohibit making a sound joint.

The CQA monitor will document all activities associated with the handling and storage of this material in order to maintain compliance with this portion of the CQA plan.

5.2.3 Conformance Testing

Prior to the installation of pipe, the pipe manufacturer will provide to the Operator and the POR a quality control certificate for each lot or batch of pipe provided. The quality control certificate will be signed by a responsible party employed by the pipe manufacturer, such as the quality control manager. The quality control certificate and documentation will include:

- A description of the pipe delivered to the project, including but not limited to the strength classification, diameter, perforations, and production lot.
- Properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications that will be developed in accordance with this LQCP for each liner construction, or equivalent.

- A certification that property values given in the properties sheet are minimum values and are guaranteed by the pipe manufacturer.
- A list of quantities and descriptions of materials other than the base resin which comprise the pipe.
- The sampling procedure and results of testing for actual samples manufactured in the same lot as the pipe delivered to the project.

The CQA monitor will observe that:

- The property values certified by the pipe manufacturer meet all of the specifications that will be developed in accordance with this LQCP for each liner construction.
- The measurements of properties by the pipe manufacturer are properly documented and that the test methods used are acceptable.
- Verification that the quality control certificates have been provided at the specified frequency for all lots or batches of pipe, and that each certificate identifies the pipe lot/batch related to it.
- The certified properties meet the specifications that will be developed in accordance with this LQCP for each liner construction.

5.2.4 Pipe and Fitting Installation

Surface Preparation. Prior to pipe installation, the CQA monitor must observe the following:

- All lines and grades have been verified by the contractor and project surveyor.
- The pipe trenches are swept clean of any deleterious material which may damage the pipe or may clog the pipe.
- Pipe perforations for the LCS are drilled in the pipe outside of the drainage trench where the pipe is to be laid. The drill cuttings must be completely removed from the pipe prior to being placed in the drainage trench.
- Pipe perforations are to the correct size and spacing according to the specifications that will be developed in accordance with this LQCP for each liner construction. Perforations can be either factory installed slots or factory predrilled holes or field drilled holes.

Pipe and Fitting Placement. During pipe and fitting installation, the CQA monitor will:

- Observe all pipe, pipe fittings, and joints as the pipe is being laid. The CQA monitor will observe that pipes and fittings are not broken, cracked, or otherwise damaged or unsatisfactory. Prior to fusing (if fusion welding is utilized) the pipe installer will provide for a fusion surface area which is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

- If fusion welding is utilized verify welder credentials and that procedures are consistent with the pipe manufacturer's recommendations.
- Observe that the pipe and fittings are being constructed in accordance with specifications that will be developed in accordance with this LQCP for each liner construction.
- Observe that the people and equipment utilized to install the pipe do not damage the pipe or any other component of the liner system.

6 LINERS CONSTRUCTED BELOW THE HIGHEST GROUNDWATER LEVEL

6.1 Introduction

Liners constructed below the groundwater surface could potentially experience uplift due to hydrostatic pressure acting on the geomembrane liner. This section of the LQCP describes procedures for short term and long-term protection of the liner system due to hydrostatic pressure uplift that may result from liner construction below the highest measured groundwater table.

The geology of the site generally consists of alluvial sands and clays overlying weathered and unweathered shale strata. The base of the proposed cell excavations will be primarily founded in the shale strata. The shallow groundwater is contained within the sand and clayey sand alluvial soils which overlie the shale, and in some instances will be exposed in the excavation sidewalls. The unweathered shale is considered an aquiclude. A temporary dewatering system will be constructed for the perimeter sidewalls above and below the contact of the water-bearing alluvium with the shale. As discussed in Section 5.6, the stability of the shale will be evaluated prior to and during liner construction for Sectors 11 through 14, the remaining unconstructed sectors.

Long-term liner stability will be provided in the form of ballast that will be created by the weight of protective cover, solid waste, and final cover as applicable. Example ballast calculations are presented in Appendix IIID-B – Example Ballast Thickness Calculations. The TCEQ's Ballast Evaluation Report forms (TCEQ-10072) are included in Appendix IIID-A. Ballast will be provided for the entire remaining unconstructed sideslope area that has a composite liner that is below the highest measured groundwater elevation. The highest measured groundwater surface (2021) is presented on Figure IIID-2 in this appendix, and will be used for future ballast demonstration calculations. A site plan showing he locations of the sideslope underdrains for Sectors 11 through 14 (approximate) is included as Figure IIID-3.

6.2 Highest Measured Groundwater Levels

Based on the current hydrogeologic investigation and previous investigations, the site geology consists of three strata: The Upper Sands, Bounding Shale, and Lower Sands. Water levels from the current monitoring wells and piezometers screened in the Upper Sands indicate that the groundwater levels are higher than the excavation floor. As discussed in Section 6.3, a temporary dewatering system is designed for the undeveloped portion to control hydrostatic pressure that may act on the liner system. Long-term stability of the liner system will be ensured by the use of waste-as-ballast to counteract potential uplift pressures created by hydrostatic forces acting on liner system in the sector sideslopes.

A highest groundwater potentiometric surface map is included as Figure IIID-2 in this appendix. Detailed groundwater information is presented in Appendix IIIG – Geology Report.

During the design of Sector 11, 12, 13, and 14, the highest measured groundwater level will be adjusted upward for possible higher well level data and the highest measured groundwater potentiometric contours for that sector at the time of design will be used for design of ballast and demonstration of adequacy. Any temporary hydrostatic relief system design different than the one presented in Appendix IIID-C will be submitted to the TCEQ for approval as a modification to the LQCP. Adjusting the elevations of the relief system design based on future changes in groundwater elevations does not require a permit modification.

6.3 Temporary Dewatering System

A temporary dewatering system was installed in portions of the developed Subtitle D areas, and a future temporary dewatering systems will be installed in the undeveloped Sectors 11, 12, 13, and 14.

6.3.1 Dewatering System for Developed Area

The existing dewatering system includes a trench installed at the perimeter sidewalls or at the toe of excavation. The dewatering system consists of a trench with a minimum depth of 2 feet and minimum width of 6 inches. The temporary trench consists of a perforated pipe enveloped with gravel and a geotextile wrap. A geocomposite drainage layer extends up the slope above the highest measured groundwater elevations to maintain the drawdown condition produced by the open excavation. The trenches are constructed at the contact of and overlain soil layer and the unweathered shale and a minimum of 2 feet of penetration into the shale.

6.3.2 Dewatering System for Undeveloped Areas

The temporary dewatering system design has been developed to prevent the build-up of hydrostatic groundwater uplift in the undeveloped areas. The temporary dewatering system will collect groundwater from the Upper Sand exposed during excavations. The design of the system is further discussed in Appendix IIID-C. The excavation sideslope temporary dewatering system design is based on the highest measured groundwater contours shown on Figure IIID-2 (2021) in this appendix. And as discussed in Section 6.2.

Appendix IIID-C includes the design calculations for the temporary dewatering system that will be installed beneath the sidewall liner. As shown in Appendix IIID-C, a drainage geocomposite will convey groundwater to a collection trench installed at the toe or on the slope of the cell. Any water collected in the sump (if used) will be removed by a submersible pump and pumped to the perimeter stormwater system where it will be discharged from the site consistent with the TPDES stormwater permit.

The temporary dewatering system will remain operational until enough ballast is placed in the form of protective cover and solid waste over the impacted area. Once sufficient ballast is in place and with the written approval (BER) of TCEQ, the dewatering system will be decommissioned. Example ballast evaluation calculations are presented in Appendix IIID-B. The pumps will be activated upon installation of the dewatering system and will remain operational until the BER is approved by the TCEQ. The pumps will be operated automatically by pressure transducers.

If the unconstructed Sectors 11 and 12 are proposed for disposal of Class 1 waste, a separation layer as described in section 2.3.1.1 of this LQCP will be installed above the pressure relief system. The 5-foot-thick separation layer will be considered in calculating ballasting. A site plan of the cell sideslopes proposed to receive the 5-foot separation layer is shown on Figure IIID-C.

A different hydrostatic pressure relief system may be used at the site if it is designed using the same methodology as the design included in Appendix IIID-C (e.g., relieve potential hydrostatic uplift pressure that may develop on the geomembrane liner) and approved by TCEQ.

6.4 Control of Seepage During Construction

Seepage of free water from the exposed soils within the bottom of the disposal cell is not expected during liner construction due to the temporary dewatering system that will be in place before liner construction is initiated, and the shale exposed within the cell bottom. During construction, the subgrade must be maintained in a firm and unyielding condition to provide a satisfactory foundation for construction of the soil liner. If unexpected seepage is encountered, the POR will inspect the seeps and delineate the area. Per the POR's direction, the wet soils will be reworked or over-excavated and replaced with compacted clayey soil to seal off the seepage. Soft areas will be undercut to firm material and backfilled with suitable compacted fill. The fill will be free from organics, foreign objects, and other deleterious matter. The fill will also be compacted sufficiently to provide a firm base for soil liner placement, as detailed in Section 2 of this LQCP.

6.5 Temporary Dewatering System Materials

6.5.1 Dewatering System Drainage Aggregate

The drainage aggregate for the dewatering trench will have a hydraulic conductivity of at least 1 cm/s and a gradation that is compatible with the underdrain pipe perforation specification. Refer to Appendix IIID-C for aggregate gradation for perforated pipe.

$$\frac{\text{85 Percent Size of Filter Material}}{\text{Hole Diameter of Pipe Perforation}} > 1.70$$

The coarse aggregate will be tested for gradation (ASTM D 448) prior to delivery of granular material to the site. Gradation testing will be performed at a minimum frequency of 1 test per 3,000 cubic yards or per specific liner project if granular material used is less than this amount. The aggregate will be free of organics and foreign objects. Calcium carbonate content testing will not be required due to (1) the dewatering system will be operational for a relatively short period of time (i.e., until enough waste-as-ballast is in place), and (2) water pH is expected to be near neutral. The physical characteristics of the aggregate will be evaluated through visual observation and laboratory classification testing before construction and visual observation during construction. During installation, the CQA monitor will observe that granular material is free of organics and foreign objects. The test results for the coarse aggregate will be included in the SLER.

6.5.2 Dewatering System Piping

The dewatering trench pipe will consist of a 4-inch-diameter HDPE SDR-17 pipe, or an engineer-approved equivalent.

Typical total pipe perforation will be 1 square inch per 1 lineal foot of pipe length. Perforation sizes (hole diameter or slot width) will be in accordance with the gradation versus perforation requirements outlined in Section 6.5.1. Prior to installation of dewatering trench pipe, the CQA monitor must observe the following:

- Installation lines and grades have been verified by the contractor and project surveyor.
- The pipe trench is clean of any deleterious material which may damage the pipe or geofabric or may clog the pipe.
- Pipe perforations are drilled outside of the underdrain trench. The drill cuttings will be completely removed from the pipe prior to being placed in the drainage trench.
- Pipe perforations are to the correct size and spacing according to the project specifications that will be developed in accordance with this LQCP for each

liner construction. Perforations can be either factory predrilled holes or field drilled holes.

- Observe all pipe, pipe fittings, and joints as the pipe is being laid. The CQA monitor will observe that pipes and fittings are not broken, cracked, or otherwise damaged or unsatisfactory. Prior to fusing, (if fusion welding is utilized) the pipe installer will provide for a fusion surface area which is clean and free of moisture, dust, dirt, debris of any kind, and foreign material.
- If fusion welding is utilized, verify welder credentials and that the procedure is consistent with the pipe manufacturer's recommendations.
- Observe that the pipe and fittings are being constructed in accordance with specifications that will be developed in accordance with this LQCP for each liner construction and accepted practices.
- Observe that geotextile wrapping around the pipes and trench complies with project specifications outlined in Section 3.5.
- Observe that the people and equipment utilized to install the pipe do not damage the pipe or any other component of the dewatering system.
- Pipe grades will be established prior to pipe placement by grading the bottom of the trench.

6.5.3 Geotextile

The non-woven geotextile will be wrapped around the drainage stone and the collection pipe in the temporary dewatering trench. It will have a weight of at least 6 oz/sy and meet the minimum requirements specified in Appendix IIID-C. There will not be any direct contact between the geotextile and any compaction equipment.

6.5.4 Drainage Geocomposite

A drainage geocomposite will be used for the dewatering layer. The drainage geocomposite will meet the requirements set forth in Appendix IIID-C and will also meet the requirements of the construction drawings and specifications for each specific liner construction. Design flow capacity for the drainage geocomposite is estimated in Appendix IIID-C. The POR will ensure that the flow capacity of drainage geocomposite is equivalent to the required capacity estimated in Appendix IIID-C under similar loading conditions, by reviewing manufacturer's certification.

Upon delivery of the drainage geocomposite the CQA monitor will observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.

- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Operator. All rolls which do not have proper manufacturer's documentation will also be stored at a separate location until all documentation has been received and approved. During the installation the CQA monitor will observe the following.

- The subgrade has been prepared in accordance with the earthwork specifications outlined in Section 2. All lines and grades have been verified by the surveyor.
- The supporting surface does not contain stones that could damage the drainage geocomposite.
- All repairs are to be made in accordance with the specifications outlined in Section 3.6.4.
- Equipment used does not damage the drainage geocomposite by handling, trafficking, leakage of hydrocarbons, or by other means.
- People working on the drainage geocomposite will not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite.
- The drainage geocomposite is anchored to prevent movement by the wind.
- The drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- The drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- On slopes the geocomposite is secured in the anchor trench and then rolled down the slope.
- Adjacent rolls of drainage geocomposite are overlapped a minimum of six inches, tied, and seamed in accordance with the manufacturer's recommendations.
- Observe that drainage geocomposite is overlapped and either heat bonded or sewn together.
- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed geocomposite by tying every 6 inches.

- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll and the two portions of the drainage geocomposite will be joined.

6.5.5 Documentation

Dewatering system installation will be incorporated into the SLER for each liner construction event in accordance with Section 8. The installed dewatering system will be operated until a BER prepared in accordance with Section 8.3 is approved by the TCEQ.

6.5.6 Dewatering System Operation

When pumps are used for the dewatering system, regardless of its location, they will be inspected on a weekly basis to monitor groundwater discharge at the pump outlet pipe. The pumps will be equipped with pressure transducers and the transducer readings will be recorded on a weekly basis to ensure that groundwater pressure in the sump is below the geomembrane elevations. As an alternative to measuring groundwater levels with automatic pressure transducers, the groundwater levels in the dewatering sump may be checked manually by using a calibrated rod that will be lowered into the extraction riser or an equivalent method. The POR will identify the allowable head in the groundwater dewatering sump for each installation. All information/data generated associated with each groundwater dewatering operation will be kept in the site operating record. Each groundwater dewatering system installed will be operational until a BER is approved by the TCEQ.

6.6 Stability of Bounding Shale

The temporary dewatering system discussed in Section 6.3 is developed for the uppermost groundwater bearing zone (Upper Sand Unit) which is present at elevations above the excavation floor grades. Below the uppermost groundwater bearing zone, the Bounding Shale Unit provides a barrier layer (or aquiclude) to the Upper Sand Unit groundwater. The top of Bounding Shale Unit contact is shown on the geologic cross sections in Appendix IIIG-C in Appendix IIIG – Geology Report.

6.7 Liner System Ballast

Ballasting is required to protect the liner system from hydrostatic uplift in areas of the landfill excavation which have been identified to exist below the highest measured groundwater potentiometric surface as defined in Section 6.2. The protective cover soil above the liner system, as well as additional waste placed above the liner system will provide the necessary ballast (weight) for protection of the liner system from hydrostatic uplift.

The factor of safety against hydrostatic uplift must be calculated for those portions of the liner where the liner is below the highest groundwater potentiometric surface. The calculated factor of safety against uplift at the liner (using the weight of the protective cover and waste) must be 1.5. The thickness of ballast required to ballast the uplift force must be calculated and submitted with the GLER. Procedures for calculating the anticipated hydrostatic uplift forces, factor of safety against uplift, and required thickness of ballast are included in Appendix IIID-B. Additionally, example ballast calculations are included in Appendix IIID-B. The most recent highest measured groundwater data as defined in Section 6.2 will be used for ballast calculation. The ballast demonstration included in Appendix IIID-B must be updated each time a dewatering system is installed to account for possible higher hydrostatic head measurements. Note that a value of 1,200 pcy (45 pcf) for solid waste will be used for future ballast calculations.

6.7.1 Waste-As-Ballast Placement Record

When waste is used for ballast, landfill personnel working under the supervision of the site manager will be on site full-time during the placement of the first 5 feet of waste over the liner system. The site operator will verify and document on a daily basis that this lower 5 feet of waste does not contain large bulky items which cannot be compacted to the required density. The site operator will also document on a daily basis that the waste used for ballast has been properly compacted with compaction equipment which weighs in excess of 40,000 pounds. When waste is used as ballast the factor of safety against hydrostatic pressure uplift at the geomembrane liner will be 1.5. This documentation will be placed in the site operating record.

Additionally, the Site Manager will complete and sign a waste-as-ballast placement record that will be attached to the BER (see Section 8.3 for BER required documentation). The form to be used by the Site Manager is included in Appendix IIID-A. One form will be required for each area (or combination of areas) described by approved liner evaluation reports.

6.8 Liner Performance Verification

When ballast is required for a liner, the POR or his representative will verify that the ballast meets the established criteria and uplift of the liner system did not occur during construction. The verification, including but not limited to inspections, compaction, weight, density of material, thickness, and top elevations, will be documented in the BER, which will be submitted to the TCEQ for approval (see Section 8). In the event that uplift occurs, the POR will develop a corrective action to remediate the uplift. The POR will immediately contact the TCEQ and implement initial procedures as soon as the uplift is detected.

6.8.1 Observations for Indications of Seepage

The POR or his representative will observe the liner subgrade for the presence of seepage during construction. To aid in the documentation that short-term uplift has not occurred during ballast placement, the POR will provide a summary of where seepage, if any, was observed, the methods and procedures used to control the seepage, and observations that all seepage has been controlled.

6.8.2 Surveying During Construction

To document that short-term uplift has not occurred during construction of the liner, the POR will verify that the elevations of the geomembrane liner are consistent with the geomembrane liner elevations shown on the construction drawings. The POR will also verify that the protective cover elevations have not increased from those submitted with the GLER. The protective cover elevations will be taken once between the GLER approval and waste placement to document no short-term uplift has occurred. Survey measurements to check against uplift will be taken at a minimum frequency of one measurement per 10,000 square feet by a third party surveyor.

6.9 Documentation

Documentation for issues related to construction below the high water table will be included in the SLER, GLER, and BER. These documents are discussed in detail in Section 8. Documentation specifically related to liners constructed below the highest measured groundwater potentiometric surface will include:

- A current highest measured potentiometric surface map and recent water-level information (Section 6.2).
- A discussion addressing the areas (if any) where the bottom of compacted clay liner extends below the highest measured potentiometric level.
- A discussion identifying the groundwater condition.
- Uplift and ballast calculations for liners with an installed dewatering system.
- A discussion addressing any seepage that may have been encountered.
- Description of the dewatering system installed.

The BER will contain the documentation substantiating that the appropriate depth of ballast has been placed over the liner system and that the liner did not experience hydrostatic uplift.

7 GEOTECHNICAL STRENGTH TESTING REQUIREMENTS

This section of the LQCP addresses the geotechnical strength requirements for the Subtitle D bottom liner and overliner system. Each component of the Subtitle D bottom liner and overliner system is subject to the material testing requirements outlined in Sections 2 through 5 of this LQCP, as applicable.

The testing will be performed under the supervision of the POR by a third-party independent geotechnical laboratory. The POR will ensure that (1) the strength values are met, or (2) provide an updated geotechnical analysis in the GLER that will be submitted to TCEQ after each liner and overliner construction event. If the geotechnical analysis is updated, the resulting factor of safety values must meet the recommended minimum factor of safety values established in Appendix IIIM-A-5.

Prior to each construction event, conformance testing will be required for the specific geosynthetic and soil liner components to be incorporated into the project. The required interface shear strength conformance testing requirements have been established for the project based on stability analyses performed for the expansion. The description of the interface shear strength conformance testing requirements and supporting stability analyses is presented in Appendix IIIM-A-5. As discussed in Appendix IIIM-A-5, the conformance testing requirements are applicable to both laboratory stack testing and single interface testing results and will be incorporated into the GLER prepared for the respective construction event.

8 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of all construction activities. Therefore, the POR and CQA monitor will document that all quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports (if necessary), progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the SLER, GCLER, and GLER. Standard report forms will be provided by the POR prior to construction.

8.1 Preparation of SLER, GCLER, and GLER

The POR will submit to the TCEQ a SLER for review and acceptance of each soil liner portion of the composite liner. After construction of the geosynthetics portion of the liner, the POR will submit and a GLER to the TCEQ for review and acceptance. For the overliner construction, submittal of a SLER, GCLER, and GLER will be required. All of these reports will be approved by TCEQ prior to placement of solid waste over the specified constructed area.

Testing, evaluation, and submission of the SLERs, GCLERs, and GLERs for the composite liner system and overliner will be in accordance with this LQCP. The construction methods and test procedures documented in the SLERs, GCLERs, and GLERs will be consistent with this LQCP and the TCEQ MSWR.

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

- 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.
- As-built record drawings signed and sealed by a licensed Texas land surveyor.
- A statement of compliance with the permit LQCP and construction plans.

- The reports will be signed and stamped by a professional engineer(s) licensed to practice in the state of Texas.

The as-built record drawings will accurately identify the constructed location of all work items, including the piping and anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the SLER, GCLER, and GLER as appropriate.

8.2 Reporting Requirements

The SLER, GCLER, and GLER will be signed and sealed by the POR and signed by the Site Manager and submitted in triplicate (including all attachments) to the MSW Permits Section of the Waste Permits Division of the TCEQ for review and acceptance. If no response is received, either oral or written, within 14 days of receipt by the Waste Permits Division of the TCEQ, the report will be considered accepted. Any notice of deficiency received from the TCEQ will be promptly addressed and incorporated into the SLER/GCLER/GLER report. No solid waste will be placed over the constructed liner areas until the final acceptance is obtained from the TCEQ. Additionally, if a new liner area is constructed a pre-opening inspection will be requested of the TCEQ prior to accepting any solid waste into the newly constructed liner area. The TCEQ staff will conduct a pre-opening inspection within 14 days of the request. If the TCEQ does not provide a written or verbal response 14 days after conducting the pre-opening inspection, the newly developed liner area will be considered acceptable for solid waste placement, provided the SLER and GLER for the area are also submitted to the TCEQ in accordance with this section.

If a layer of waste is not placed over the top of the protective cover (applicable to both liner and overliner areas) within six months, then the POR will visually observe that the liner is not damaged (i.e., excessive erosion) due to prolonged exposure of the surface of the protective cover and will submit a letter report of the findings to the TCEQ. Repairs will be done promptly and the POR will report findings and measures taken to repair damage in a letter report to the executive director for review and acceptance.

8.3 Ballast Evaluation Report

Existing and future dewatering system BERs will be submitted in accordance with this section. A BER will be completed and filed with the TCEQ documenting that enough ballast has been placed in a lined area to offset the potential hydrostatic uplift forces which may exist below the liner system. At a minimum, the information listed below will be included as applicable with the BER.

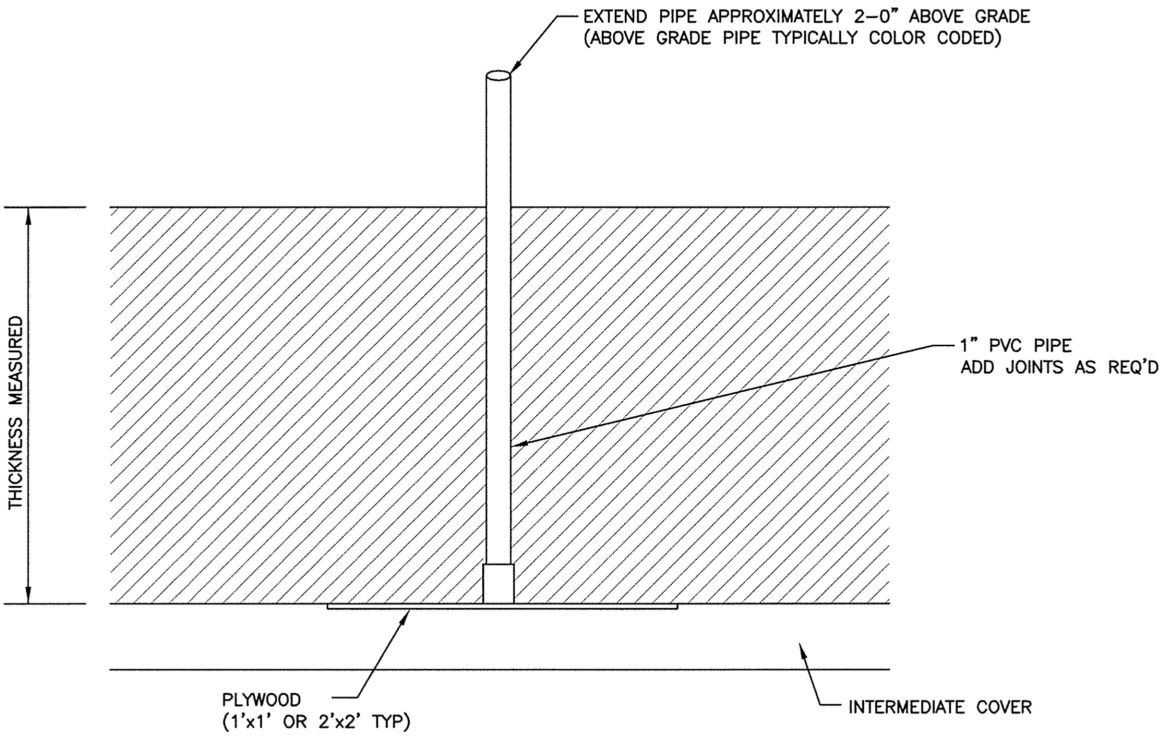
- The top of protective cover elevations immediately after construction compared to the elevations obtained between SLER approval and waste placement, to document the liner did not undergo uplift prior to placement of waste (whether waste ballast is required or not).

- If waste is used for ballast, verification from the Site Manager that the weight of the compaction equipment being used to compact the waste ballast is no less than 40,000 pounds, and that this compaction equipment was utilized during the entire period of placing waste ballast.
- If waste is used for ballast, documentation of the observations that the initial 5 feet of waste used for ballast on the liner system is free of brush and large bulky items, which may not be compacted to the required density.
- A waste-as-ballast placement record (Appendix IIID-A) completed and signed by the Site Manager.
- Survey of the top of waste to document that the required waste ballast thickness has been placed.
- Water-level measurements taken in the site monitor well/piezometer system adjacent to the liner construction area to verify that the groundwater level has not exceeded the design high water level.
- Final ballast thickness calculation using procedures included in Appendix IIID-B and the as-built minimum densities and thicknesses for each component as well as updated groundwater levels.
- A BER will be prepared and signed and sealed by a professional engineer licensed to practice in Texas.

APPENDIX IIID FIGURES

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

02-22-2022



SETTLEMENT PLATE (TYP)

NTS

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

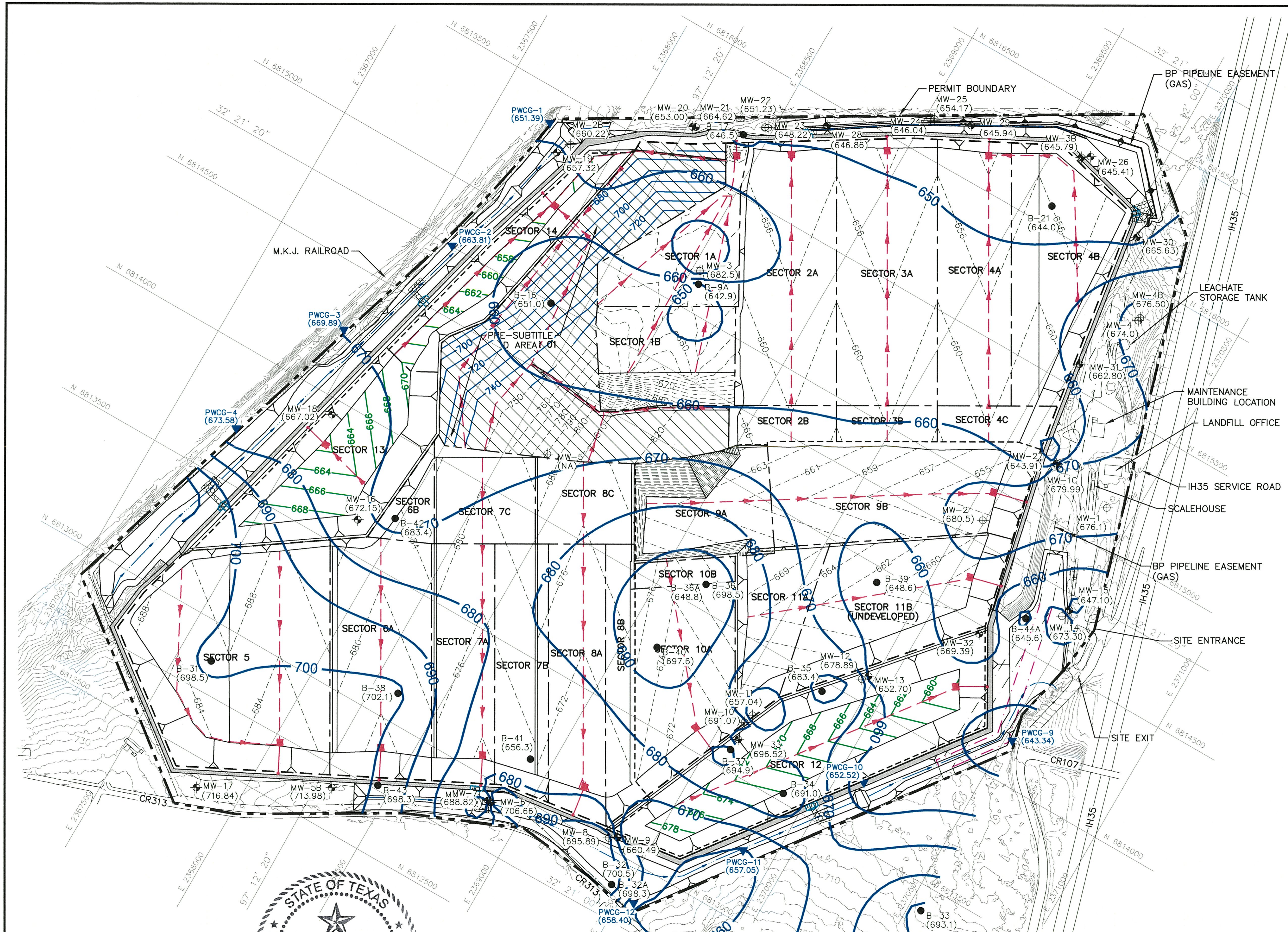
02-22-2022

MAJOR PERMIT AMENDMENT
TYPICAL SETTLEMENT PLATE

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

Weaver Consultants Group
REGISTRATION NO. F-3727

DRAWN BY: JDW	DATE: 02/2022	FILE: 0771-368-11
REVIEWED BY: MDM	CAD: FIG IIID-1.DWG	FIGURE IIID-1



LEGEND

PERMIT BOUNDARY	
PROPOSED LIMITS OF WASTE	
PERMITTED LIMITS OF WASTE	
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
	EASEMENT
	RELOCATED EASEMENT (SEE NOTE 5)
	SECTOR BOUNDARY
800	OVERLINER CONTOUR
670	PERMITTED/EXISTING TOP OF LINER CONTOUR
662	PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
	PERMITTED/UNDEVELOPED LEACHATE LINE
	LEACHATE COLLECTION SUMP
	PRE SUBTITLE D AREA
MW-7 (688.82)	EXISTING GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
MW-1 (676.1)	FORMER GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
B-44A (645.6)	FORMER GROUNDWATER PIEZOMETER WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
PWCG-1 (651.37)	2021 EXPANSION PIEZOMETER WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
670	HIGHEST MEASURED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. MONITORING WELL AND PIEZOMETER LOCATION COORDINATES OBTAINED FROM PREVIOUS SUBSURFACE EXPLORATION BORING LOGS, INVESTIGATION REPORTS, INSTALLATION REPORTS, AND AS-BUILT SURVEY REPORTS.
3. GROUNDWATER ELEVATION DATA OBTAINED FROM THE FACILITY'S SUBTITLE D GROUNDWATER MONITORING DATABASE PROVIDED BY THE CAREL CORPORATION IN OCTOBER 2021 FROM PREVIOUS SUBSURFACE EXPLORATION AND INVESTIGATION REPORTS, AND FROM GAUGING CONDUCTED BY WCG IN 2021.
4. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELLS HIGHEST MEASURED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER SURFACE.
5. THE PROPOSED EASEMENT SHOWN IS FOR ILLUSTRATION PURPOSES ONLY. THE ACTUAL LOCATION WILL BE DETERMINED AT A LATER DATE IN COORDINATION WITH THE EASEMENT HOLDER.

STATE OF TEXAS
DAVID E. POE
81734
LICENSED PROFESSIONAL ENGINEER
02-22-2022

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: IIID.2-HIGHEST MEASURED GW.DWG

DRAWN BY: SRF
DESIGN BY: AKE
REVIEWED BY: NT

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT HIGHEST MEASURED GROUNDWATER ELEVATION MAP (2021)

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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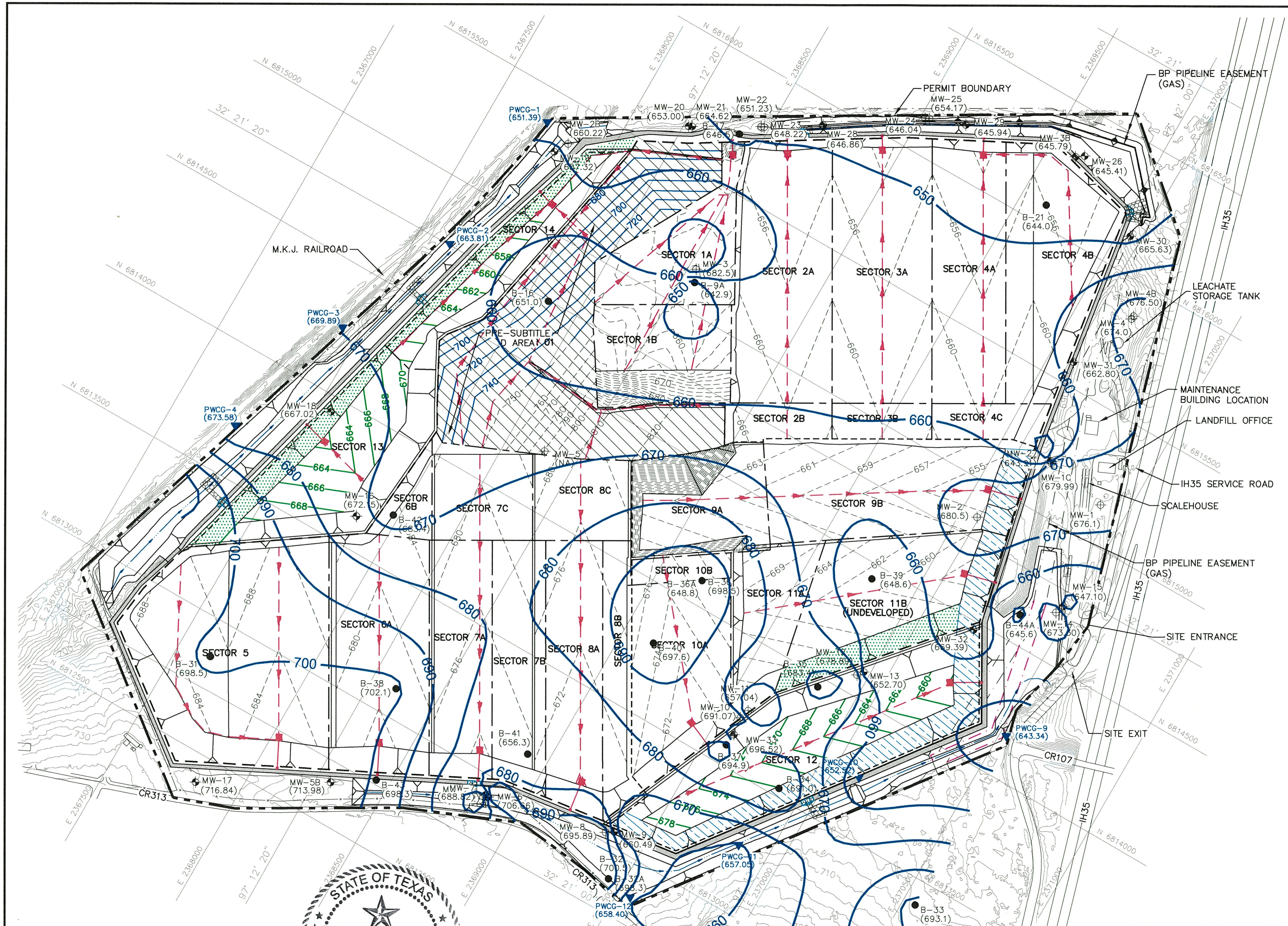
FIGURE IIID-2

O:\0771\368\EXPANSION 2021\PART III\IIID\IIID-2-HIGHEST MEASURED GW MAP.dwg, rfarrington, 1:2



LEGEND

	PERMIT BOUNDARY
	PROPOSED LIMITS OF WASTE
	PERMITTED LIMITS OF WASTE
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
	EASEMENT
	RELOCATED EASEMENT (SEE NOTE 5)
	SECTOR BOUNDARY
800	OVERLINER CONTOUR
670	PERMITTED/EXISTING TOP OF LINER CONTOUR
662	PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
	PERMITTED/UNDEVELOPED LEACHATE LINE
	LEACHATE COLLECTION SUMP
	PRE SUBTITLE D AREA
MW-7 (688.82)	EXISTING GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
MW-1 (676.1)	FORMER GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
B-44A (645.6)	FORMER GROUNDWATER PIEZOMETER WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
PWCG-1 (651.37)	2021 EXPANSION PIEZOMETER WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
670	HIGHEST MEASURED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)
	SIDESLOPE UNDERDRAIN ONLY
	SIDESLOPE UNDERDRAIN AND 5-FT CLAY SEPARATION LAYER (CLASS 1 ONLY)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. MONITORING WELL AND PIEZOMETER LOCATION COORDINATES OBTAINED FROM PREVIOUS SUBSURFACE EXPLORATION BORING LOGS, INVESTIGATION REPORTS, INSTALLATION REPORTS, AND AS-BUILT SURVEY REPORTS.
3. GROUNDWATER ELEVATION DATA OBTAINED FROM THE FACILITY'S SUBTITLE D GROUNDWATER MONITORING DATABASE PROVIDED BY THE CAREL CORPORATION IN OCTOBER 2021 FROM PREVIOUS SUBSURFACE EXPLORATION AND INVESTIGATION REPORTS, AND FROM GAUGING CONDUCTED BY WCG IN 2021.
4. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELLS HIGHEST MEASURED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER FLOW.

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
02-22-2022

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: IIID-2-UNDERDRAIN PLAN.DWG

DRAWN BY: RAA
DESIGN BY: DEP
REVIEWED BY: DEP/NT

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT UNDERDRAIN AND CLASS 1 5-FT SEPARATION LAYER PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE IIID-3

O:\0771\368\EXPANSION 2021\PART III\IIID\IIID-3-UNDERDRAIN PLAN.dwg, rarrington, 1:2

APPENDIX IIID-A

BALLAST EVALUATION REPORT FORMS

Texas Commission on Environmental Quality
Municipal Solid Waste Landfill
Ballast Evaluation Report

TCEQ

Part A: Facility Identification

Permittee: ____

Permit No.: ____________ Operational Classification Type: ____________________

County: ____

Part B: General Information

1. Describe liner system cross-section in bottom, sidewalls, leachate collection trenches, and sumps.
   ____
   ____
   ____
   ____

2. Does the SDP require an active or passive dewatering system for this liner system?
   ____
   ____

3. Which cell, area, or sector does the BER represent? ____________________
   ____
   ____

4. Date of the current LQCP that was used to develop this BER? ____________________
   a. Was this plan followed? ______________________________
   b. If not followed, why not? ______________________________

5. Dates the certifying engineer and the technician visited the site (other than previously reported in SLER/GLER).
   ____
   ____

Part C: Groundwater and Ballast Data

1. Attach to this report a map(s) of the area under evaluation showing the site grid system and elevation contours of seasonal high groundwater level, liner system, and top of ballast. Also include actual groundwater elevation contours if lower than seasonal high groundwater levels due to dewatering or other causes if these lower groundwater levels are being used to demonstrate uplift stability during construction or during waste-as-ballast placement.

2. Attach instrumentation data (from piezometers, pneumatic pore pressure cells, etc.) taken during liner construction and since the end of construction or last BER.

3. Attach surveyed elevations of top of ballast. Was all surveying performed under the supervision of a registered surveyor? ________________________________

4. Attach any test or other documentation of unit weights of soil materials used as ballast.

5. If waste was used as ballast, submit Waste-as-Ballast Placement Record (attached) with authorized signature of facility operator or permittee. Does the record indicate that the waste ballast is in accordance with the LQCP? __________________________

   If not, provide explanation. _______________________________________

   Does the record indicate that a minimum 40,000-pound wheeled compactor was used throughout the period covered by this BER? ______. If not, indicate the following:

   Time period covered? ____

   Approximate volume of airspace consumed during period? _________________

   Tons of waste from landfill gate records during period? ___________________

   Approximate percentage of daily/intermediate cover? __________________

   Unit weight of waste (attach calculations)? __________________________

   (Note: Ballast calculations must not use unit weight of waste greater than 1,200 lbs/yd^3).

Part D: Calculations of Uplift Stability

1. Provide calculated factors of safety against uplift for all critical locations in the area covered by this BER (see attached table). The factors of safety must be checked at critical points in the liner system (i.e. at bottom of geomembrane, bottom of compacted clay, etc.). The factors of safety must cover stability using the appropriate piezometric heads after completion of waste-as-ballast placement. Include sample uplift stability calculation(s).
2. Do the analyses conducted in D.1 indicate adequate factors of safety against uplift (1.2 if only soil is used as ballast and 1.5 if waste is used as ballast from the seasonal high groundwater level?

   ____

Part E: Engineer Certification

I certify that the liner has been constructed as designed in accordance with the issued permit and in general compliance with the regulations.

Affix Professional Engineer's Seal (Date & Sign)

[seal]

____
(typed or printed name)

____
(date signed)

____
(phone number)

____
(fax number)

____
(company or business name)

____
(address, city, zip code)

Note: A professional engineer must be registered in Texas.

Part F: Signature of Permittee

1. I have read and fully understand the findings of the BER submittal.
2. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

____
(signature)

____
(typed or printed name)

____
(title)

____
(date signed)

____
(phone number)

____
(fax number)

____
(company or business name)

____
(*address, city, state, zip code*)

APPENDIX IIID-B

EXAMPLE BALLAST THICKNESS CALCULATIONS

Includes pages IIID-B-1 through IIID-B-5

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER

02-22-2022

EXAMPLE BALLAST CALCULATIONS

Introduction

For excavations extending below the potentiometric surface, the MSW Regulations require that long-term hydrostatic uplift pressures on the base of the bottom or sidewall liner systems be offset using ballast in accordance with the regulations contained in 30 TAC §330.337. The hydrostatic uplift pressures on the liner system and the ballast requirements to offset the uplift pressures were evaluated and an example is included in this Appendix. The ballast calculations include an evaluation of the magnitude of the hydrostatic uplift pressures on the bottom and sidewall liner systems based on the difference in elevation between the highest measured potentiometric surface and the base of the liner system. In addition, the resistance pressure of the proposed liner system was evaluated and compared to the hydrostatic uplift pressure to determine if additional ballast in the form of solid waste or soil will be necessary.

At the Turkey Creek Landfill, excavation below the potentiometric surface or through water bearing zones will be necessary in future Sectors 11 through 14. A shallow water bearing zone, called the upper sand, will be exposed completely within the sidewall excavation along the southern and western portion of the landfill.

Short-term dewatering requirements for construction of the liner system and placement of required ballast are presented in Appendix IIID-C. The location of the Sidewall Dewatering Systems are shown on Figure IIID-3.

Excavation Through Upper Sands

The upper sand unit and associated groundwater is exposed in only the sidewall liner along the southern sideslopes and a portion of the southeastern side of the site (Sectors 11 and 12), and along western sideslopes (Sectors 13 and 14). The excavation base in this area will be in the shales underlying the upper sands and therefore will not be subjected to hydrostatic forces. The top of potentiometric surface contours in the upper sand unit and the bottom of the upper sand contours were overlaid on the top of the liner plan to determine the hydrostatic head on the sidewall liner based in the highest measured water levels to date (2021) as illustrated on Figure IIID-2.

The hydrostatic pressures on the sidewall geomembrane liner will be offset by the leachate collection and protective cover layers and additional solid waste or soil ballast above the liner system as required.

The waste ballast will be placed out onto the bottom of the landfill a minimum horizontal distance of 100 feet from the toe of the slope before temporary dewatering methods are discontinued. The waste-as-ballast example calculations are presented on Pages IIID-B-3 through IIID-B-5. The analysis points used for the calculations are shown on Figure IIID-B-1. If soil is used for ballast, it will be placed in horizontal lifts and keyed into the protective cover (note soil ballast will not be used if tire chips are used for the protective cover layer). Chimney drains will be extended up through the soil ballast, if used.

Ballast Evaluation Report

A Ballast Evaluation Report (BER) will be prepared for each landfill sector constructed below the seasonal high water table. The BER will be prepared in accordance with the Section 6.9 of the LQCP.

TURKEY CREEK LANDFILL
0771-368-11-123
APPENDIX IIID-B
EXAMPLE BALLAST CALCULATIONS

Required: Demonstrate that the fill placed above the bottom liner system provides sufficient ballasting to allow decommissioning of the underdrain system for Sector 13.

Assumptions: The approximated highest measured groundwater contours are shown on Drawing IIID-B-1.

Solution:

An example calculation using Ballast Evaluation Point BEP-1 is shown below (assumed at liner elevation 672 ft-msl). A summary of the calculation results for the evaluation points is given in the following table. Drawing IIID-B-1 shows the location of the ballast evaluation points and the higheast measured groundwater contours for Sector 13. The calculations were performed assuming waste has been placed to a fill elevation of approximately 725 ft-msl, or approximately 50 feet of fill.

Definition of terms/variables:

E_{H2O} = Highest measured groundwater elevation, ft-msl
E_{liner} = Elevation of top of clay liner, ft-msl
H = Maximum groundwater head above top of liner, ft
γ_{H2O} = Unit weight of water, pcf
P_{H2O} = Maximum uplift pressure created by groundwater head, psf
T_{pc} = Thickness of protective cover as ballast, ft
γ_{pc} = Unit weight of protective cover, pcf
E_{pc} = Elevation of top of protective cover, ft-msl
R_{pc} = Counteracting ballast pressure from protective cover, psf
FS_{pc} = Calculated factor of safety with protective cover installed
γ_W = Unit weight of waste, pcf
$E_{top\ waste}$ = Elevation of Top of Waste, ft-msl
T_W = Waste Column Thickness, ft
R_W = Counteracting ballast pressure from waste, psf
$R_{pc,w}$ = Counteracting ballast pressure from protective cover and waste, psf
$FS_{pc,w}$ = Calculated factor of safety with protective cover and waste installed

Example calculation using BEP-1:

Parameters:

E_{H2O} =	680.0	ft-msl	γ_W =	45	pcf
E_{liner} =	670.0	ft-msl	$E_{top\ waste}$ =	725.0	ft-msl
E_{pc}=	672.0	ft-msl	T_W=	51.0	ft
γ_{H2O} =	62.4	pcf			
T_{pc} =	2.0	ft			
γ_{pc} =	120	pcf			

Calculate the maximum groundwater head above the top of liner (geomembrane).

$H = E_{H2O} - E_{liner}$
$H = 10.0$ ft

Calculate the maximum hydrostatic uplift pressure created by the groundwater head.

$P_{H2O} = (\gamma_{H2O} \times H)$
$P_{H2O} = 624.0$ psf

Calculate the counteracting ballast pressure from the protective cover.

$R_{pc} = (\gamma_{pc} \times T_{pc})$
$R_{pc} = 240$ psf

Compare the uplift pressure to the ballast pressure by calculating the factor of safety with protective cover as ballast.

$FS_{pc} = R_{pc}/P_{H2O} = 0.4$

The minimum required factor of safety for protective cover as ballast is 1.2. Since the factor of safety against uplift is less than 1.2, additional ballast (in the form of waste) will be necessary to offset the hydrostatic uplift pressure acting at the top of liner. If the factor of safety were 1.2 or greater, then no additional ballast would be necessary, indicating that the protective cover provides enough ballast to counteract the hydrostatic uplift pressure acting at the top of liner. When solid waste is necessary as ballast, a factor of safety of 1.5 is used for protective cover and solid waste.

Determine amount of additional ballast in the form of waste necessary to offset the hydrostatic uplift pressure acting at the top of liner. Use a factor of safety of 1.5 protective cover and solid waste.

Calculate the counteracting ballast pressure from the waste.

$R_W = (\gamma_w \times T_w)$
$R_W = 2{,}295$ psf

Calculate the counteracting ballast pressure from the protective cover and waste.

$R_{pc,w} = (R_{pc} + R_w)$
$R_{pc,W} = 2{,}535$ psf

Compare the uplift pressure to the ballast pressure by calculating the factor of safety with protective cover and waste as ballast.

$FS_{pc,w} = R_{pc,w}/P_{H2O} = 4.1$

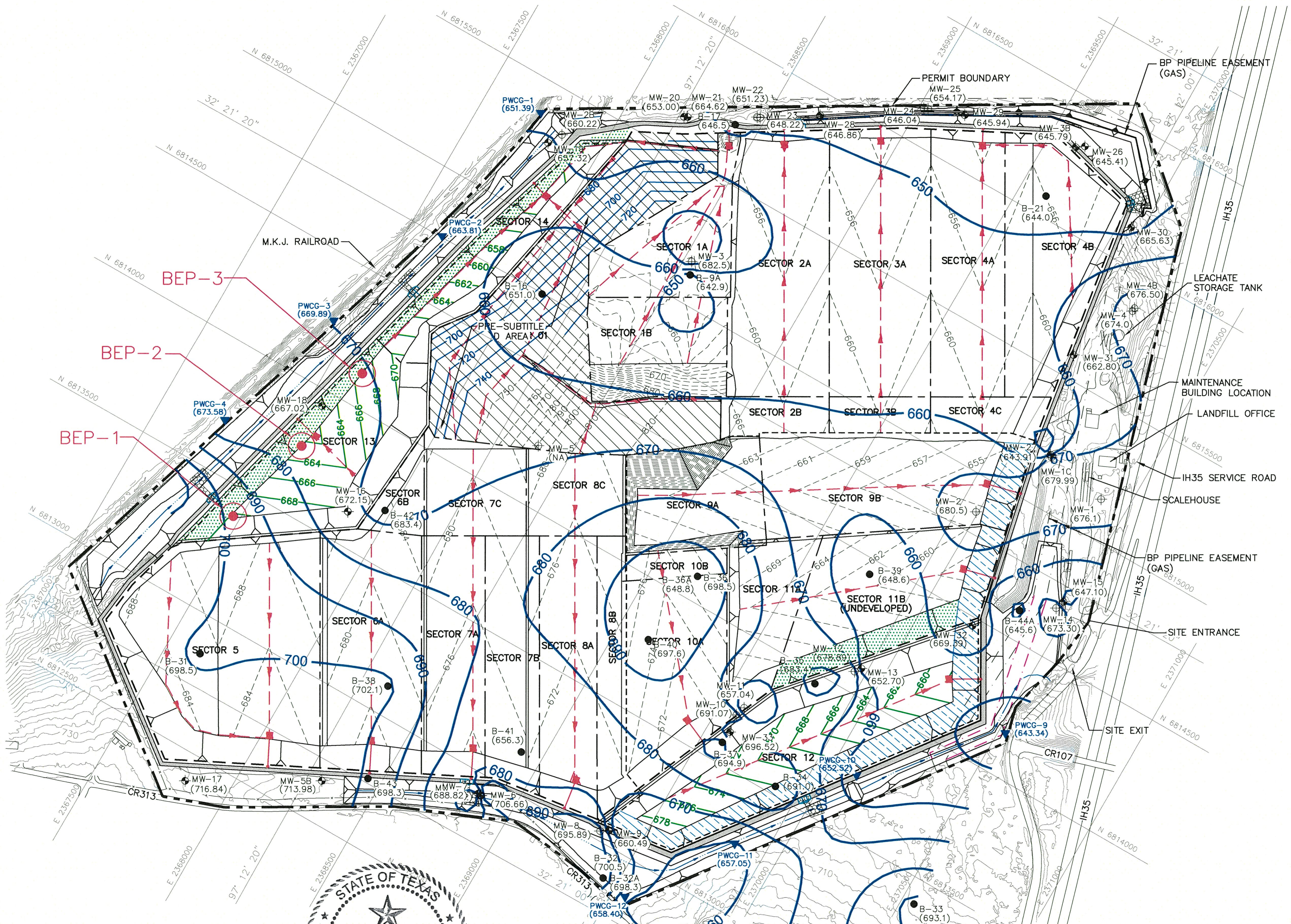
The factor of safety against uplift for BEP-1 in Sector 13 is greater than 1.5 after placement of waste to elevation 725 ft-msl . Therefore, there will be sufficient ballast in the form of soil (protective cover) and solid waste from the landfill filling to prevent uplift of the liner system in Sector 13 due to hydrostatic head. A Ballast Evaluation Report (BER) will be required to be completed and submitted to the TCEQ for approval prior to decommissioning the underdrain system in Sector 13.

TURKEY CREEK LANDFILL
0771-368-11-123
SECTOR 13 CONSTRUCTION
SUMMARY OF BALLAST CALCULATIONS EXAMPLE

Unit Weight of Water =	62.4	pcf
Unit Weight of Protective Cover =	120	pcf
Unit Weight of Waste =	45	pcf
Thickness of Protective Cover - Normal =	2.0	ft

Evaluation Point (Sector 13)	Highest Measured Groundwater Elevation[1], E_{H20} (ft-msl)	Elevation of Top of Clay Liner, E_{liner} (ft-msl)	Maximum Groundwater Head Above Top of Liner H (ft)	Maximum Uplift Pressure Created by Groundwater Head, P_{H20} (psf)	Elevation of Top of Protective Cover, E_{pc} (ft-msl)	Counteracting Ballast Pressure from Protective Cover, R_{pc} (psf)	Calculated Factor of Safety with Protective Cover Installed, FS_{pc}	Factor of Safety > 1.2?	Elevation of Top of Waste, $E_{top\ waste}$ (ft-msl)	Waste Column Thickness, T_w (ft)	Counteracting Ballast Pressure from Waste, R_w (psf)	Counteracting Ballast Pressure from Protective Cover and Waste, $R_{pc,w}$ (psf)	Calculated Factor of Safety with Protective Cover and waste Installed, $FS_{pc,w}$	Factor of Safety>1.5?
BEP-1	698.00	672.0	26.0	1,622.4	674.0	240.0	0.1	NO	725	51.0	2,295.0	2,535.0	1.6	YES
BEP-2	678.00	665.0	13.0	811.2	667.0	240.0	0.3	NO	725	58.0	2,610.0	2,850.0	3.5	YES
BEP-3	672.00	669.0	3.0	187.2	671.0	240.0	1.3	YES	725	54.0	2,430.0	2,670.0	14.3	YES

[1] Highest measured Groundwater Contours were reproduced using historical groundwater measurements from 2021



LEGEND

	PERMIT BOUNDARY
	PROPOSED LIMITS OF WASTE
	PERMITTED LIMITS OF WASTE
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
	EASEMENT
	RELOCATED EASEMENT (SEE NOTE 5)
	SECTOR BOUNDARY
800	OVERLINER CONTOUR
670	PERMITTED/EXISTING TOP OF LINER CONTOUR
662	PERMITTED/UNDEVELOPED EXCAVATION CONTOUR
	PERMITTED/UNDEVELOPED LEACHATE LINE
	LEACHATE COLLECTION SUMP
	PRE SUBTITLE D AREA
MW-7 (688.82)	EXISTING GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
MW-1 (676.1)	FORMER GROUNDWATER MONITORING WELL WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
B-44A (645.6)	FORMER GROUNDWATER PIEZOMETER WITH HIGHEST MEASURED GROUNDWATER ELEVATION POSTED IN FT-MSL
PWCG-1 (651.37)	2021 EXPANSION PIEZOMETER WITH GROUNDWATER ELEVATION POSTED IN FT-MSL
670	HIGHEST MEASURED GROUNDWATER ELEVATION CONTOUR IN FT-MSL (SEE NOTE 4)
	SIDESLOPE UNDERDRAIN ONLY
	SIDESLOPE UNDERDRAIN AND 5-FT CLAY SEPARATION LAYER (CLASS 1 ONLY)

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. MONITORING WELL AND PIEZOMETER LOCATION COORDINATES OBTAINED FROM PREVIOUS SUBSURFACE EXPLORATION BORING LOGS, INVESTIGATION REPORTS, INSTALLATION REPORTS, AND AS-BUILT SURVEY REPORTS.
3. GROUNDWATER ELEVATION DATA OBTAINED FROM THE FACILITY'S SUBTITLE D GROUNDWATER MONITORING DATABASE PROVIDED BY THE CAREL CORPORATION IN OCTOBER 2021 FROM PREVIOUS SUBSURFACE EXPLORATION AND INVESTIGATION REPORTS, AND FROM GAUGING CONDUCTED BY WCG IN 2021.
4. GROUNDWATER CONTOURS WERE PRODUCED USING EACH WELLS HIGHEST MEASURED GROUNDWATER ELEVATION AND DO NOT REPRESENT A SINGLE GROUNDWATER MONITORING EVENT OR ACTUAL GROUNDWATER FLOW.

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
02-22-2022

☐ DRAFT
☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: IIID-B-1-BALLAST POINTS.DWG

DRAWN BY: SRF
DESIGN BY: AKE
REVIEWED BY: NT

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
BALLAST EVALUATION POINTS
EXAMPLE CALCULATIONS

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE IIID-B-1

0:\0771\368\EXPANSION 2021\PART III\IIID-B-1-BER POINTS.dwg, rarrington, 1:2

APPENDIX IIID-C

TEMPORARY DEWATERING SYSTEM DESIGN

(PREVIOUS PERMIT ATTACHMENT 10 – APPENDICES 10C, 10D, AND 10E)

Includes pages IIID-C-1 through IIID-C-44

STATE OF TEXAS
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ATTACHMENT 10

APPENDIX 10C

SOUTH TEMPORARY DEWATERING SYSTEM DESIGN

Includes pages 10C-1 through 10C-32

STATE OF TEXAS
DAVID R. FRIELS
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12-29-99

INTRODUCTION

The following South Temporary Dewatering System Design provides demonstration of the adequacy of the dewatering trenches proposed to be installed in the sidewalls of Sectors 11, 12, 13 and 14. The following is noted in support of the calculations presented in the following calculations:

- The calculations presented in this appendix are applicable to the remaining sidewall drains to be installed in the remaining Sectors 11, 12, 13 and 14.
- Attachment No. (Figure) 10C1 has been replaced by Figure IIID-2 included in Appendix IIID.
- A site plan presenting the location of the sidewall temporary dewatering trenches is presented as Figure IIID-3 included Appendix IIID.

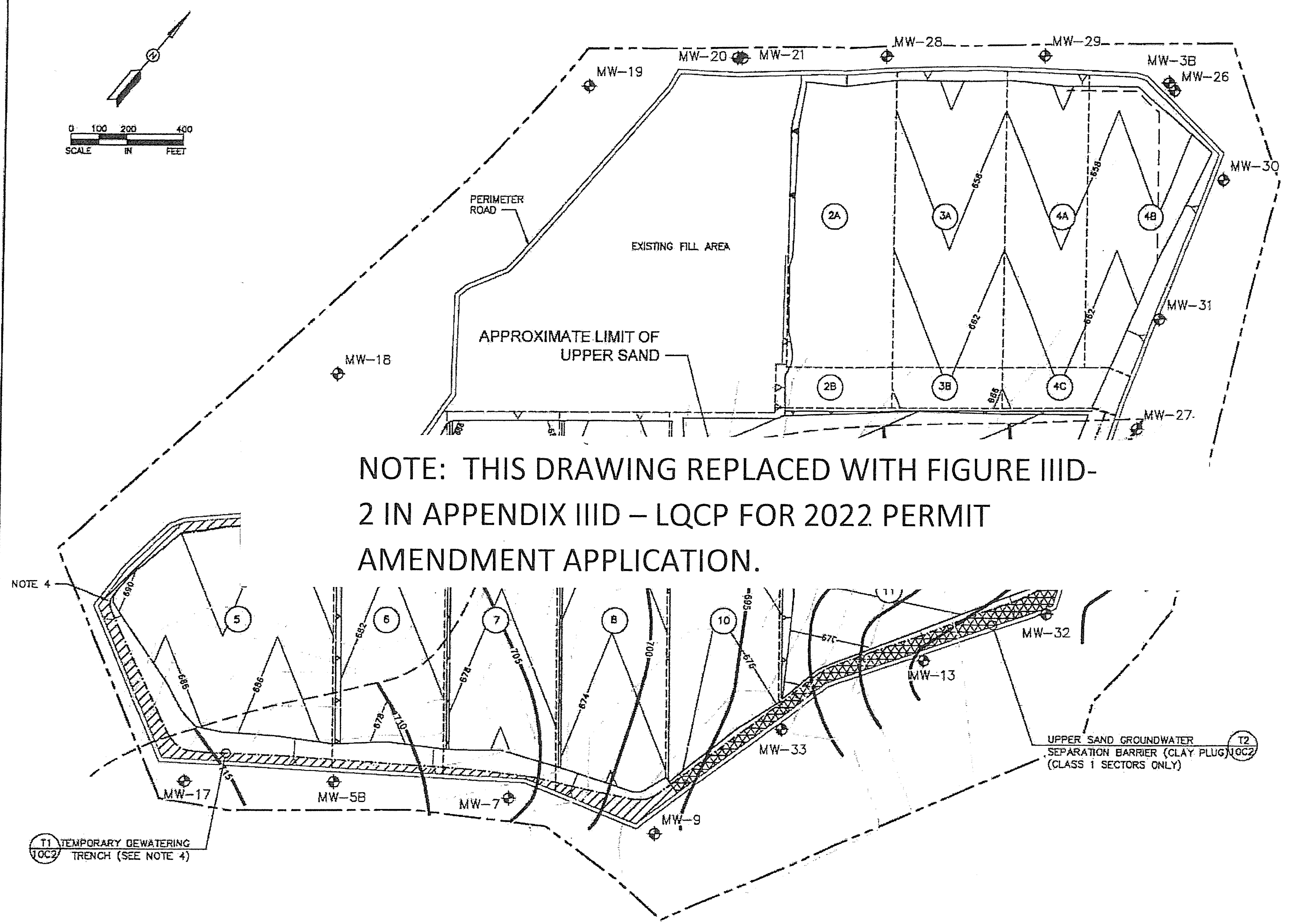
SOUTH TEMPORARY DEWATERING TRENCH DESIGN

There is one continuous excavation proposed for the landfill. The excavation will be approximately 10 to 40 feet below the existing ground surface and founded in the low-permeable shale material which is located beneath the upper sand. By founding the excavation within the shale layer, only portions of the sideslope area will expose the upper sand. Consistent with the site characterization, there is a potential for seepage or excessive hydrostatic pressure only where the upper sand is exposed. Therefore, dewatering during construction, and ballasting for hydrostatic pressure will only be required for the perimeter sidewalls above the contact of the upper sand and the shale. The approximate areas were the excavation will expose the upper sand are shown on Figure 10C1.

Typical details for the temporary dewatering trench system are provided on Figure 10C2, and design calculations for the system are included in this appendix. The dewatering trench will be constructed at the contact of the upper sand and underlying shale, with a minimum depth of 3 feet and minimum width of 6-inches. The temporary trench will be lined with a geotextile and contain a 4-inch diameter perforated pipe, enveloped with gravel. To maintain the drawdown condition produced by the open excavation, a geocomposite drainage layer will extend up the slope to above the seasonal high water table and terminate a minimum of 1 foot into the trench. The geocomposite will be anchored on the upslope side a minimum of two feet into the side slope. The dewatering trenches shall be constructed at the face of the slope with 1 foot above the bottom of the upper sand and a minimum of 2 feet of penetration into the shale. The dewatering trench design is presented on pages 10C-3 through 10C-20.

The temporary dewatering trench will be graded to drain to the nearest open excavation, where it will be pumped out of the cell area. A temporary sump consisting of drainage stone enveloped in geotextile will be used where necessary to provide positive drainage. Groundwater will be removed from the sump using an 18-inch diameter HDPE riser pipe and submersible pump.

Liner areas that extend below the seasonal high water table, for the upper sand, will be designed and constructed to provide long-term protection against uplift from hydrostatic forces by the use of ballast in accordance with 30 TAC §330.203. Ballast, if required, will be designed, installed, and verified as described in Section 6 (and Appendix 10B) of the SLQCP. Once the BER is approved by TNRCC, the underdrain pipe will be decommissioned.



NOTE: THIS DRAWING REPLACED WITH FIGURE IIID-2 IN APPENDIX IIID – LQCP FOR 2022 PERMIT AMENDMENT APPLICATION.

LEGEND

- PERMIT BOUNDARY
- BOTTOM OF UPPER SAND CONTOURS (FEET M.S.L.)
- 700 — TOP OF UPPER SAND (ALLUVIUM FORMATION) SEASONAL HIGH POTENTIOMETRIC SURFACE CONTOURS (GROUNDWATER WATER LEVEL)
- TEMPORARY GROUNDWATER DEWATERING TRENCH FOR UPPER SAND UNIT (SEE NOTE 3)
- 656 — TOP OF LINER CONTOURS
- MW-18 GROUNDWATER MONITOR WELL
- APPROXIMATE AREA WHERE UPPER SAND WILL BE EXPOSED DURING LINER CONSTRUCTION
- APPROXIMATE AREA WHERE UPPER SAND GROUNDWATER SEPARATION BARRIER (CLAY PLUG) REQUIRED
- 4A SECTOR DESIGNATION

NOTES:

1. BOTTOM OF UPPER SAND CONTOURS WERE OBTAINED USING POINT ELEVATIONS OF THE BOTTOM OF THE UPPER SAND AS INDICATED ON THE LOGS OF BORINGS.
2. TOP OF POTENTIOMETRIC SURFACE CONTOURS FOR THE UPPER SAND WERE PREPARED BASED ON HISTORICAL GROUNDWATER DATA USING THE HIGHEST MEASURED WATER LEVEL ELEVATIONS FROM 1995 THROUGH EARLY 2011 PROVIDED BY IESI TX LANDFILL, LP.
3. BOTTOM OF GROUNDWATER DEWATERING TRENCH WILL BE A MINIMUM OF TWO FEET BELOW THE BOTTOM OF THE UPPER SAND LAYER.
4. TEMPORARY UNDERDRAIN SUMPS WILL BE CONSTRUCTED AS NECESSARY TO PROVIDE POSITIVE DRAINAGE FOR UNDERDRAIN SYSTEM. DESIGN OF TEMPORARY SUMPS WILL BE DOCUMENTED IN SLER FOR EACH CELL.

6/4/2012

STATE OF TEXAS
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86557
LICENSED PROFESSIONAL ENGINEER

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REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
1	05-12	SECTOR 9-11 LAYOUT	JJV	SMG	SMG	SMG

DATE OF ISSUE 9-?? DWN BY SRC DES BY JJV CHK BY ORF APP BY SPY

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IESI TX LANDFILL, LP

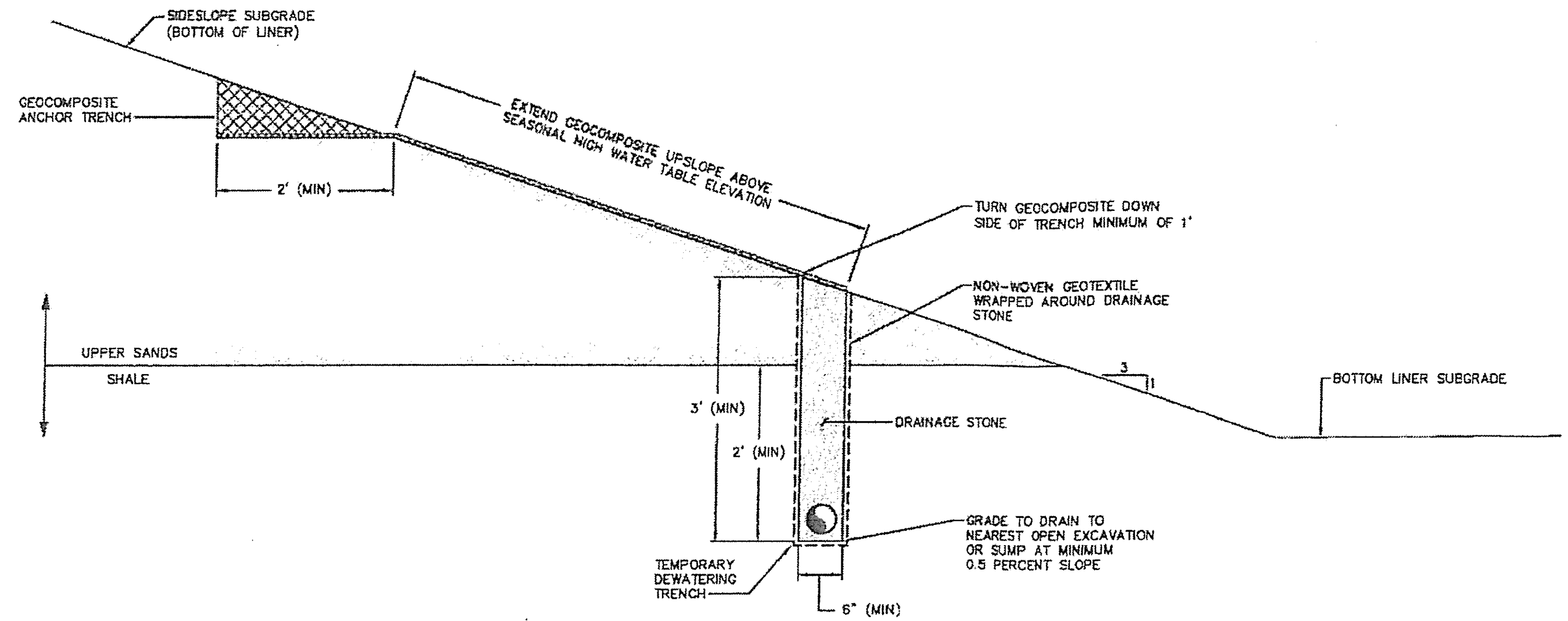
SOUTH AREA UNDERDRAIN PLAN AND UPPER SAND SEPARATION BARRIER (CLAY PLUG) LOCATION
TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

ATTACHMENT NO. 10C1

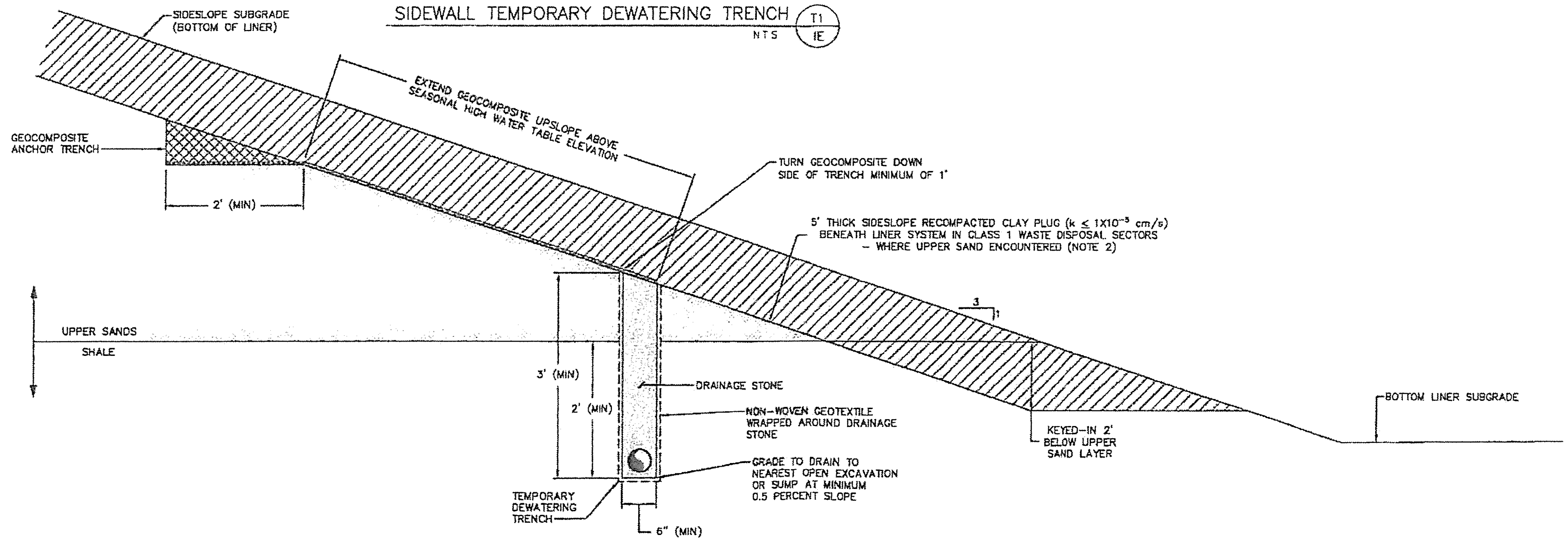
P:\CADD\Projects\T\Turkey Creek LF\Permit\MOD Solid Facility & Class 1 (TXL0201)\Dwgs-Rev0\10C1-Underdrain Plan.dwg

NOTES:

1. DETAIL T2 SHALL APPLY INSTEAD OF T1 TO SECTORS DESIGNATED FOR CLASS 1 WASTE DISPOSAL.
2. THE PURPOSE OF THE CLAY PLUG IN CLASS 1 SECTORS IS TO PROVIDE THE SEPARATION BARRIER FROM THE UPPER SAND FORMATION REQUIRED UNDER 30 TAC335.584(b)(1).
3. RECOMPACTED CLAY PLUG SHALL HAVE $k \leq 1X10^{-5}$ cm/s AND SHALL BE CONSTRUCTED IN A CONSISTENT MANNER WITH SOIL LINER AS SET FORTH IN THE SLQCP.



SIDEWALL TEMPORARY DEWATERING TRENCH (T1 / IE)
NTS



UPPER SAND SEPARATION BARRIER (CLAY PLUG) (T2 / IE)
(CLASS 1 SECTORS ONLY)
NTS

6/14/2012

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P:\CADD\Projects\T\Turkey Creek LF\Permit\MOD Solid Facility & Class 1 (TXL0201)\Dwgs-Rev0\10C2-DEWATER DETAILS.dwg

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY
1	05-12	ADD CLAY PLUG DETAIL	JAV	SMG	SMG	SMG

DATE OF ISSUE 9-99 DWN BY GLW DES BY JAV CHK BY DRF APP BY JPY

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IESI TX LANDFILL, LP

TEMPORARY DEWATERING TRENCH DETAILS AND UPPER SAND SEPARATION BARRIER (CLAY PLUG)
TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

ATTACHMENT NO
10C2

The design calculations for the underdrain trench system are attached behind the referenced figures. The following material performance specifications will be included in the project specifications.

Geocomposite Draining Layer

The geocomposite will consist of an HDPE geonet with a non-woven geotextile heat bonded to both sides of the geonet. The geocomposite will meet the requirements of Poly-Flex Drainage Geocomposite as given in the design on page 10C-21.

Collection Pipe

The underdrain collection pipe shall consist of 4-inch-diameter SDR 17 HDPE perforated pipe or engineer approved equivalent.

Geotextile Around Drainage Stone

The geotextile around the drainage stone will meet the minimum requirements given in the design on page 10C-26.

Prep By: JAV
Date: 12/29/99

TURKEY CREEK LANDFILL
65500-011.104
PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

Chkd By: [signature]
Date: 12-29-99

Required:

1. Estimate the flow into the temporary dewatering trench.
2. Determine the size of the temporary dewatering trench pipe.
3. Determine the stability of the temporary dewatering trench pipe.
4. Determine the properties of the drainage geocomposite.
5. Determine the geotextile properties around the granular drainage material.

References:

1. NAVFAC P-418/AFM 88-5

Procedure:

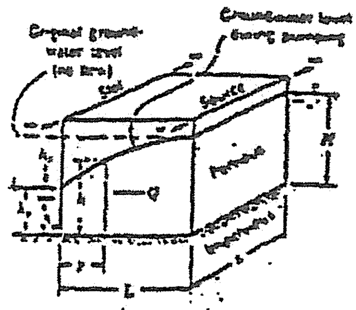
1. Determine the soil profile through which the temporary dewatering trench will be cut and estimate the in-situ hydraulic conductivity of the soil strata in the profile.
2. Use NAVFAC P-418 procedure to estimate the flow to the trench.
3. Design the temporary dewatering trench pipe.
4. Verify pipe structural stability.
5. Design drainage geocomposite.
6. Design filter geotextile.

Prep By: JAV
Date: 12/29/99

TURKEY CREEK LANDFILL
65500-011.104
PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

Chkd By: [signature]
Date: 12-29-99

Solution: 1. Flow into temporary dewatering trench



$$Q = \frac{kx}{2L}(H^2 - h_o^2)$$

K = Hydraulic Conductivity (cm/sec)
(Based on soil tests and field observations of site conditions).

L = Length of drawdown

H = height from bottom of trench to highest groundwater level, within the upper sands.
(Assuming a trench depth to elevation 690ft msl and groundwater at 715ft msl).

3:1 Slope

K =	1.00E-04	cm/sec
	3.28E-06	ft/sec
X =	1	
H =	25	
h_o =	0.5	
L =	50	

Q = 2.05E-05 ft3/s/ft

Q = 9.20E-03 gpm/ft

The pump rate required will be estimated by assuming approximately 50 percent of the entire trench length is in operation.

L_{max} = 2750 ft

Q = 9.20E-03 gpm/ft x 2750 ft

Q = 25.30 gpm

REQUIRED: Size the temporary dewatering trench pipe.

METHOD:

A. Use the flow rate determined for the temporary dewatering trench (see page 10C-4) to size the pipe.

B. Determine required hole size (perforations) based on characteristics of the surrounding drainage media.

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

SOLUTION: Use the peak flow rate to determine the size of the pipe.

Determine the design flow rate:

The maximum flow rate through the pipe will be the peak flow rate determined on Page 10C-4.

Peak Flow Rate (Q_{max}) 25.3 gpm or 5.64E-02 cfs

Determination of flow capacity (Q_{full}) for a 4 inch perforated pipe:

$$Q_{full} = \frac{1.486}{n} AR^{2/3}S^{1/2}$$

Where: A = Cross-sectional area of pipe, with d representing the inside diameter in feet
R = Hydraulic radius of pipe in feet under full flow conditions

From Pipe Structural Stability Calculations:

Standard dimension ratio (SDR) = 17.0

ID = 3.845 in
= 0.320 ft

TURKEY CREEK LANDFILL
65500-011.104
PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN
PIPE CAPACITY

$$A = \frac{\Pi \times d^2}{4}$$ A = 0.081 sq ft

$$R = \frac{d}{4}$$ R = 0.080 ft

S = Design slope of pipe S = 0.005 ft / ft

n = Manning's number n = 0.015

Q_{full} =	0.105	cfs

Compare Q_{max} and Q_{full}:

Q_{full} =	0.105	cfs	>>	Q_{max} =	0.0564	cfs

Conclusion:

An SDR 17.0 pipe with an outer diameter of 4 inches exceeds flow capacity requirements. Because the minimum recommended size of pipe for use is 4 inches, a perforated SDR 17.0 HDPE pipe will be used in the temporary dewatering trenches.

B. Perforation configuration

Pipe perforations must allow free passage of groundwater and also prevent migration of drainage media into the pipe. Therefore, size of perforations depends on media particle size.

For temporary underdrain pipes with slotted perforations:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} > 2.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D number 8 aggregate

D_{85} = 8.5 mm
= 0.335 in

Standard slot width: d = 0.125 in

TURKEY CREEK LANDFILL
65500-011.104
PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN
PIPE CAPACITY

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Slot Width}} = 2.7 \quad > 2.0 \quad \text{(acceptable)}$$

For temporary dewatering trench pipes with circular holes:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} > 1.0$$

Where: D_{85} = Particle size for which 85% of all particles are smaller than

Assume: Drainage media is an ASTM D number 57 aggregate

D_{85} = 18 mm
= 0.709 in

Standard hole diameter d = 0.5 in

Check values to find that:

$$\frac{D_{85} \text{ of Filter}}{\text{Hole Diameter}} = 1.4 \quad > 1.0 \quad \text{(acceptable)}$$

In Addition:

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation.

Prep By: JAV
Date: 12/29/99

TURKEY CREEK LANDFILL
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PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

Chkd By: DH
Date: 12-29-99

REQUIRED: Analyze structural stability of the temporary dewatering trench pipe.

A. 4-inch-diameter HDPE perforated temporary dewatering trench pipe.

METHOD A. Determine the critical load under the following two conditions:

1. Construction loading
2. Overburden loading

B. Use the critical loading pressure to analyze pipe stability under the following three possible failure conditions:

1. Wall crushing
2. Wall buckling
3. Ring deflection

REFERENCES:

1. Bass, J., *Avoiding Failure of Leachate Collection and Cap Drainage Systems*, Pollution Technology Review No. 138, Noyles Data Corporation, 1986.

2. Texas Natural Resource Conservation Commission, *Leachate Collection System Handbook*, 30 TAC 330.201, 1993.

3. Phillips 66 Driscopipe, *System Design*, 1991.

4. Landfill Design Series, *Leachate Gas Management Systems Design, Volume 5, Leachate Management and Storage*, Appendix A, 1993.

5. Caterpillar Tractor Company, *Caterpillar Performance Handbook*, Edition 27, October 1996.

SOLUTION:

A. Critical Load on the 4-inch-diameter HDPE perforated temporary dewatering trench pipe

1. Maximum construction loading

Assume: CAT 637E Series II scraper with an even load distribution

Loaded weight = 190,500 lb
Tire pressure = 80 psi
Number of tires = 4

For a circular tire imprint:

$$F = \frac{\text{Loaded Weight}}{\text{Number of Tires}}$$

Where: F = Force exerted by one tire (lb)

F =	47,625	lb

Determine area of contact for circular tire imprint:

$$r = (F/\pi p)^{1/2}$$

Where:
r = Radius of contact (in)
F = Force exerted by one tire (lb)
p = Tire pressure (psi)

r =	13.8	in

Use Boussinesq's solution to find the stress at a point below a uniformly loaded circular area:

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

Where:
y = Change in vertical stress (psi)
p = Tire pressure (psi)
r = Radius of contact (in)
z = Trench depth to top of pipe (in)

z = 30 in

y =	19.9	psi

TURKEY CREEK LANDFILL
65500-011.104
PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

Assume only one wheel load on pipe and add 50% for impact loading:

$P_L = 1.5y$

Where: P_L = Maximum live load (psi)

P_L =	29.9	psi

$P_D = (zw)/1728$

Where: P_D = Maximum dead load (psi)
z = Protective cover thickness (in)
w = Unit weight of protective cover (pcf)

z = 30 in
w = 120 pcf

P_D =	2.08	psi

$P_T = P_L + P_D$

Where: P_T = Maximum construction load (psi)

P_T =	32.0	psi

2. Overburden loading (postclosure load)

For maximum fill load on pipe:

7.0	ft gravel & cover @	125	pcf =	875	psf
4.5	ft final & intrm cover @	125	pcf =	562.5	psf
50.5	ft solid waste & daily cover @	75	pcf =	3,788	psf
			Σ =	5,225	psf

P_T =	36.3	psi

Determine critical loading condition:

Construction loading:	P_T =	32.0	psi
Overburden loading:	P_T =	36.3	psi

Overburden loading is most critical to the structural stability of the pipe and will be used to determine the design pipe stress.

B. Determine the Design Stress

Adjust critical stress to account for loss of strength in the pipe due to perforations:

$$P_{DES1} = 12P_T / (12 - l_p)$$

Where:

l_p	= Cumulative length of perforations per foot of pipe
P_T	= Critical pipe stress (psi)
P_{DES1}	= Pipe stress adjusted for loss of strength (psi)

6	holes / foot
0.5	in / hole

l_p =	3.0	in/ft

From determination of critical loading:

P_T =	36.3	psi
P_{DES1} =	48.4	psi

Adjust pipe stress determined above to account for effects of soil arching:

The design pipe stress is estimated by accounting for the soil structure interaction between the buried uderdrain pipe and its backfill to obtain a realistic loading condition on the pipe.

3a. The pipe is assumed to be a positive projecting conduit.

3b. Because the pipe is flexible and will deflect in the vertical plane the pipe will experience a reduction in loading due to soil arching. Soil arching is present when the soil column over the pipe settles and creates shear stresses in the surrounding soil. Those shear stresses will support the soil column, thereby reducing the load experienced by the pipe (see Figure 3, page 10C-18).

3c. The load on the pipe will be estimated using Marston's Formula:

$$W_c = \gamma C_c B_c^2 \tag{1}$$

$$C_c = \frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} + \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right)e^{\pm 2k\mu(H_e/B_c)} \tag{2}$$

Where:

W_c	= Load per unit length of conduit (lb/ft)
γ	= Unit weight of soil above conduit (pcf)
B_c	= Outer diameter of conduit (ft)
H	= Height of fill above conduit (ft)
H_e	= Height of plane of equal settlement above critical plane (ft)
k	= Lateral pressure ratio (earth pressure coefficient)
μ	= tan ϕ
ϕ	= Angle of internal friction of pipe-zone backfill (PZB) (degrees)

$$H_e = \pm r_{sd}\, p\left(\frac{H}{B_c}\right) \tag{3}$$

Where:

r_{sd}	= Settlement ratio
p	= Ratio of the conduit projection above the compacted soil liner to its diameter

$$r_{sd} = \frac{(S_m + S_g) - (S_f + dc)}{S_m} \tag{4}$$

Where:

S_m	= Compression deformation of soil column adjacent to conduit
S_g	= Settlement of natural ground adjacent to conduit
S_f	= Settlement of conduit into foundation material
dc	= Vertical deflection of the conduit

It is assumed that for a leachate collection pipe S_g and S_f are equivalent. The equation settlement ratio, therefore, reduces to the following:

$$r_{sd} = \frac{S_m - dc}{S_m} \tag{5}$$

Since the PZB is much stiffer than the pipe, dc is larger than S_m implying that r_{sd} will be negative. Because r_{sd} is negative, the pipe is categorized as an incomplete ditch as specified by Marston. Note that in the above equations, where a + and a - sign are used together, the upper sign corresponds to a positive r_{sd} and a the lower sign to a negative r_{sd}.

3d. Load analysis solution by trial and error

Step 1: Assume a value for the settlement ratio, r_{sd}.

r_{sd} = -0.24

Step 2: Calculate S_m based on the estimated vertical stress at the level of the pipe and the deformation modulus E of the PZB.

$$S_m = P_{DES1}\, D / E_s$$

Where:
- P_{DES1} = Pipe stress adjusted for loss of strength (psi)
- D = Pipe diameter (in)
- E_s = PZB soil modulus (psi)

P_{DES1} =	48.4	psi
D =	4	in
E_s =	3,000	psi

S_m =	0.065	in

Step 3: Calculate dc using Equation (5):

$$dc = S_m\,(1 - r_{sd})$$

dc =	0.080	in

Step 4: Use the Iowa Formula (provided below) to calculate W_c.

$$W_c = \frac{dc}{(DL)k}\left(\frac{EI}{r^3} + 0.061E'\right)$$

Where:
- DL = Deflection lag factor
- k = Bedding factor
- E = Young's modulus for pipe material (psi)
- I = Moment of inertia for pipe wall = $t^3/12$ (in^4/in)
- r = Pipe radius (in)
- E' = Modulus of soil reaction (psi)

TURKEY CREEK LANDFILL
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PERMIT MODIFICATION
TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

DL =	1.5	
k =	0.1	
E =	17,800	psi
t =	0.390	in (SDR 17.0 pipe)
I =	0.005	in^4/in
r =	2.0	in
E' =	3,000	psi

W_c =	103	lb/in

Step 5: Calculate C_c using Equation 1:

$$C_c = \frac{W_c}{\gamma B_c^{\ 2}}$$

Composite unit weight for waste and soil:

50.5	ft waste & cover @	75	pcf =	3,788	psf
11.5	ft soil @	125	pcf =	1,438	psf
			Total =	5,225	psf

γ =	81	pcf (weighted average based on above table)
B_c =	4	in

C_c =	137.9	(unitless)

Step 6: Solve for H_e/B_c using Equation 2 in an iterative manner:

H =	62	ft
H/B_c =	186.0	

Assume: H_e/B_c = 1.24

kμ =	0.13	(Ref 4)
$e^{-2k\mu(He/Bc)}-1$ =	-0.28	
-2kμ =	-0.26	
$(H/B_c - H_e/B_c)$	184.8	
$e^{-2k\mu(He/Bc)}$ =	0.72	

Left-hand-side of equation (LHS) = 138
Right-hand-side of equation (RHS) = 135

Step 7: Substitute H_e/B_c into equation given below to determine if proper value for r_{sd} was used.

$$\left[\frac{1}{2k\mu} \pm \left(\frac{H}{B_c} - \frac{H_e}{B_c}\right) \pm \frac{r_{sd}p}{3}\right]\frac{e^{\pm 2k\mu(H_e/B_c)} - 1}{\pm 2k\mu} \pm \frac{1}{2}\left(\frac{H_e}{B_c}\right)^2$$

$$\pm \frac{r_{sd}p}{3}\left(\frac{H}{B_c} - \frac{H_e}{B_c}\right)e^{\pm 2k\mu(H_e/B_c)} - \frac{1}{2k\mu}\left(\frac{H_e}{B_c}\right) \mp \left(\frac{H}{B_c}\right)\left(\frac{H_e}{B_c}\right) = \pm r_{sd}p\left(\frac{H}{B_c}\right)$$

Because r_{sd} is negative for the incomplete ditch condition, the lower signs in the above equation are used.

p =	1
kμ =	0.13
H/B_c =	186.0
H_e/B_c =	1.24
r_{sd} =	-0.24
LHS =	44
RHS =	45

If LHS is not approximately equal to RHS, adjust value for r_{sd} in Step 1 and repeat solution procedure.

5. Once the solutions to the above equations are determined, the design pipe stress may be calculated and the deflection of the pipe determined.

$P_{DES2} = W_c / D$

Where: P_{DES2} = Load on pipe adjusted to account for effects of soil arching (psi)

W_c =	103	lb/in
D =	4.000	in

P_{DES2} =	26	psi

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TEMPORARY DEWATERING TRENCH SYSTEM DESIGN

C. Check Structural Stability of SDR 17 pipe

SDR	= Standard dimension ratio	=	17.0	
S_Y	= compressive yield strength	=	1,500	psi
RD_{all}	= allowable ring deflection	=	4.2	%

1. Wall crushing (Ref 3)

$S_A = P_{DES2}(SDR - 1)/2$ FS $= S_Y / S_A$

Where:
- S_A = Actual compressive stress (psi)
- SDR = Standard dimension ratio
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- S_Y = Compressive yield strength (psi)
- FS = Factor of safety against wall crushing

P_{DES2} = 26 psi

S_A =	206.9	psi
FS =	7.2	

Compare calculated and suggested factor of safety:	7.2	> 1.0

2. Wall buckling (Ref 3)

$P_{cb} = 0.8\,(E'\,(2.32E / SDR^3))^{1/2}$ FS $= P_{cb} / P_{DES2}$

Where:
- P_{cb} = Critical buckling pressure at top of pipe (psi)
- E' = Soil modulus (psi)
- E = Stress/time dependent tensile modulus for design loading conditions (psi)
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- FS = Factor of safety against wall buckling

E' = 3,000 psi (see chart page 10C-19)
E = 17,800 psi for 50 years @ 560 psi (see chart page 10C-20)
P_{DES2} = 26 psi

P_{cb} =	127.0	psi
FS =	4.9	

Compare calculated and suggested factor of safety:	4.9	> 1.0

3. Ring deflection (Ref 3)

$$E_S = P_{DES2} / E'$$

Where:
- E_S = Soil strain (%)
- P_{DES2} = Load pipe adjusted to account for effects of soil arching (psi)
- E' = Soil modulus (psi)

P_{DES2} =	26	psi
E' =	3,000	psi

E_S =	0.9	%

Ring deflection for buried HDPE pipe is conservatively the same (no more than) the vertical compression of the soil envelope around the pipe. Therefore, assumed actual ring deflection (RD_{act}) is equal to soil strain.

RD_{act} = 0.9 %

Allowable ring deflection, RD_{all} = 4.20 %

$RD_{act} < RD_{all}$, design is acceptable

Note: An additional factor of safety is inherent to the design of the temporary dewatering trench pipe system to the presence of a gravel envelope surrounding the temporary dewatering trench pipe. The gravel layer will transmit leachate in the event that the temporary dewatering trench pipe becomes plugged or crushed.

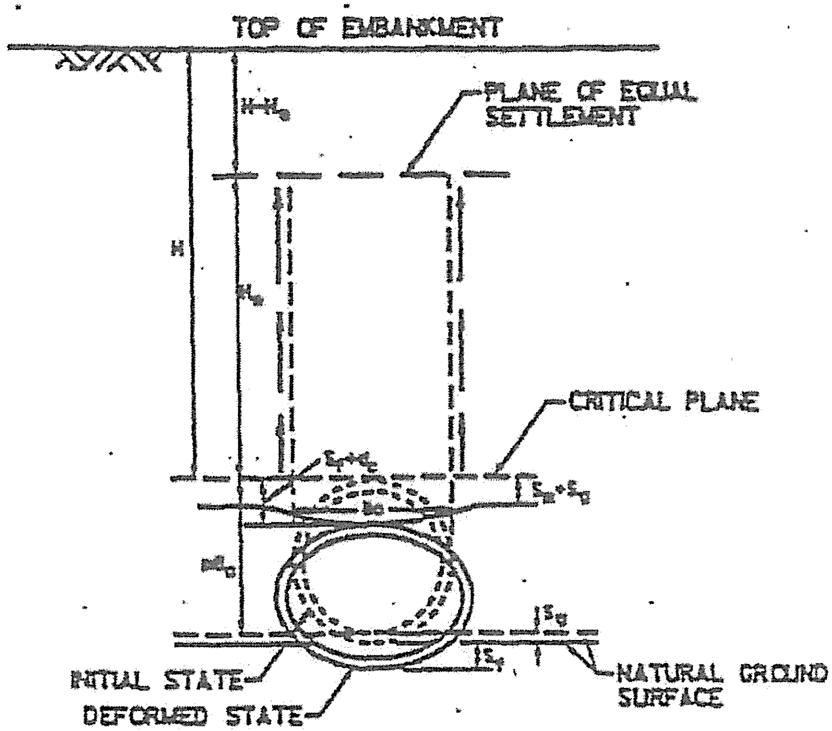


FIGURE 3: CASE OF AN INCOMPLETE DITCH CONDITION FOR A POSITIVE PROJECTING CONDUIT

DRISCOPIPE

Simplified Burial Design: A conservative estimate of the ability of Driscopipe pipelines to perform in a buried environment is found in Chart 24. It is based on a minimum 2:1 safety factor and 50 year design service life. A detailed burial design starts on page 37. The detailed design should be used for critical or marginal applications or whenever a more precise solution is desired.

Detailed Burial Design:
Design by Wall Crushing: Wall crushing would theoretically occur when the stress in a pipe wall, due to the external vertical pressure, exceeded the long-term compressive strength of the pipe material. To ensure that the Driscopipe wall is strong enough to endure the external pressure the following check should be made:

$$S_A = \frac{(SDR - 1)}{2} P_T$$

Values of E'

Based on Soil Type (ASTM D2321) and Degree of Compaction

Soil Type of Initial Backfill Embedment Material	Description	E' (psi) for Degree of Compaction (Proctor Density, %) Loose	Slight (70-85%)	Moderate (85-95%)	High (95%)
I	Manufactured angular, granular materials (crushed stone or rock, broken coral, cinders, etc.)	1,000	3,000	3,000	3,000
II	Coarse grained soils with little or no fines	N.R.	1,000	2,000	3,000
III	Coarse grained soils with fines	N.R.	N.R.	1,000	2,000
IV	Fine-grained soils	N.R.	N.R.	N.R.	N.R.
V	Organic soils (peat, muck, clay, etc.)	N.R.	N.R.	N.R.	N.R.

N.R. = Not Recommended for use by ASTM D2321 for pipe wall support

Chart 24

SDR	Maximum Burial Depth, ft. in dry soil of 100 lbs/cu. ft. — Soil Modulus, psi* 1000	2000	3000	Maximum External Pressure psi — Soil Modulus, psi* 1000	2000	3000	Maximum Deflection, % after Installation — Soil Modulus, psi* 1000	2000	3000
32.5	25	32	37	17	22	26	1.7	0.9	0.6
26	33	45	52	23	31	36	2.3	1.2	0.8
21	46	61	71	32	42	49	3.2	1.6	1.1
19	52	69	81	36	48	56	3.6	1.8	1.2
17	61	121	181	42	84	126	4.2	2.1	1.4
15.5	56	112	168	39	78	117	3.9	2.0	1.3
13.5	49	98	147	34	68	102	3.4	1.7	1.1
11	39	78	117	27	54	81	2.7	1.4	0.9
9.3	33	68	101	23	47	70	2.3	1.2	0.8
8.3	30	61	89	21	42	62	2.1	1.1	0.7
7.3	26	52	79	18	36	55	1.8	0.9	0.6

* ...umes no external loads

·· S_A = Actual compressive stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

Safety Factor = 1500 psi ÷ S_A where 1500 psi is the Compressive Yield Strength of Driscopipe.

Design by Wall Buckling: Local wall buckling is a longitudinal wrinkling of the pipe wall. Tests of *non-pressurized* Driscopipe show that buckling and collapse do not occur when the soil envelope is in full contact with the pipe and is compacted to a dense state. However, it can be forced to occur over the long term in *non-pressurized* pipe if the total external soil pressure, P_t, is allowed to exceed the pipe-soil system's critical buckling pressure, P_{cb}. If $P_t > P_{cb}$, gradual collapse may occur over the long term. A calculated, conservative value for the critical buckling pressure may be obtained by the following approximate formula. All pipe diameters with the same SDR in the same burial situation have the same critical collapse and critical buckling endurance

$$P_{cb} = 0.8\sqrt{E' \times P_c}$$

Where:

·· Total vertical soil pressure at the top the pipe, psi

P_{cb} = Critical buckling soil pressure at the top of the pipe, psi

E' = Soil modulus in psi calculated as the ratio of the vertical soil pressure to vertical soil strain at a specified density

P_c = Hydrostatic, critical-collapse differential pressure, psi

$$P_c = \frac{2E\,(t/D)^3\,(D_{MIN}/D_{MAX})^3}{(1-\mu^2)}$$

$$P_c = \frac{2.32\,E}{(SDR)^3}$$

Where: $(D_{MIN}/D_{MAX}) = .95$
μ = Poisson's Ratio
μ = .45 for Driscopipe
E = stress and time dependent tensile modulus of elasticity, psi

In a direct burial pressurized pipeline, the internal pressure is usually great enough to exceed the external critical-buckling soil pressure. When a pressurized line is to be shut down for a period, wall buckling be examined.

Design by Wall Buckling Guidelines:
Although wall buckling is seldom the limiting factor in the design of a Driscopipe system, a check of non-pressurized pipelines can be made according to the following steps to insure $P_t < P_{cb}$.

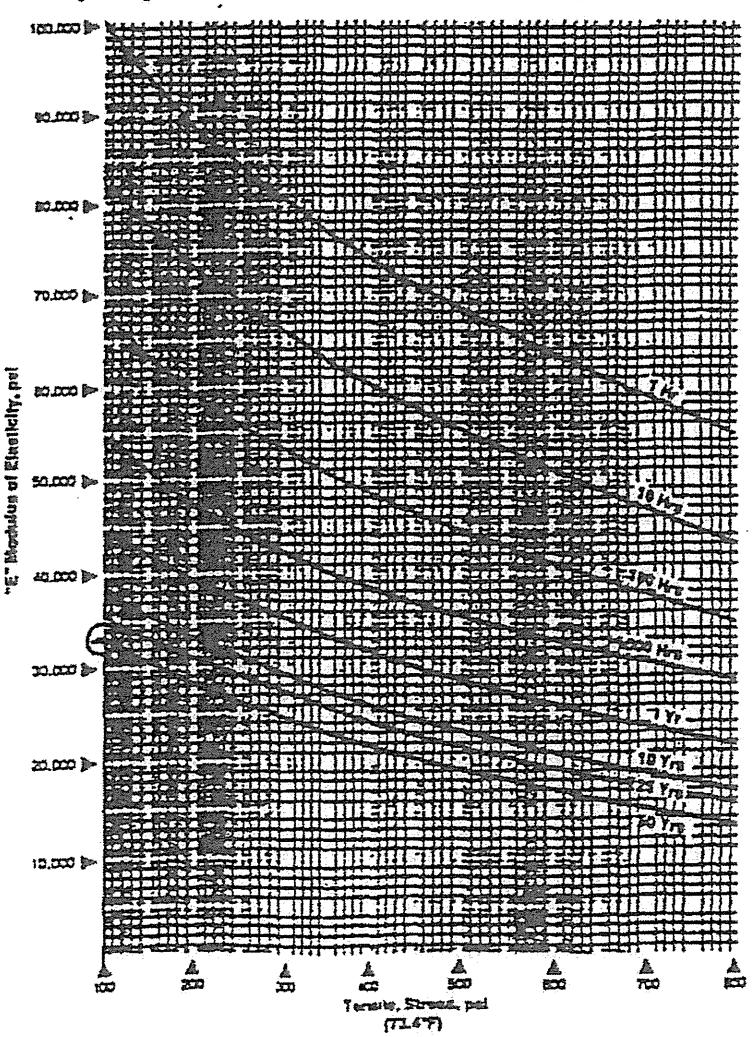
1. Calculate or estimate the total soil pressure, P_t, at the top of the pipe.
2. Calculate the stress "S_A" in the pipe wall according to the formula:

$$S_A = \frac{(SDR - 1)\,P_t}{2}$$

3. Based upon the stress "S_A" and the estimated time duration of non-pressurization, use Chart 25 to find the value of the pipe's modulus of elasticity, E, in psi.

Chart 25

Time Dependent Modulus of Elasticity for Polyethylene Pipe vs. Stress Intensity (73.4°F)



NOTE: The short term modulus of elasticity of Driscopipe per ASTM D 638 is approximately 100,000 psi. Due to the cold flow (creep) characteristic of the pipe material, this modulus is dependent upon the stress intensity and the time duration of the applied stress.

Prep By: JAV
Date: 12/29/99

TURKEY CREEK LANDFILL
65500-011.104
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TEMPORARY DEWATERING TRENCH SYSTEM DESIGN
GEOCOMPOSITE LAYER

Chkd By: [signature]
Date: 12-29-99

Required:

Determine the minimum requirements of the geocomposite drainage layer.

Method:

1. Determine the geocomposite thickness under the expected loading conditions.
2. Determine factors of safety for strength and environmental conditions based on expected duration in each stage of landfill development.
3. Obtain estimates for geocomposite transmissivity from manufacturer's data and specify as minimum values for the geocomposite drainage layer.
4. Compute the required hydraulic conductivity of the geocomposite for each stage of landfill development using the calculated thicknesses and the factors of safety.
5. Determine the suitability of the geocomposite for use in the underdrain.

References:

1. Koerner, R.M., Designing With Geosynthetics, second edition, 1990.
2. Poly-Flex, Inc., FNC 200-2-6 Geocomposite Property Data.

TURKEY CREEK LANDFILL
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TEMPORARY DEWATERING TRENCH SYSTEM DESIGN
GEOCOMPOSITE LAYER

Solution:

1. Geocomposite Thickness

Assume the geocomposite will undergo linear compression due to the weight of soil (in the form of daily cover, intermediate cover, protective cover, or final cover) and waste.

Unloaded Geocomposite Thickness =	0.20	in
Compressibility at 20,000 psf =	50	%
Unit Weight of Waste =	65	pcf
Unit Weight of Soil =	125	pcf
Composite Unit Weight of Waste and Soil = (85% Waste and 15% Daily Cover)	74	pcf

Table 1 - Geocomposite Thickness

Fill Condition	d_w[1] (ft)	d_s[2] (ft)	P[3] (psf)	t[4] (in)
End of Construction	0	4	500	0.20
Interim	49.5	5	4,288	0.18
Closed	49.5	8.5	4,726	0.18

[1] d_w is the depth of waste and daily cover soil above the geocomposite.
[2] d_s is the depth of soil above the geocomposite.
[3] P is the pressure on the geocomposite due to the weight of the waste and soil.
[4] t is the thickness of the geocomposite after being subjected to linear compression.

2. Factors of Safety for Strength and Environmental Conditions

Table 2 - Factors of Safety

Factor of Safety	Fill Condition		
	End of Construction (No Waste)	Interim (49.5' Waste)	Closed Final Cover
Geotextile Intrusion	1.0	1.5	2.0
Creep Deformation	1.0	1.0	1.0
Chemical Clogging	1.0	1.5	2.0
Biological Clogging	1.0	1.5	2.0
FS Factor[1]	1.00	3.38	8.00

[1] The FS Factor is the product of all of the factors of safety for each fill condition.
[2] The FS Factor for the active condition is 1.0 since the geocomposite is new at this time.
[3] The FS Factor for creep is 1.0 because the geocomposite thickness has been adjusted for the overburden pressure.

3. Manufacturer's Transmissivity Data

Manufacturer's transmissivity values represent the lowest transmissivity values obtained during product data research. (Refer to chart on page 10C-25).

4. Compute the design transmissivity (T) of the geocomposite.

Table 3 - Required Transmissivity

Fill Condition	d_W[1] (ft)	P[2] (psf)	t[3] (in)	T[4] (m^2/s)	FS Factor[5]	T_{DES}[6] (m^2/s)	T_{DES}[7] (gpm/ft)
End of Construction	0	500	0.20	1.0E-04	1.00	1.0E-04	0.48
Interim	49.5	4,288	0.18	1.0E-04	3.38	3.0E-05	0.14
Closed	49.5	4,726	0.18	1.0E-04	8.00	1.3E-05	0.06

[1] d_W is the depth of waste above the geocomposite.

[2] P is the pressure on the geocomposite due to the weight of the waste and soil from Table 1.

[3] t is the calculated geocomposite thickness from Table 1.

[4] T is the published transmissivity values for a representative geocomposite (see pages 10C-25 and for product data for Poly-FlexFNC 200-2-6).

[5] FS Factor is the product of the factors of safety from Table 2.

[6] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (\text{FS Factor})$$

[7] The conversion factor used was:

$T_{DES} = T_{DES} \times (60s/min)(60min/h)(24h/d) = m^3/md \times 80.53 = gpd/ft \times (d/24hr) \times (h/60\ min) = gpm/ft$

5. Design summary

From page 10C-4, the seepage of the 3:1slope is:

3:1 slope 9.20E-03 gpm/ft

From Table 3 above, the lowest transmissivity of the drainage geocomposite is:

Closed Condition: 6.04E-02 gpm/ft

Since the geocomposite's lowest transmissivity (0.06 gpm/ft) is still greater than than the estimated seepage (0.0092 gpm/ft), the geocomposite design is acceptable.

Prep By: JAV
Date: 12/29/99

Chkd By: DH
Date 12-29-99

TURKEY CREEK LANDFILL
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GEOCOMPOSITE LAYER

If a drainage geocomposite with lower transmissivity characteristics than Poly-Flex FNC 200-2-6 under similar loads is selected, then a demonstration of that materials ability to prevent the development of hydrostatic forces will be made (using the methodology used above) and included in the SLER.

FNC 200-2-6
DOUBLE-SIDED DRAINAGE COMPOSITE

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

DRAINAGE COMPOSITE PROPERTIES

Property	Test Method	Minimum Average Values
Transmissivity, (MD), m^2/sec metal plate/geocomposite/metal plate hydraulic gradient, i = 1 normal pressure = 15,000 psf	ASTM D 4716	1×10^{-4}
Peel Adhesion, lb/in peak load on 2" wide specimen	ASTM D 413 or F 904	1
Roll Width, ft		14
Roll Length, ft		250

COMPONENT PROPERTIES

GEONET

Thickness, mil	ASTM D 5199	200
Mass Per Unit Area, lbs/ft^2	ASTM D 5261	0.162
Density, min., g/cc	ASTM D 1505	0.940
Carbon Black Content, min., %	ASTM D 1603	2
Tensile Strength, lbs/in	ASTM D 1682 or 5053	45
Transmissivity, (MD), m^2/sec metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 15,000 psf	ASTM D 4716	1×10^{-3}

GEOTEXTILE

Unit Weight, oz/yd^2	ASTM D 5261	6
Grab Tensile, lb	ASTM D 4632	160
Mullen Burst, psi	ASTM D 3786	350
Puncture, lb	ASTM D 4833	90
AOS	ASTM D 4751	70 sieve
Flow Rate, $gal/min/ft^2$	ASTM D 4491	110

These specifications are subject to change without notice. The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen. Geonet and Geotextile properties are tested prior to lamination.
2/99

POLY-FLEX, INC.
2000 West Marshall Drive • Grand Prairie, Texas 75051, U.S.A.
888-765-9359 • 972-337-7113 • Fax 972-337-7233
www.poly-flex.com

Prep By: JAV
Date: 12/29/99

TURKEY CREEK LANDFILL
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TEMPORARY DEWATERING TRENCH DESIGN
GEOTEXTILE DESIGN

Chkd By: [signature]
Date: 12-29-99

REQUIRED: Determine geotextile properties around granular drainage material in the temporary dewatering trench.

METHOD: Design geotextiles and determine properties according to Reference 1.

REFERENCES:

1. Nicolon Corporation, *Geotextile Filter Design Manual*, 1991.
2. Koerner, R.M., *Designing With Geosynthetics*, second edition, 1990.

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TEMPORARY DEWATERING TRENCH DESIGN
GEOTEXTILE DESIGN

SOLUTION:

Geotextile "A" Around Granular Drainage Material

The design calculations assume the protective cover soil will consist of one of the following:

Case 1: Hydraulic conductivity greater than or equal to 1×10^{-4} cm/s and percent fines greater than 20 percent.

Case 2: Hydraulic conductivity less than 1×10^{-4} cm/s and percent fines greater than 20 percent.

If the subgrade material contains less than 20 percent fines, these geotextile calculations will be revised.

Retention:

For Case 1 and Case 2:

Based on Chart 1 - "Soil Retention Criteria" (shown on page 10C-30) the apparent opening size (O_{95}) may be determined.

$O_{95} <$ 0.21 mm — For both protective cover materials (cases 1 & 2 listed above)

Permeability:

For Case 1:

For subgrade soils that have a hydraulic conductivity (k_{pc}) greater than or equal to 1×10^{-4} cm/s:

$k_{pc} =$ 1.00E-04 cm/s

Based on Figure 3, "Typical Hydraulic Gradients" (shown on page 10C-31):

$i =$ 1.0 cm/cm

Geotextile hydraulic conductivity (k_g) (normal to the geotextile surface):

$k_g = i\,(k_{pc}) =$ 1.00E-04 cm/s

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Chkd By [signature]
Date 12-29-99

TURKEY CREEK LANDFILL
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TEMPORARY DEWATERING TRENCH DESIGN
GEOTEXTILE DESIGN

Geotextile permittivity (Ψ):

For Case 1:

$\Psi_{all} = k_g / t$ Where: Ψ_{all} = Allowable permittivity
t = Thickness of geotextile

k_g = 1.00E-04 cm/s
t = 0.24 cm

Ψ_{all} = 4.2E-04 sec^{-1}

$$\psi_{man} = \psi_{all}\left[FS_{cb} \times FS_i \times FS_{cr} \times FS_{cc} \times FS_{bl}\right]$$

Where:
Ψ_{man} = Manufacturer's published permittivity
FS_{cb} = FS against soil clogging and binding
FS_i = FS against intrusion of adjacent materials
FS_{cr} = FS against creep reductions of void space
FS_{cc} = FS against chemical clogging
FS_{bl} = FS against biological clogging

FS_{cb} =	3.0	(Long-term, fine soils)
FS_i =	1.2	(Moderate normal stresses)
FS_{cr} =	1.5	(Long-term installation)
FS_{cc} =	1.5	(Groundwater unknown)
FS_{bl} =	2.0	(Groundwater unknown)

Calculated factor = 16.2

Ψ_{man} =	6.8E-03	sec^{-1}
$k_{g(man)}$ =	1.6E-03	cm/s

For Case 2:

For the surrounding stratum(s) that has a hydraulic conductivity less than 1×10^{-4} cm/s, it is assumed that the conductivity of the geotextile will be much greater than the conductivity of the surrounding stratum(s). Therefore, the minimum conductivity is not calculated for this case (i.e. the conductivity of the geotextile will be sufficient to prevent head from developing in the stratum(s)).

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TEMPORARY DEWATERING TRENCH DESIGN
GEOTEXTILE DESIGN

Clogging:

For Case 1 and Case 2:

For geotextile filters where retention is important, use smallest O_{95} that meets the geotextile permeability requirement.

Survivability:

For Case 1 and Case 2:

Based on Figure 4, "Survivability Strength Requirements", (see page 10C-32), geotextile properties should be selected considering moderate installation conditions and high contact stresses (due to angular drainage media).

Durability:

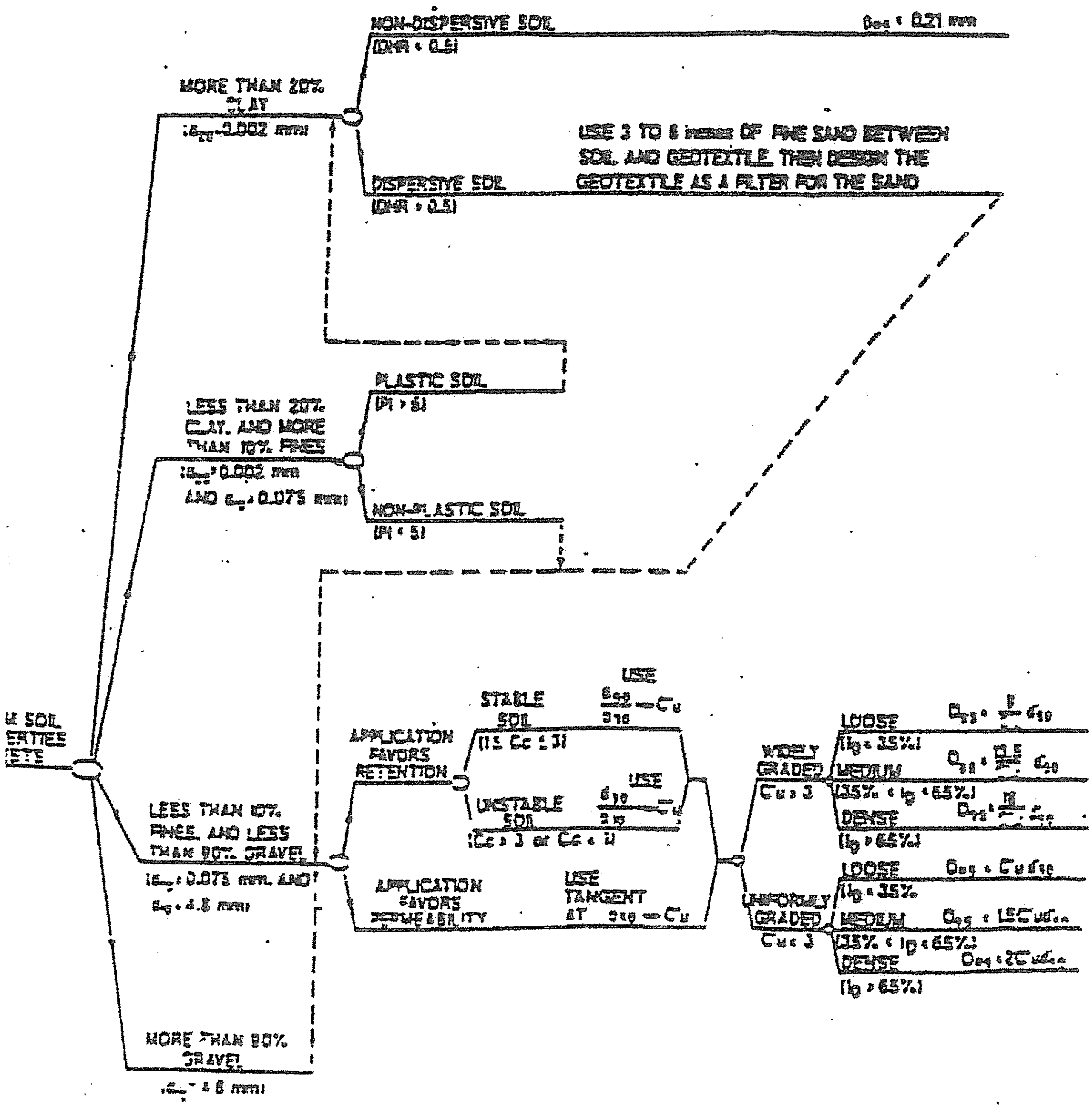
For Case 1 and Case 2:

Ultraviolet light resistance should be considered due to the likelihood of geotextile exposure during construction. A high carbon black content should be included in geotextile.

Summary of required properties for geotextile "A" (around granular drainage material) for both Case 1 and Case 2:

Apparent opening size	<	0.21	mm
Hydraulic conductivity	>	1.6E-03	cm/sec
Grab tensile strength	>	180	lbs
Sewn seam strength	>	160	lbs
Puncture strength	>	80	lbs
Burst strength	>	290	psi
Trapezoid tear	>	50	lbs

CHART 1
SOIL RETENTION CRITERIA
FOR STEADY-STATE FLOW CONDITIONS



NOTES.

d_x is the particle size of which x percent is smaller

where d_{100} and d_0 are the extremities of a straight line drawn through the particle-size distribution, as directed above, and d_{50} is the midpoint of this line.

I_D is the relative density of the soil

FIGURE 3

TYPICAL HYDRAULIC GRADIENTS[a]

DRAINAGE APPLICATION	TYPICAL HYDRAULIC GRADIENT
STANDARD DEWATERING TRENCH	1.0
VERTICAL WALL DRAIN	1.5
PAVEMENT EDGE DRAIN	1[b]
LANDFILL LCDRS	1.5
LANDFILL LCRS	1.5
LANDFILL SWCRS	1.5
DAMS	10[b]
INLAND CHANNEL PROTECTION	1[b]
SHORELINE PROTECTION	10[b]
LIQUID IMPOUNDMENTS	10[b]

NOTES: (a) Table developed after Giroud, 1988.

(b) Critical applications may require designing with higher gradients than those given.

ATTACHMENT 10

APPENDIX 10D

TIRE CHIP STABILITY ANALYSIS

Includes pages 10D-1 through 10D-3

STATE OF TEXAS
DAVID R. FRIELS
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REGISTERED
PROFESSIONAL ENGINEER
12-29-99

CONTENTS

REQUIRED:

USE INFINITE SLOPE STABILITY ANALYSIS TO VERIFY TIRE CHIPS UTILIZED IN THE LEACHATE COLLECTION AND PROTECTIVE COVER LAYERS ARE STABLE ON 3H:1V SIDESLOPES.

METHODOLOGY:

USE DUNCAN AND BUCHIGNANI'S METHOD FOR INFINITE SLOPE STABILITY ANALYSIS.

ASSUMPTION:

UNIT WEIGHT AND STRENGTH CHARACTERISTICS ASSUMED BASED ON REFERENCE TO "THE POTENTIAL FOR USE OF SHREDDED TIRE CHIPS AS A LEACHATE DRAINAGE AND COLLECTION MEDIUM: DESIGN, CONSTRUCTION AND PERFORMANCE CONSIDERATIONS" BY DANIEL P. DUFFY, P.E.

REFERENCES:

1. DUNCAN, J.M. AND BUCHIGNANI, A.L., "AN ENGINEERING MANUAL FOR SLOPE STABILITY STUDIES", DEPT. OF CIVIL ENGINEERING - UNIVERSITY OF CALIFORNIA-BERKELEY, 1975.
2. LANDFILL DESIGN USING TIRE SHREDS SEMINAR PROCEEDINGS, ARLINGTON, TEXAS, MARCH 12, 1996.

SOLUTION:

INFINITE SLOPE ANALYSIS OF LEACHATE COLLECTION AND PROTECTIVE COVER LAYERS

$$F.S. = A\frac{\tan\phi}{\tan\beta} + B\frac{C}{\gamma H}$$

SEE "STABILITY CHARTS FOR INFINITE SLOPES" FOR EXPLANATION OF EQUATION AND PARAMETERS "A" AND "B" (SEE NEXT PAGE)

INPUT PARAMETERS:

PROTECTIVE COVER (TIRE CHIPS)/LEACH. COLLECTION (SOIL) INTERFACE:

ϕ =	27	deg	T =	2	ft
C =	150	psf	X =	1	ft
β =	18.43	deg	γ_{lc} =	91.5	pcf
γ_w =	62.4	pcf	γ_{pc} =	30	pcf

THE INTERNAL ANGLE OF FRICTION IS ASSUMED TO BE EQUAL TO THE LESSER OR THE INTERNAL FRICTION OF THE SOIL AND THE INTERNAL FRICTION OF THE TIRE CHIPS. THE COHESION/ADHESION STRENGTH ALONG THE INTERFACE IS ASSUMED TO BE EQUAL TO THE COHESION/ADHESION STRENGTH OF THE TIRE CHIPS.

THE SEEPAGE WILL BE WITHIN THE TIRE CHIP PORTION OF THE LEACHATE COLLECTION LAYER. DETERMINE A COMPOSITE UNIT WEIGHT FOR THE 2 FEET ABOVE THE FML:

γ = ((1.0 ft x 30 pcf) + (1.0 ft x 91.5 pcf)) / 2 ft = 60.8 pcf

CALCULATING THE PORE PRESSURE COEFFICIENT, r_u, AS SHOWN ON THE ATTACHED PAGE:

r_U = $(X/T) \times (\gamma_w/\gamma) \times \cos^2\beta$ = 0.46

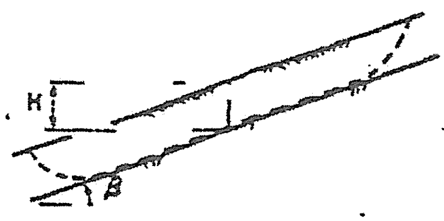
FROM THE STABILITY CHARTS ATTACHED:

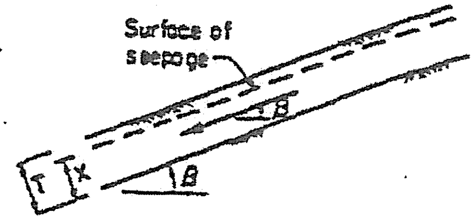
A = 0.5
B = 3.3

THE FACTOR OF SAFETY OF THE TIRE CHIP/SOIL INTERFACE IS, THEREFORE:

F.S. = 4.8

REFERENCE 1.





γ = total unit weight of soil

γ_w = unit weight of water

C' = cohesion intercept } Effective Stress

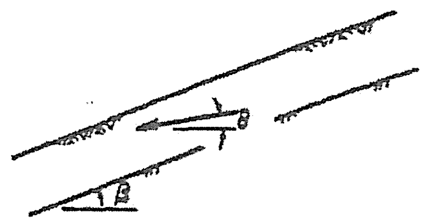
ϕ' = friction angle } Effective Stress

r_u = pore pressure ratio = $\frac{u}{\gamma H}$

u = pore pressure at depth H

Seepage parallel to slope

$$r_u = \frac{X}{T}\,\frac{\gamma_w}{\gamma}\cos^2\beta$$



Seepage emerging from slope

$$r_u = \frac{\gamma_w}{\gamma}\,\frac{1}{1+\tan\beta\tan\theta}$$

Steps:

① Determine r_u from measured pore pressures or formulas at right

② Determine A and B from charts below

③ Calculate $F = A\,\frac{\tan\phi'}{\tan\beta} + B\,\frac{C'}{\gamma H}$

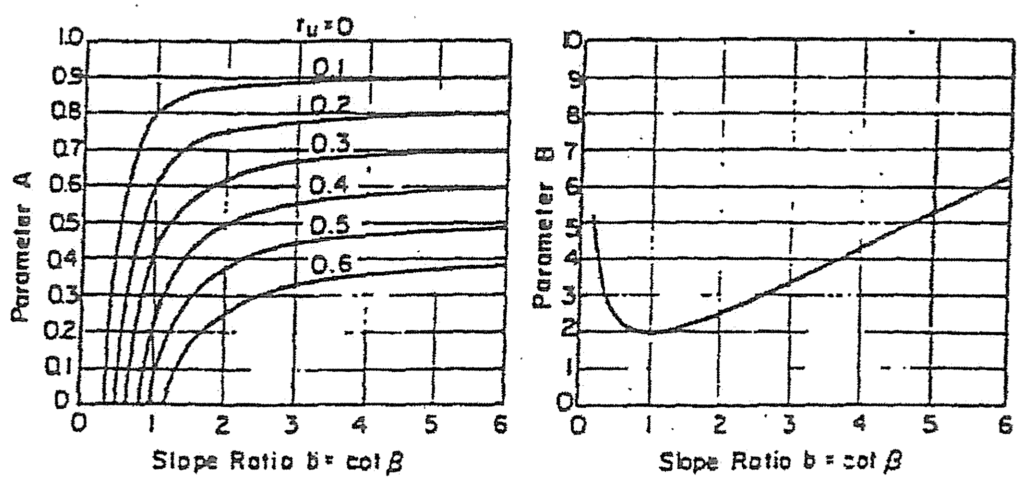


Fig.10 STABILITY CHARTS FOR INFINITE SLOPES.

ATTACHMENT 10

APPENDIX 10E

GROUNDWATER FLOW INTO LEACHATE COLLECTION SYSTEM DEMONSTRATION

Includes pages 10E-1 through 10E-3

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REQUIRED:

DEMONSTRATE ADEQUACY OF LEACHATE COLLECTION SYSTEM TO HANDLE THE POTENTIAL ADDITIONAL FLOW FROM GROUNDWATER INFILTRATION THROUGH THE LINER SYSTEM.

GIVEN:

1. FROM DRAWING 10B1 - POTENTIAL HYDROSTATIC HEAD ON LINER SYSTEM, THE MAXIMUM HYDRAULIC HEAD ON THE LINER SYSTEM IS 13 feet.

2. THE CONTROLLING SOIL LAYER FOR GROUNDWATER INFLOW THROUGH THE LINER SYSTEM IS THE COMPACTED CLAY LINER WITH A MAXIMUM HYDRAULIC CONDUCTIVITY OF 1×10^{-7} cm/sec AND A THICKNESS OF 2 feet.

REFERENCES:

1. HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL, ENGINEERING DOCUMENTATION FOR VERSION 3.

SOLUTION:

FOR GOOD LINER CONTACT WITH LOW PERMEABILITY SOIL:

RADIUS OF LEAKAGE FROM PINHOLE:

$R = 0.174 * h^{0.45} * K^{-0.13}$ REFERENCE 1, Eq. 163

WHERE:
R = RADIUS OF WETTED AREA AROUND PINHOLE, inches
h = AVERAGE HYDRAULIC HEAD ON LINER, inches
K = HYDRAULIC CONDUCTIVITY OF CONTROLLING SOIL LAYER, inches/day

FROM GIVEN INFORMATION:

h =	13	ft	=	156	in
K =	1.00E-07	cm/sec	=	3.40E-03	in/day

R =	3.53	in

RADIUS OF LEAKAGE FROM INSTALLATION DEFECTS

$R = 0.222 * h^{0.45} * K^{-0.13}$ REFERENCE 1, Eq. 164

WHERE:
R = RADIUS OF WETTED AREA AROUND DEFECT, inches
h = AVERAGE HYDRAULIC HEAD ON LINER, inches
K = HYDRAULIC CONDUCTIVITY OF CONTROLLING SOIL, inches/day

h = 156 in
K = 3.40E-03 in/day

R =	4.51	in

AVERAGE HYDRAULIC GRADIENT ON WETTED AREA:

$i = 1 + [h/(2*T*\ln(R/r))]$ REFERENCE 1, Eq. 152

WHERE:
i = AVERAGE HYDRAULIC GRADIENT ON WETTED AREA
h = AVERAGE HYDRAULIC HEAD ON LINER, inches
T = THICKNESS OF CONTROLLING SOIL LAYER, inch
R = RADIUS OF WETTED AREA, inches
r = RADIUS OF FLAW, inches

FROM GIVEN INFORMATION AND PREVIOUS CALCULATIONS:

PINHOLE:

h = 156 in
T = 0.25 in
R = 3.53 in
r = 0.02 in REFERENCE 1

i =	61.29

INSTALLATION DEFECT:

h = 156 in
T = 0.25 in
R = 4.51 in
r = 0.22 in REFERENCE 1

i =	104.30

LEAKAGE RATE:

$q = 0.877*[(K*i*n*\pi*R^2)/6,276,640]$ REFERENCE 1, Eq 151

WHERE:
q = LEAKAGE RATE THROUGH FLAW, inches/day/acre
K = HYDRAULIC CONDUCTIVITY OF CONTROLLING SOIL, inches/day
i = AVERAGE HYDRAULIC GRADIENT ON WETTED AREA
n = DENSITY OF FLAWS, number/acre
R = RADIUS OF WETTED AREA, inches

FROM GIVEN INFORMATION AND PREVIOUS CALCULATIONS:

PINHOLE:
K = 3.40E-03 in/day
i = 61.29
n = 0.5 holes/acre
R = 3.53 in

q = 5.72E-07 in/day/ac

INSTALLATION DEFECT:
K = 3.40E-03 in/day
i = 104.30
n = 1 holes/acre
R = 4.51 in

q = 3.17E-06 in/day/ac

GEOMEMBRANE LEAKAGE RATE (VAPOR DIFFUSION THROUGH INTACT FML):

$q_L = K_m * ((h+T)/T)$ REFERENCE 1, Eq. 141

WHERE:
q_L = GEOMEMBRANE LEAKAGE RATE, inches/day
K_m = SATURATED HYDRAULIC CONDUCTIVITY OF FML, inches/day
h = AVERAGE HYDRAULIC HEAD ON LINER, inches
T = THICKNESS OF FML, inches

K_m = 2.00E-13 cm/sec = 6.80E-09 in/day
h = 156 in
T = 0.06 in

q_L = 1.77E-05 in/day/ac

TOTAL LEAKAGE (INFLOW) INTO LEACHATE COLLECTION SYSTEM:

$q_T = q_{pinhole} + q_{defect} + q_L$

q_T = 2.14E-05 in/day/ac or
= 0.08 ft³/day

CONCLUSION:
THE CALCULATED RATE OF GROUNDWATER INFLOW, (0.08 ft³/day) THROUGH THE LINER SYSTEM IS INSIGNIFICANT (0.016%) COMPARED TO THE CALCULATED FLOW IN THE LATERAL DRAINAGE LAYER (505 ft³/day - SEE SHEET C-6 IN APPENDIX C OF THE SECTOR 2 PERMIT MOD.) AND THEREFORE WILL NOT AFFECT THE DESIGN OF THE LEACHATE COLLECTION SYSTEM.

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIE
FINAL COVER SYSTEM QUALITY CONTROL PLAN
STANDARD SUBTITLE D FINAL COVER

Prepared for

Texas Regional Landfill Company, LP

February 2022

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This document is intended for permitting purposes only.

CONTENTS

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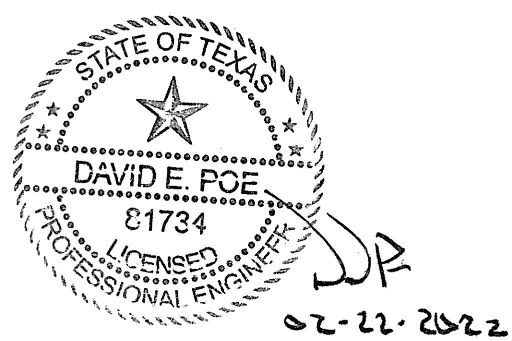
CONTENTS (Continued)



TABLES

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02-22-2022

1 INTRODUCTION

1.1 Purpose

This Final Cover System Quality Control Plan (FCSQCP) has been prepared to provide the Owner, Operator, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Regulations (MSWR). More specifically, the FCSQCP addresses the soil and geosynthetic components of the final cover system.

This FCSQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Soil Infiltration Layer
- Section 3 – Construction Quality Assurance for Geosynthetics
- Section 4 – Construction Quality Assurance for Erosion Layer
- Section 5 – Geotechnical Strength Testing Requirements
- Section 6 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

American Society for Testing and Materials.

Atterberg Limits

A series of six "limits of consistency" of fine-grained soils defined by Swedish soil scientist Albert Atterberg, two of which are frequently used today to establish a soil's physical boundaries dealing with its plasticity characteristics. These soil boundaries or limits used most frequently in geotechnical engineering are based upon the numerical difference of the Liquid Limit and the Plastic Limit as defined below:

- Liquid Limit (LL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the upper point at which the soil's consistency changes from the plastic to the liquid state.
- Plastic Limit (PL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the lower point at which the soil's consistency changes from the plastic to the semi-solid state.
- Plasticity Index (PI) – The numerical difference between the LL and the PL of a fine-grained soil that denotes the soils plastic range. The larger the PI the greater a soil's plasticity range and the greater it's plasticity characteristics.

Compactive Effort

The amount of compaction energy held constant, and usually transferred into a soil sample with a compaction hammer device, used on soil samples in various laboratory test procedures to establish a soil's density at various moisture contents.

Construction Quality Assurance (CQA)

A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design (EPA, 1986). Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing will be NICET-certified in geotechnical engineering technology at level two or higher for soils and FML testing; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) under the direction of the POR. Additional CQA monitors may be used. If working under the direction of a CQA monitor, the second CQA monitor will have a minimum of one year of directly related experience.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer in

Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitors working under the POR's direction. The POR or his designated representative will be on-site during all final cover system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Contract Documents

These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer".

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction drawings and specifications and Section 2 of this plan.

Film Tear Bond (FTB)

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Final Cover System Evaluation Report (FCSER)

Upon completion of closure activities, the certification will be in the form of the FCSER which will be signed by the POR and include all the documentation necessary for certification of closure.

Fish Mouth

A semi-conical opening of the seam that is formed by an edge wrinkle in one sheet of the geomembrane.

Geomembrane Liner (GM)

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM.

Geosynthetics Contractor

This individual is also referred to as the "contractor" or "installer", and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or other geosynthetic materials, even if not his primary function.

Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the final cover or the manufacturer of the final cover products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of nonconformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit.

Operator's Representative

This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Panel

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

Permeant Fluid

Fluid used in a laboratory coefficient of permeability test and limited to tap water or 0.005 Normal solution of $CaSO_4$. Distilled water will not be used in these test procedures.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor.

Representative Sample

A representative sample of FML material consists of 1 or more specimens (commonly referred to as coupons) from the same rectangular portion of FML material, oriented along a seam, that is removed for field or laboratory testing purposes.

Soil Borrow Source

Soils in which the Liquid Limit (LL) and Plasticity Index (PI) do not vary by 10 points. A soil that varies by 10 or more points from the originally established LL or PI is considered as a separate soil source for the purpose of this FCSQCP and requires a separate soil test series.

Soil Test Series

Tests performed to determine a soil's physical characteristics and to document its ability to satisfy the MSWR soil infiltration layer requirements. These tests include sieve analysis (gradation), Atterberg Limits, moisture/density, and coefficient of permeability.

Specimen

(With respect to FML destructive testing) – A specimen is the individual test strip (also referred to as a coupon) from a sample location. A sample location usually consists of many specimens.

2 CONSTRUCTION QUALITY ASSURANCE FOR SOIL INFILTRATION LAYER

2.1 Introduction

This section of the FCSQCP addresses the construction of the soil infiltration layer component of the final cover system and outlines the FCSQCP program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements and treatment of problems.

The scope of soil infiltration layer related construction quality assurance includes the following elements:

- Subgrade preparation
- Soil infiltration layer stockpile
- Soil infiltration layer placement
- General fill

2.2 Composite Final Cover

The landfill is designed to include a composite final cover system over the waste fill footprint as discussed in Section 2.2 of the Closure Plan (Appendix IIIJ). The cover system includes an 18-inch-thick compacted clay infiltration layer, 40-mil LLDPE geomembrane, drainage geocomposite, and 12-inch-thick erosion layer capable of sustaining vegetative growth. In addition, the infiltration layer thickness will be increased to 4 feet with a coefficient of permeability of less than or equal to $1x10^{-7}$ cm/s and will be placed on top of the outside slope of the Class 1 containment dike or soil cover system, as shown on Drawings A.8 through A.10 in Appendix IIIA. The final cover system is designed to minimize the amount of precipitation that infiltrates the deposited waste, thus minimizing the amount of leachate generated. The final cover system is designed to convey stormwater to detention ponds via final cover erosion control structures and perimeter channels.

2.3 Soil Infiltration Layer Construction

Sections 2.3.1 and 2.3.2 describe general construction procedures to be used for the soil infiltration layer and the preparation of the intermediate cover layer. Construction must be conducted in accordance with the project construction drawings, which will be developed in accordance with this FCSQCP and the Closure Plan (Appendix IIIJ) at the time of each final cover construction.

2.3.1 Intermediate Cover and Containment Dikes

Intermediate Cover

Before soil infiltration layer construction, the vegetation on the intermediate cover will be removed. The surface of the intermediate cover will be compacted to prepare the working surface for the first lift of infiltration layer soil. The CQA monitor will visually inspect and approve the prepared intermediate cover prior to the placement of the soil infiltration layer or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the intermediate cover preparation.

Surveying will be performed to verify that the finished intermediate cover is completed consistent with the lines and grades specified in the design.

Class 1 Containment Dikes

Before soil infiltration layer construction, the vegetation on the containment dike will be removed. An equivalent amount of soil will be added to the surface of the containment dike and constructed to containment dike standards (refer to Section 6.3.2 in Appendix IIIA) to replace the amount of soil removed to clear the vegetation layer. The surface of the containment dike will then be compacted with a pad/tamping-foot or prong-foot roller to provide sufficient roughening of the exterior slope of the containment dike to ensure bonding between the containment dike and the first lift of infiltration layer material. The CQA monitor will visually inspect and approve the prepared containment dike prior to the placement of the soil infiltration layer or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the containment dike preparation.

Class 1 Soil Cover System

For this option, a 4.5-foot-thick cover soil layer will be placed on the exterior sideslopes, extending from the top of the perimeter containment dike to the maximum Class 1 fill elevation to meet the requirements listed in Title 30 Texas Administrative Code (TAC) §335.590(24)(F)(i). The final cover will be constructed by stripping the upper 6 inches of topsoil and 3 feet from the soil cover layer (leaving 1 foot of soil as intermediate cover), and constructing a final cover in compliance with Title 30 TAC §335.590(24)(E) which will include a 4-foot-thick compacted clay-rich infiltration layer. The stripped soil cover system will be inspected by the CQA monitor prior to placement of the infiltration layer.

As an option to the above described placement of the 4.5-foot-thick soil cover layer, the 4.5-foot-thick soil cover layer may be placed (during initial installation) in accordance with the soil infiltration layer requirements described in Section 2.3.2 of this FCSQCP, thus allowing the soil cover layer to be incorporated into the final cover system during final closure. This option will require the topsoil layer be stripped, and the POR inspect the soil cover layer to confirm the soil cover layer is suitable for use as the soil infiltration layer component of the final cover.

2.3.2 Soil Infiltration Layer

The soil infiltration layer will consist of a minimum 18-inch-thick compacted soil barrier (measured perpendicular to the subgrade surface) that will extend along the sideslopes and topslopes of the landfill. However, where Class 1 waste is filled above grade the thickness of the infiltration layer that is located adjacent to the Class 1 waste disposal area will be increased to 4 feet with a coefficient of permeability of less than or equal to $1x10^{-7}$ cm/s. All soils used in soil infiltration layers will have the following minimum values verified by testing in a third party soil laboratory:

- Plasticity Index equal to or greater than 15.
- Liquid Limit equal to or greater than 30.
- Percent passing the No. 200 mesh sieve equal to or greater than 30 percent.
- Percent passing the 1-inch screen equal to 100 percent.
- Coefficient of permeability of less than or equal to $1x10^{-5}$ cm/s for the composite Subtitle D cover infiltration layer. Coefficient of permeability of less than or equal to $1x10^{-7}$ cm/s for the Class 1 area that is filled above grade.

The soil infiltration layer material will consist of relatively homogeneous clay and clayey soils. The soil will be free of debris, rock greater than 1 inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Testing will be performed in accordance with Section 2.4 (refer to Table 2-1 for test methods) for each borrow source. A permeability test will be conducted on samples from each borrow source. The permeability test specimens will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor (ASTM D 698) maximum dry density at a moisture content at or above the optimum moisture content. One Proctor moisture-density relationship and remolded permeability test will be required for each different material as determined by a change in the liquid limit or plasticity index of more than 10 points.

The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of previously compacted lift; therefore, the compacted lift thickness will not be greater than the pad or prong length of the compaction equipment. The material will be compacted to a minimum of 95 percent of the maximum dry density determined by Standard Proctor (ASTM D 698) at a moisture content between the Standard Proctor optimum and 5 percentage points above optimum. The CQA monitor, earthwork contractor, and/or Operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required.

Because of possible variability of the available clay materials, additional stockpile testing will be performed if different physical properties of the borrow soil (color, texture, etc.) are observed by the CQA monitor, and the materials vary by more than ten points in either liquid limit or plasticity index from previously evaluated materials.

The clay materials to be used for infiltration layer may require processing to achieve the required moisture content for compaction. The physical characteristics of the clay materials will be evaluated through visual observation before and during construction. To add moisture to the material properly, the clod sizes will first be crushed into manageable sizes of 1 inch in diameter or less. Rocks within the infiltration layer should be less than 1 inch in diameter and will not total more than 10 percent by weight. The prepared infiltration layer will be observed such that rock content will not be a detriment to the integrity of the overlying geomembrane.

Clod-size reduction, if necessary, may be achieved using a disc harrow, soil pulverizer, or other method acceptable to the POR. In order to efficiently break down the clods and pieces of shale, multiple passes of the processing equipment in two directions are recommended. Water will be applied as necessary to the material and worked into the material with the processing or compacting equipment. If necessary to achieve even moisture distribution or break down clods, the material will be watered and processed in the stockpile prior to placing in the infiltration layer to allow the soil adequate time to hydrate. Water used for the soil infiltration layer must be clean and not contaminated by waste or any objectionable material. Collected onsite stormwater may be utilized to moist-condition soils if it has not come into contact with the solid waste.

The soil infiltration layer must be compacted with a pad/tamping-foot or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the compacted lift thickness must not be greater than the pad or prong length. The top of intermediate cover will be scarified a minimum of two inches prior to placement of the first lift of soil infiltration layer. Use of pad/tamping foot or prong-foot rollers will provide sufficient roughening of soil infiltration layer lift's surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways.

Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, the weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds, and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (1 direction) of the compactor, not just an axle, over a given area. The recommended minimum of four passes is for a vehicle with front and rear drums. The Caterpillar 815B and 825C are examples of equipment typically used to achieve satisfactory results. The soil infiltration layer will not be compacted solely with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller.

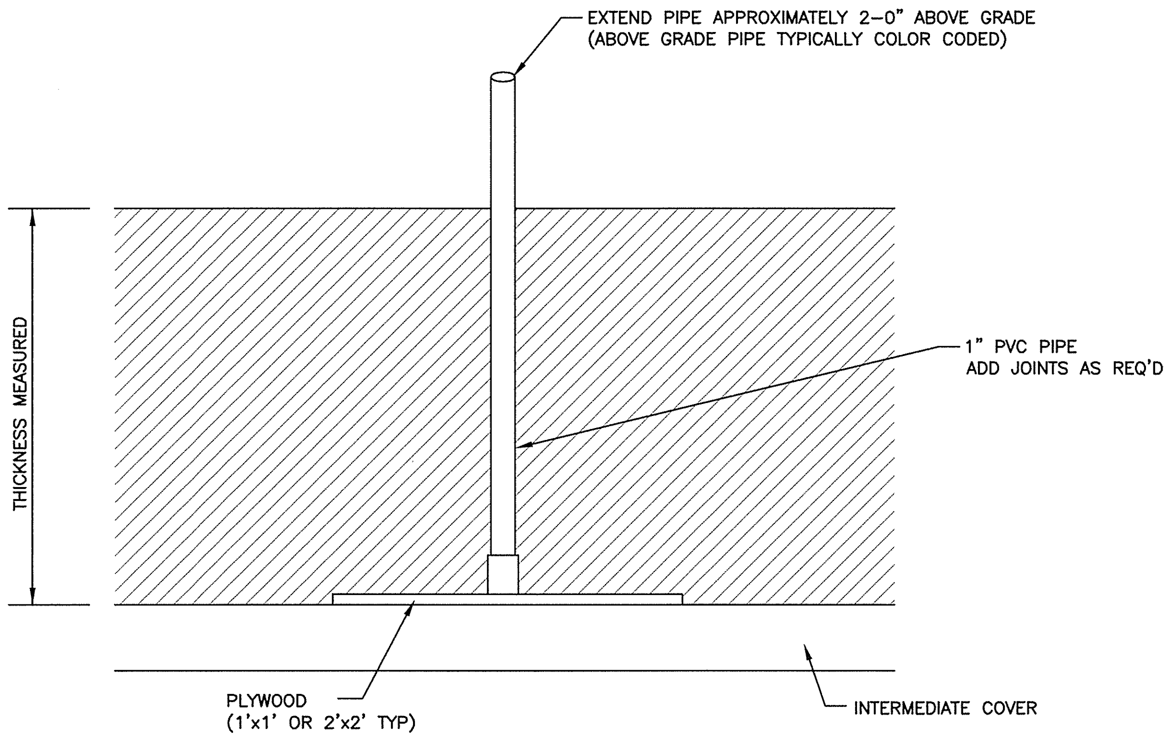
CQA testing of the soil infiltration layer will be performed as the infiltration layer is being constructed. Testing procedures, frequency, and passing criteria will be in accordance with Section 2.4 (Table 2-1).

Soil infiltration layer construction and testing will be conducted in a systematic and timely fashion on each lift. In general, delays will be avoided in infiltration layer construction (typically no more than 14 days). Reasons for any delays in infiltration layer construction (greater than 14 days) should be fully explained in the FCSER submittal.

The finished top surface of the soil infiltration layer must be rolled with a smooth, steel-drum roller to obtain a hard, uniform, and smooth surface. The surface of the soil infiltration layer will then be carefully inspected by the CQA monitor for any gravel, rock pieces, and deleterious materials, which might impact the integrity of the geomembrane to be placed upon it. All voids created by removing gravel, rock pieces, or other deleterious materials will be backfilled with infiltration layer material to the density specifications outlined for soil infiltration construction and tested at the discretion of the CQA monitor.

Surveying will be performed to document that the finished soil infiltration layer has been constructed to a minimum thickness of 18 inches (or 4 feet in the above grade Class 1 area). Thickness verification may be performed by using settlement plates (e.g., plywood sheet or similar material) on a 100-foot grid. The infiltration layer will be surveyed as indicated in Table 2-1 to verify that a minimum 18-inch-thick (or 4-foot-thick in the above grade Class 1 areas) soil layer is present at each location.

A typical settlement plate diagram is shown on Figure IIIE.1. The location of the settlement plates will be established by a Texas registered surveyor on a 100-foot grid. The shaft extending upward from the base will be marked to indicate the minimum required thickness of the infiltration layer. The infiltration layer will be constructed to the minimum thickness marked on the shaft of the settlement plate.



SETTLEMENT PLATE (TYP)
NTS

STATE OF TEXAS
DAVID E. POE
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02-22-2022

TYPICAL SETTLEMENT PLATE

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

Weaver Consultants Group
REGISTRATION NO. F-3727

DRAWN BY: JDW	DATE: 02/2022	FILE: 0771-368-00
REVIEWED BY: BPY	CAD: FIG IIIJ-A.1.DWG	FIGURE IIIE.1

The POR and CQA monitor will verify that the infiltration layer is placed uniformly between each settlement plate.

An infiltration layer thickness drawing at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the final cover system will be called out on the final drawings. The infiltration layer thickness drawing will be sealed by a Texas registered surveyor. After the construction of the infiltration layer is complete, the Texas registered surveyor will survey the final elevation of the infiltration layer. The infiltration layer certification drawing will be included in the FCSER. In addition, the elevations obtained for the top of the infiltration layer will be used to verify that the as-built slopes are consistent with the approved landfill completion plan (Drawing A.3 in Appendix IIIA-A). A statement that confirms that the as-built slopes are consistent with the approved landfill completion plan will be included in the FCSER.

Once the survey is complete, the settlement plate shafts will be removed and the resulting holes will be backfilled with bentonite or a bentonite/infiltration layer soil mixture consisting of at least 20 percent bentonite.

Testing and evaluation of the soil infiltration layer during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with the FCSQCP.

The soil infiltration layer will be prevented from losing moisture prior to placement of geomembrane. Preserving the moisture content of the installed soil infiltration layer will be dependent on the earthwork contractor's means and methods and is subject to POR approval.

Sections of the soil infiltration layer which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density test results will be incorporated into the FCSER.

Hydraulic conductivity samples will be obtained by pushing a sampler through the constructed infiltration layer. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/infiltration layer soil material mixture consisting of at least 20 percent bentonite.

If the integrity of the "A" sample appears to have been compromised during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the minimum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample, the ASTM D 5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned.

The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the FCSER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or sample "A" fails in such a way that there is not an option to use the "B" sample), the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location). Additional tests may be taken to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section. Furthermore, if it is determined that the "B" sample may not be used to replace the "A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed soil infiltration layer lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test, and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each repair area, given that the reconstructed soil infiltration layer area is not larger than one acre. The reconstructed soil infiltration layer area will be tied into the currently constructed soil infiltration layer with a 5H:1V transition slope. The reconstructed soil infiltration layer area is also subject to field density and moisture content testing per Table 2-1 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed). The testing frequency for reconstructed areas will be in accordance with Table 2-1.

Reconstruction activities, including additional testing and surveying, will be incorporated into the FCSER.

2.3.3 Structural Fill

Structural fill material placed below the final cover (e.g., compacted backfill in liner anchor trench) will be placed in uniform lifts which do not exceed 12 inches in loose thickness and are compacted to at least 90 percent of Standard Proctor (ASTM D 698) at a moisture content ranging from 2 percentage points below optimum to 3 percentage points above optimum (-2 to +3). Structural fill will be uncontaminated earthen material.

2.3.4 Surface Water Removal

The prepared intermediate cover or infiltration layer which is under construction may encounter water from storm events. Prior to placement of the soil infiltration layer, intermediate cover will be graded to provide positive drainage for the base grades of the soil infiltration layer. The soil infiltration layer will not be placed in standing water and water will not be allowed to accumulate over constructed infiltration layer. The construction area will be graded to provide for positive drainage. Temporary diversion berms will be constructed as needed to divert surface flow away from the construction area.

2.3.5 Infiltration Layer Tie-In Construction

Newly constructed infiltration layer will be tied-in with any adjoining existing infiltration layers. Additionally, terminations will be constructed for future tie-ins along edges where the infiltration layer will be extended in the future. During the construction of continuous infiltration layers, the new infiltration layer segment will not be constructed by "butting" the entire thickness of the new infiltration layer directly against the edge of the old infiltration layer. The tie-in will be constructed either by a sloped transition (typically 5H:1V) or a stair-stepped transition (typically 1 lift thickness per step). The length of the tie-in should be at least 5 feet per foot of infiltration layer thickness. The tie-ins with existing clay infiltration layer will be constructed utilizing a sloped or stair-stepped transition. In general, terminations for future tie-ins will be constructed by extending the infiltration layer approximately 7.5 feet past the limits for the final cover area under construction.

2.4 Construction Testing

2.4.1 Standard Operating Procedures

CQA monitors will perform field and laboratory tests in accordance with applicable standards specified in this FCSQCP. Sampling will be performed by using standard ASTM practices for recovering thin-walled tube samples (ASTM D 1587). The sampling holes (i.e., samples collected for hydraulic conductivity testing) will be backfilled with bentonite or bentonite/infiltration layer soil material mixture consisting of at least 20 percent bentonite.

2.4.2 Test Frequencies

The test frequencies for the infiltration layer are listed in Table 2-1. Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Further testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

2.5 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of each final cover area. Section 6 describes the documentation requirements.

Table 2-1
Standard Tests on Infiltration Layer Soils

Soil Test Category	Type of Test	Standard Test Method	Frequency of Testing
Quality Control Testing of Source Borrow Materials	Unified Soil Classification	ASTM D 2487	Once per soil type
	Moisture/Density Relationship	ASTM D 698 or D 1557	
	Grain Size	ASTM D 422 or D 1140	
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906	1/Moisture/Density Relationship
Constructed Soil Infiltration Layer	Field Density	ASTM D 6938 and D2216 [A]	1/8,000 ft^2 per 6-inch lift[B]
	Grain Size	ASTM D 422 or D 1140	1/100,000 ft^2 per 6-inch lift[B]
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906	1/surface acre (evenly distributed through all lifts)[B, D]
	Thickness[C]	Texas Licensed Surveyor	1/10,000 ft^2

[A] This method is not applicable if the field measuring device (i.e., nuclear gauge) also measures moisture.
[B] A minimum of 1 of each of the designated tests must be conducted for each lift, regardless of cover area.
[C] If the option to use settlement plates to verify the thickness of the final cover layers is utilized, the procedure outlined in Section 2.3.2 will be followed.
[D] One permeability test is required for each acre of final cover construction area. In addition, one permeability test is required for each lift of final cover construction area (or reconstructed area). Therefore, a 1-acre final cover construction area constructed in three lifts will require three permeability tests (one for each lift), while a 9-acre final cover construction area constructed in three lifts will require one permeability test per acre for a total of nine permeability tests with three tests on each lift.

3 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

3.1 Introduction

This section describes CQA procedures for the installation of geosynthetic components.

The scope of geosynthetic-related construction quality assurance includes the following elements:

- Geomembrane Liner
  - 40-mil LLDPE – smooth on the top slopes and textured on both sides for the side slopes. Minimum required material properties for the geomembrane are listed in Table 3-2.
- Drainage Layer
  - Drainage geocomposite (single-sided on the top slopes and double-sided on the side slopes). Minimum required material properties for the drainage layer are listed in Table 3-3.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this FCSQCP, the construction and testing of all elements of the final cover are performed in accordance with this FCSQCP and the Closure Plan (Appendix IIIJ), and that the project is built in accordance with the project construction drawings and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. The FCSER, prepared after project completion, will document that the constructed facility meets design intent and specifications and that all final cover construction and QA/QC testing are performed in accordance with this FCSQCP.

3.2 Geosynthetics Quality Assurance

3.2.1 General

A geomembrane and a drainage geocomposite are the geosynthetic components of the composite final cover system. All testing requirements and minimum required properties are listed in Tables 3-1, 3-2, and 3-3. Construction quality control for the geosynthetic installation will be performed by the geosynthetic installation contractor. Construction quality assurance for the geosynthetic installation will be performed by the POR to assure the geosynthetic is constructed as specified in the design. Construction must be conducted in accordance with the project construction drawings, which will be developed in accordance with this FCSQCP and the Closure Plan (Appendix IIIJ) at the time of each final cover construction and in accordance with specifications outlined in this FCSQCP. To monitor compliance, a quality assurance program will include the following:

- A review of the manufacturer's quality control submittals;
- Material conformance testing;
- Field and construction testing; and
- Construction monitoring.

The manufacturer's quality control submittals will include resin and physical material testing. Conformance testing refers to verification tests conducted by an independent third party laboratory to confirm the material meets the required specification prior to acceptance of the geosynthetic from the manufacturer. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this FCSQCP, the project construction drawings, and specifications. Field testing will be observed by the CQA monitor. Documentation must meet the requirements of this FCSQCP.

3.3 Geomembrane

3.3.1 General

This section describes material types, handling, installation, and testing of geomembrane. Smooth geomembrane will be used on top slopes (slopes less than 6 percent) and textured geomembrane will be used on sideslopes (3.5H:IV to 4H:IV slopes).

3.3.2 Delivery

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

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the specifications and stacked not more than five rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications. This documentation will be included in the FCSER.
- The geosynthetics receipt log form has been completed for materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, reviewed, and accepted.

3.3.3 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane installed. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5199 for smooth geomembrane and ASTM D 5994 for textured geomembrane)
- Tensile properties (ASTM D 638/Type IV Specimen)

The density of the geomembrane must be less than 0.939 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. No single measurement may be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 40 mil geomembrane a minimum thickness of 36 mils is required), and the average must be at least 40 mils.

Sampling Procedure. Samples will be taken across the entire roll width. Unless otherwise specified, samples should be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

Table 3-1
Required Testing for Geomembranes

Responsible Party	Type of Test		Standard Test Method	Frequency of Testing
Resin Manufacturer	Resin	Density	ASTM D 1505/D792	Per 100,000 ft^2 and every resin lot
		Melt Flow Index	ASTM D 1238 (Condition E)	
	Resin/Compound Evaluation		Per manufacturer's quality control specifications	Per manufacturer's quality control specifications
Geomembrane Manufacturer	Manufacturer's Quality Control		Testing per GRI Standard, GRI Test Method GM17 for 40 mil LLDPE[1]	
Conformance Testing by Third Party Independent Laboratory	Thickness[2]		ASTM D 5199 (smooth LLDPE), or D 5994 (textured LLDPE)	Per 100,000 ft^2 and every resin lot
	Specific Gravity/Density		ASTM D 1505/D 792	
	Carbon Black Content		ASTM D 1603	
	Carbon Black Dispersion		ASTM D 5596	
	Tensile Properties		ASTM D 6693 (Type IV)	
Third Party CQA	Destructive Seam Field Testing[3]	Shear & Peel	ASTM D 6392	Various for field, lab, and archive
	Non-Destructive Seam Field Testing	Air Pressure	ASTM D 5820	All dual-track fusion weld seams
		Vacuum	ASTM D 5641	All non-air pressure tested seams when possible

1 UV Resistance testing not required for geomembrane, which is to be immediately covered.
2 Field thickness measurements for each panel must be conducted. Use ASTM D 5199/D 5994 and perform 1 series of measurements along the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than 10% below the required nominal thickness in order for the panel to be acceptable.
3 Passing criteria for seams are listed in Table 3-2.

Table 3-2
Minimum Required Properties of 40-mil-thick Smooth and Textured (Both Sides) LLDPE Geomembrane

Property	Test Method	Minimum Required Property[7]	
		Smooth	Textured
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199 (smooth) ASTM D 5994 (textured)	40 36 NA	38 34 36
Density, g/cc (maximum)	ASTM D 1505/ D 792	0.939	0.939
Asperity Height, mils	GRI GM12	NA	16
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	152 800	60 250
Tear Resistance, lb	ASTM D 1004	22	22
Puncture Resistance, lb	ASTM D 4833	56	44
Break Resistance Strain, % (min)	ASTM D 5617	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0-3.0	2.0 – 3.0
Carbon Black Dispersion[3], Category	ASTM D 5596	1 or 2 and 3	1 or 2 and 3
Oxidative Induction Time (OIT), minimum average Standard OIT, minutes, or High Pressure OIT, minutes	ASTM D 3895 ASTM D 5885	100 400	100 400
Oven Aging at 85ºC, minimum average Standard OIT – % retained after 90 days or High Pressure OIT – % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	35 60	35 60
UV Resistance[4], minimum average High Pressure OIT[5] – % retained after 1600 hrs	GRI GM 11 ASTM D 5885	35	35
Seam Properties[6] Shear Strength, lb/in Peel Strength, lb/in	ASTM D 6392	60 50 (44, Extrusion Weld)	60 50 (44, Extrusion Weld)

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views; 9 in Categories 1 or 2 and 1 in Category 3.
4 The condition of the test should be 20 hr UV cycle at 75ºC followed by 4 hr. condensation at 60ºC.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.
6 Values listed for shear strength and peel strength are for 4 out of 5 specimens. The 5th specimen can be as low as 80% of the listed values.
7 Minimum required property values are based on GRI GM17, except for seam properties, which are based on GRI GM19. If newer version of GRI GM17 and/or GRI GM19 becomes available in the future the POR may utilize values or guidance in this FCSQCP from updated GRI documents.

3.3.4 Anchor Trench Backfill

General fill material placed in anchor trenches will be uncontaminated earthen material and will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted to at least 90 percent of Standard Proctor maximum dry density (ASTM D 698). In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the FCSER. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of final cover system.

3.3.5 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the subgrade (i.e., soil infiltration layer) should be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- Lines and grades for the infiltration layer have been verified by the contractor and surveying of top of soil infiltration grades has been completed in accordance with Section 2.
- Soil infiltration layer construction has been completed in areas with no ponded water.
- The infiltration layer has been placed in accordance with the specification.
- No signs of desiccation exist, and the moisture content of the infiltration layer surface was controlled. A smooth drum roller will be used, as necessary, to minimize desiccation.
- The infiltration layer is free of surface irregularities and protrusions.
- The infiltration layer surface does not contain stones or other objects that could damage the geomembrane and underlain infiltration layer. The surface will be smooth and free of foreign and organic material, sharp objects, stones greater than 3/4 inches, or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- The geomembrane will not be placed during inclement weather such as rain or high winds.
- Construction stakes and hubs have been removed and the resultant holes have been properly backfilled. There are no rocks, debris, or any other objects on the infiltration layer surface.

- The geosynthetics contractor, POR or his representative, and the permittee or his representative have certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying soil infiltration layer.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (See Section 3.5).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.). In addition, geomembrane seaming operation should not be performed when the air temperature is less than 40°F or greater than 105°F, or when standing water or frost is on the ground, unless these requirements

are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.

- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown geomembrane). Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that seams are oriented parallel to the slip direction, and the textured material extends a minimum of approximately 5 feet out past the side slope.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels should be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welder) must be tested, at a minimum, at daily start-up and immediately after any break, and/or anytime the machine is turned off for more than 30 minutes in accordance with the specifications to determine if the equipment is functioning properly. The FCSER should include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work and when the type of geomembrane seam (e.g., smooth to smooth, smooth to textured, etc.) is changed. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.3.6 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392:

Hot Wedge: AD and AD-Brk>25%

Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld should be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane material over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR's direction. The welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).

- The ambient temperature, measured 6 inches above the geomembrane surface, is between 40°F and 105°F, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels should be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specification. Seams should be oriented parallel to the line of maximum slope with no horizontal seams on side slopes or top slopes. In corners and odd-shaped geometric locations, the number of field seams should be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.3.6 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing performance is in compliance with the specifications and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel should be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications.
- Observe that the entire length of each seam is tested in accordance with the specifications.
- Observe all continuity testing and record results on the appropriate log.
- Observe that testing is completed in accordance with the project specifications.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that repairs are completed and tested in accordance with the project specifications.
- Record completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam
- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one stratified location for every 500 feet of field seam length or major fraction thereof.
- Sample locations should not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is a film tear bond (FTB) and the seam strength meets the required strength values for peel and shear given previously in Table 4-2 and below in the subsection "Passing Criteria for Welds" for both field testing and third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples should be identified by assigning an identifying letter to the initial destructive test sample number (For example, DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the Operator to archive. The laboratory sample will be shipped to the third party laboratory for delivery and subsequent testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. Seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third Party Laboratory Testing. Destructive samples must be shipped to the third party laboratory for seam testing. Testing for each sample will include five bonded seam shear strength tests and five peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the manufacturer's specifications. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by GRI Test Method GM-19 for geomembrane seams and are listed in Table 3-2. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 40-mil smooth and textured LLDPE. Elongation measurements should be omitted for field testing.

- Shear strength (lb/in) 60
- Shear elongation at break (%) 50
- Peel strength (lb/in) 50 (44, Extrusion weld)
- Peel separation (%) 25

3.3.7 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specifications developed for each phase of final cover construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 3 of this FCSQCP. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.
- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

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 surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round 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.
- Perform testing on repair seams consistent with Section 3.3.6 – Construction Testing.

3.3.8 Wrinkles

Wrinkles must be walked-out or removed as much as possible prior to field seaming. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The

CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.3.9 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.

3.3.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane in accordance with Section 2.3.3.

3.3.11 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- Seams have been inspected and verified to be acceptable.
- Required laboratory and field tests have been completed, reviewed, and verified to be acceptable.
- Required contractor-supplied documentation has been received, reviewed, and verified to be acceptable.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the FCSER by TCEQ.

3.3.12 Bridging

Bridging must be removed.

3.4 Drainage Geocomposite – Geonet and Geotextile

3.4.1 General

The drainage layer consists of a drainage geocomposite overlying the geomembrane and infiltration layer on the topslopes and sideslopes. The CQA monitor will provide on-site observation of drainage layer installation. The POR will make sufficient site visits during the drainage layer installation to document the installation in the FCSER.

Double-sided drainage geocomposite (non-woven geotextile bonded to the top and bottom of HDPE drainage net) will be installed on the sideslopes and single-sided drainage geocomposite (non-woven geotextile bonded to the top of the HDPE drainage net) will be installed on the top slope. The drainage geocomposite will have the minimum properties listed in Table 3-3.

Manufacturer quality control testing procedures and frequencies for drainage geocomposite are discussed in Section 3.4.3 and Table 3-3.

The drainage layer for Subtitle D areas has been designed to include a network of drainage pipes that will convey flow from the drainage geocomposite to either the final cover drainage letdowns or the perimeter drainage system. The drainage layer component design and specifications (including the pipe design and specifications) are included in Appendix IIIE-A.

3.4.2 Delivery

Upon delivery the CQA monitor must observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.
- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. Rolls that do not have proper manufacturer's documentation will also be stored at a separate location until documentation has been received and approved. The references herein to drainage geocomposite also apply to geonet and geotextile as applicable.

3.4.3 Testing

The drainage geocomposite manufacturer (or supplier) will conduct quality control testing and certify that materials delivered to the site comply with project specifications for each phase of final cover construction. The minimum testing frequency will be one test sample per 100,000 square feet of drainage geocomposite (or geonet/geotextile). The material certifications will be reviewed by the POR to verify that the drainage geocomposite meets the values given in the FCSQCP or specifications. Third party laboratory testing will be required for drainage layer geocomposite transmissivity. Additionally, material strength parameters used for geotechnical analysis in Appendix IIIM will be verified by a third party laboratory prior to construction, and slope stability analysis will be updated as necessary based on site-specific material data.

Geonet will be tested by the manufacturer for thickness, tensile strength, and carbon black content. Geotextile will be tested for mass per unit area, grab tensile strength, and Apparent Opening Size (AOS). The finished drainage geocomposite will be tested for peel adhesion and transmissivity. Table 3-3 summarizes testing requirements for drainage geocomposite and geotextile.

Where optional procedures are noted in the test method, the specification requirements will prevail. The CQA monitor will review test results and will report any nonconformance to the POR and to the contractor.

3.4.4 Installation

Surface Preparation. Prior to drainage geocomposite installation, the CQA monitor must observe the following:

- Lines and grades have been verified by the surveyor (where required).
- The subgrade has been prepared in accordance with the specifications and the geomembrane has been installed as outlined in Section 3.3.5.
- The geomembrane installation, including required documentation, has been completed.
- The supporting surface (i.e., the geomembrane) does not contain stones that could damage the drainage geocomposite or the geomembrane.

Drainage Geocomposite Placement. During placement, the CQA monitor must:

- Ensure that single-sided geocomposite is placed on slopes less than 7H:1V and double-sided geocomposite is placed on slopes equal to or steeper than 7H:1V.
- Observe the drainage geocomposite as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications.
- Verify that equipment used does not damage the drainage geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that people working on the drainage geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying geomembrane.

Table 3-3
Geotextile and Drainage Geocomposite
Required Testing and Properties[1]

Responsible Party	Material	Test	Standard	Required Bottom Liner Property[5]	Required Overliner Property[5]
Manufacturer	Geotextile (before lamination)	Unit Weight	ASTM D 5261	8 oz/sy	6 oz/sy
		Apparent Opening Size	ASTM D 4751	0.180 mm	0.25 mm
		Grab Strength	ASTM D 4632	220 lbs	157 lbs
		Grab Elongation	ASTM D 4632	50%	50%
		Tear Strength	ASTM D 4533	95 lbs	55 lbs
		Puncture Strength	ASTM D 6241	575 lbs	310 lbs
		Permeability	ASTM D 4491	1.3 cm/s	0.2 cm/s
		UV Stability	ASTM D 4355	50%	50%
Manufacturer	HDPE Geonet (before lamination)	Density	ASTM D 1505	0.94 g/cm^3	0.94 g/cm^3
		Thickness	ASTM D 5199	0.25 inch	0.30 inch
		Carbon Black Content	ASTM D 1603	2%	2%
		Tensile Strength	ASTM D 7179	55 lb/in	75 lb/in
		Compressive Strength	ASTM D 6364		120 lb/in^2
		Transmissivity	ASTM D 4716	14.49 gpm/ft	9.0 gpm/ft
Third Party Laboratory	Drainage Geocomposite	Transmissivity	ASTM D 4716	See Note 2	See Note 2
		Strength[3]	ASTM D 5321	Refer to Section 5 for geotechnical strength requirements.	Refer to Section 5 for geotechnical strength requirements.
Manufacturer		Ply Adhesion	ASTM D 7005	1.0 lb/in	1.0 lb/in

1 The minimum testing frequency will be one test sample per 100,000 square feet.

2 As noted in Appendix IIIE-A, the transmissivity of the single-sided geocomposite will be 1.57×10^{-3} m^2/s, measured at a minimum gradient of 0.06 under a minimum normal pressure of 120 psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours. The transmissivity of the double-sided geocomposite on 4H:1V sideslopes will be 1.09×10^{-4} m^2/s, measured at a gradient of 0.25 under a minimum normal pressure 124 psf, boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours. The transmissivity of the double-sided geocomposite on 3.5H:1V sideslopes will be 4.87×10^{-4} m^2/s, measured at a gradient of 0.286 under a minimum normal pressure 125 psf, boundary conditions consisting of soil/geocomposite/geomembrane with a minimum seating time of 100 hours. As shown in Appendix IIIC-A, the HELP Model was developed for a 220-mil geocomposite. 220-mil geocomposite may be utilized as long as the required values (eg. transmissivity) are met.

3 The adhesion and interface friction angle of the geocomposite components will be determined to verify they meet the values used in the slope stability analysis of Appendix IIIM-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the final cover system). The slope stability analysis may be repeated to demonstrate that the actual materials used for construction will result in an acceptable factor of safety.

4 Different testing gradients for the geocomposite may be specified in the project specifications if the specified gradients are not applicable or no longer conservative in view of existing or expected slope conditions.

5 Minimum required property values for the geotextile and drainage geocomposite transmissivity are based on calculations provided in Appendix IIIE-A. The geonet material properties are based on values specified by multiple manufacturers which are consistent with GRI-GM-4. In addition, each material will be tested prior to construction to verify that it meets the minimum required properties. At the time of each construction event, an updated GRI-GM-4 will be used if available.

- Verify that the drainage geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from windblown geocomposite).
- Verify that the drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- Observe that the drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- Observe that on slopes the drainage geocomposite is secured with sand bag anchoring at the top of the slope and then rolled down the slope.
- Observe that adjacent rolls of drainage geocomposite are overlapped, tied, and seamed in accordance with the specifications and manufacturer's recommendations.
- Observe that tying is with plastic fasteners in accordance with the manufactures recommendations. In the absence of other specifications the geonet panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).
- Observe that geotextile component is overlapped and either heat bonded or sewn together.
- Observe that the drainage collection pipe is secured to the drainage geocomposite by using zip ties at a maximum spacing of 50 feet.

3.4.5 Repairs

Repair procedures include:

- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed drainage geocomposite by tying every 6 inches.
- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll, and the two portions of the drainage geocomposite will be jointed.
- Patches will be installed in accordance with "Drainage Geocomposite Placement" under Section 3.4.4.

3.5 Equipment on Geosynthetic Materials

Construction equipment on the composite final cover system will be minimized to reduce the potential for geosynthetic material puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap geomembrane material (rub sheets) above geosynthetic materials in the final cover system. The erosion layer will be placed using low ground pressure equipment. The CQA monitor will verify that the geosynthetics are not displaced while the soil layers (e.g., erosion layer) are being placed.

Unless otherwise specified by the POR, lifts of soil material placed over geosynthetics will conform to the following guidelines:

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in.)
< 5.0	12 and under
5.1 - 8.0	18
8.1 - 16.0	24
>16.0	36

No equipment will be left running and unattended over the constructed geosynthetics.

3.6 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of the constructed final cover system. Section 6 describes the documentation requirements.

4 CONSTRUCTION QUALITY ASSURANCE FOR EROSION LAYER

The erosion layer will consist of a minimum of 12 inches of earthen material and will be capable of sustaining native and introduced vegetative growth and must be seeded immediately after completion of the final cover. Temporary or permanent erosion control materials may be used to minimize erosion and aid establishment of vegetation. The physical characteristics of the erosion layer will be evaluated through visual observation (and laboratory testing if deemed necessary by the POR) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the POR.

The erosion layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics. Equipment used to install the erosion layer must meet the requirement of Section 3.5.

The thickness of the erosion layer will be verified with surveying procedures at a minimum of one survey point per 10,000 square feet of constructed area by a licensed Texas surveyor with a minimum of one reference point. The survey results for the erosion layer will be included in the FCSER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Monitor haul-road thickness over installed geosynthetics and verify that equipment hauling and material placement meet equipment specifications. (See Section 3.5).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the erosion layer materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey. Thickness surveying to determine minimum erosion layer thickness will be performed similar to the infiltration layer thickness verification shown in Table 2-1.

5 GEOTECHNICAL STRENGTH TESTING REQUIREMENTS

This section of the FCSQCP addresses the geotechnical strength requirements for the Subtitle D final cover system. Each component of the final cover system is subject to the material testing requirements outlined in Sections 2 through 4 of this FCSQCP, as applicable. Prior to each final cover construction event, the geotechnical testing outlined in Table 5-1 will be performed using actual materials to verify that the final cover meets the material strength requirements. A geotechnical analysis using the strength parameters listed in Table 5-1 is presented in Appendix IIIM.

The testing outlined in Table 5-1 will be performed under the supervision of the POR by a third party independent geotechnical laboratory. The POR will ensure that (1) the strength values are met, or (2) provide an updated geotechnical analysis in the FCSER that will be submitted to TCEQ after each final cover construction event. If the geotechnical analysis is updated, the resulting factor of safety values must meet the recommended minimum factor of safety values established in Appendix IIIM.

Table 5-1
Minimum Required Strength for Various Final Cover Components[1]

Final Cover System Component Interface	Peak Strength		Residual Strength	
	Adhesion (psf)	Friction Angle (degree)	Adhesion (psf)	Friction Angle (degree)
Erosion Layer/Double-sided Geocomposite Interface	100	18	80	14
Double-sided Geocomposite/Textured LLDPE Geomembrane Interface	100	21	80	10
Textured LLDPE Geomembrane/Clay Infiltration Layer Interface	200	15	80	10
Geocomposite/Smooth LLDPE Geomembrane Interface	100	13	80	8
Smooth LLDPE Geomembrane/Clay Infiltration Layer Interface	100	13	80	8

[1] The adhesion and interface friction angle of final cover components will be determined using ASTM D5321 by a third party verified geotechnical laboratory to verify they meet the values used in the slope stability analysis included in IIIE-A. This test may be performed using stack testing (i.e., performing a single test combining all components of the final cover). The slope stability analysis may be repeated to demonstrate that the actual materials used for construction will result in an acceptable factor of safety. Refer to Appendix IIIM for detailed strength information and procedures for calculating factors of safety.

6 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports, progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the FCSER. Standard report forms will be provided by the POR prior to construction.

6.1 Preparation of FCSER

The POR, on behalf of the Operator, will submit to the TCEQ a FCSER for approval of each portion of final cover system constructed.

Testing, evaluation, and submission of the FCSER for the final cover system during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with this FCSQCP.

At a minimum, the FCSER will contain:

- A summary of all construction activities.
- All laboratory and field test results.
- Third party conformance test results for geocomposite transmissivity and strength parameters.
- Manufacturer's certifications for all geosynthetics.
- Documentation of thickness of the infiltration and erosion layers by a Texas registered Surveyor.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings, including all previous FCSER submittals and dates of TCEQ approval.
- A statement of compliance with the permit FCSQCP and construction plans.

- The reports will be signed and sealed by a professional engineer(s) licensed in the State of Texas.

The as-built record drawings will accurately site the constructed location of work items, including the anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the FCSER.

6.2 Reporting Requirements

The FCSER will be signed and sealed by the POR, signed by the Operator, and submitted to the MSW Permits Section of the Waste Permits Division of the TCEQ for approval.

APPENDIX IIIE-A

FINAL COVER DRAINAGE LAYER DESIGN

Includes pages IIIE-A-1 through IIIE-A-32

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LICENSED
PROFESSIONAL ENGINEER

02-22-2022

Required:

The purpose of this appendix is to design the drainage layer that is located between the geomembrane and erosion layer. As shown on Drawing A.17 in Appendix IIIA-A (Details FC1A and FC2A), the drainage layer will consist of a single-sided drainage geocomposite on the topslope and a double-sided geocomposite on the sideslope at this site. In addition, a network of drainage pipes will convey flow from the drainage geocomposite to either a drainage letdown structure (refer to Sheet IIIJ-A-16) or to the perimeter drainage system (as shown on Drawing A.19-Detail FC5A). A detail of the drainage pipe in the final cover is provided on Drawing A.17-Detail FC4A. The following design criteria are used to design the geocomposite drainage layers.

1. Sideslope. The sideslope drainage layer is designed to prevent uplift forces from occurring on the erosion layer. This will ensure the stability of the erosion layer.

2. Topslope. The topslope drainage layer is designed so that the erosion layer located on the topslope does not become completely saturated and is designed to withstand potential estimated hydrostatic uplift forces.

3. Topslope/Sideslope Transition. This drainage layer is designed to prevent uplift forces from occurring on the erosion layer along the grade break. This will ensure the stability of the erosion layer.

Method:

Sideslope

1. Estimate the percolation into the drainage geocomposite from the erosion layer. To provide for a conservative analysis, it is assumed that the permeability of the cover soils is equal to the percolation rate into the drainage geocomposite.

2. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

3. Determine the pipe capacity, spacing, and size to ensure that no uplift forces on the erosion layer will occur (i.e., demonstrate that the flow depth within the drainage geocomposite is less than the drainage geocomposite thickness).

Topslope

1. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

2. Use HELP to demonstrate that the proposed pipe spacing and single-sided drainage geocomposite are adequate to keep the erosion layer from becoming completely saturated. Also, verify that potential uplift forces will not cause a stability issue with the erosion layer.

Topslope/Sideslope Transition

1. Estimate the percolation into the drainage geocomposite from the erosion layer. To provide for a conservative analysis, it is assumed that the permeability of the cover soils is equal to the percolation rate into the drainage geocomposite.

2. Determine the transmissivity of the specified drainage geocomposite. The laboratory transmissivity is reduced to simulate the actual transmissivity after strength and environmental factors are taken into consideration.

3. Determine the pipe capacity, spacing, and size to ensure that no uplift forces on the erosion layer will occur (i.e., demonstrate that the flow depth within the drainage geocomposite is less than the drainage geocomposite thickness).

References:

1. Koerner, R.M., *Designing With Geosynthetics*, third edition, 1994.
2. Maidment, David R., *Handbook of Hydrology*. McGraw-Hill, Inc. 1993.
3. *The Hydrologic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3.* EPA/600/R-94/168a, September 1994.
4. Giroud, J.P., Zornberg, J.G., Zhao, A., *Hydraulic Design of Geosynthetic and Granular Liquid Collection Layer*, 2000.
5. Gray, Donald H., Koerner, Robert M., Qian, Xuede, Geotechnical Aspects of Landfill Design and Construction, 2002.
6. Geosynthetic Institute, GRI Standard GC-8, 2001.
7. GSE Drainage Design Manual, Second Edition, June 2007.

Solution:

1. **Sideslope**

1.1 Estimate the percolation into the drainage geocomposite from the erosion layer.

Calculate the flow entering the geocomposite from unit area of erosion layer (q_f):

k_{cover} = 1.2E-04 cm/s

$q_f = k_{cover} * i$ (i is the gradient of water percolating within the drainage layer, and it is equal to 1 for vertical percolation.)

q_f = 1.2E-4 cm/s * 1 / (30.48 cm/ 1 ft)

q_f = 3.94E-06 cfs/sf

Calculate the maximum flow in drainage geocomposite on the sideslope:

L = 180 ft, longest flow length between two drain pipes on sideslope.

$q_p = q_f * L$

q_p = 0.00071 sf/s

1.2 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of a geocomposite - double-sided 250 mil geonet with 6 oz/sy geotextiles.

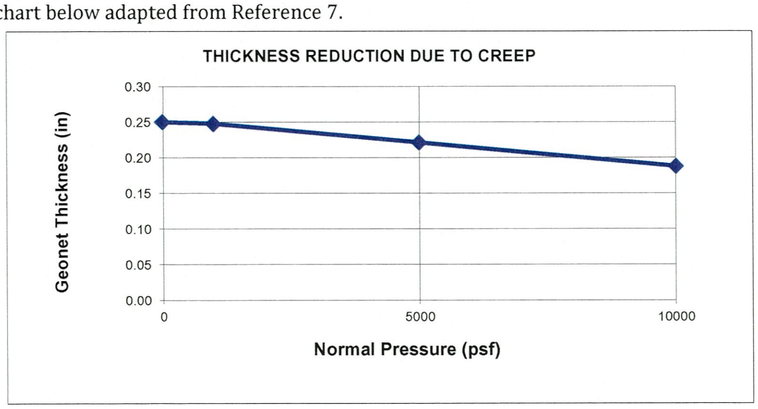
Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 120 pcf
Thickness of Erosion Layer = 1 ft

Table 1.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (4H:1V)	25	1.03	124	0.250	0.006
Closed (3.5H:1V)	28.6	1.04	125	0.250	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.
[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.
[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart below adapted from Reference 7.



Reduction Factors for Strength and Environmental Conditions:

Table 1.2 - Reduction Factors

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick double-sided geocomposite is shown on Sheet IIIE-A-14.

Calculate the Design Transmissivity (T_{DES}) of the final cover geocomposite drainage layer:

Table 1.3 - Transmissivity of the Specified Geocomposite Material

Fill Condition	P[1] (psf)	t[2] (in)	T[3] (m^2/s)	ORF[4]	T_{DES}[5] (m^2/s)	T_{DES}[5] (sf/s)
Closed (4H:1V)	124	0.250	5.77E-04	5.28	1.09E-04	1.18E-03
Closed (3.5H:1V)	125	0.250	4.87E-04	5.28	9.22E-05	9.93E-04

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 1.1.

[2] t is the drainage layer thickness from Table 1.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy geotextiles) as shown on Sheet IIIE-A-14.

[4] ORF is the Overall Reduction Factor obtained from Table 1.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / ORF$$

Determine the capacity of the drainage geocomposite based on the estimated transmissivity and compare to the estimated flow rate that occurs due to infiltration.

The maximum required design transmissivity (T_{DES}) is: 0.00118 sf/s

T_{DES}	>	q_p
(flow capacity of the drainage geocomposite per unit width)		(estimated flow in the drainage geocomposite per unit width)
0.00118 sf/s	>	0.00071 sf/s

Since the capacity of the drainage geocomposite is greater than the estimated flow in the geocomposite, the actual flow depth is contained within the geocomposite and the design is acceptable. Therefore, the maximum spacing between the drain pipes located on the 3.5H:1V or 4H:1V sideslopes is 180 feet. As shown on Sheet IIIE-A-16, the distance between the pipes is equal to no more than 180 feet.

1.3 Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

Maximum Flow to Collection Pipe for Various Pipe Lengths:

$Q_{max} = L_{p\text{-}max} \times q_p$

Pipe Length, $L_{p\text{-}max}$ (ft)	Flow per Unit Length of Pipe, q_p (cfs/ft)	Maximum Pipe Flow, Q_{max}[1] (cfs)
< 240	0.00071	0.170
240 - 700	0.00071	0.496
700 - 1500	0.00071	1.063

[1] Maximum pipe flow is calculated using the maximum pipe length in each range.

Capacity of collection pipe:

Use Manning Equation to determine the pipe capacity.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$

(from Chapter 10 of Ref 2)

where:

Q_{pc}: Full flow pipe capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes						
d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
4	0.09	1.05	0.08	0.005	0.010	0.175
6	0.20	1.57	0.13	0.005	0.010	0.517
8	0.35	2.09	0.17	0.005	0.010	1.114

Fullness Ratio of Pipe (f):

$f = Q_{max}/Q_{pc}$

Fullness Ratio of Pipe (f)					
Fill Condition	Pipe Length (ft)	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (sideslope)	< 240	4	0.170	0.175	0.97
	240 - 700	6	0.496	0.517	0.96
	700 - 1500	8	1.063	1.114	0.95

Conclusion: A pipe size of 4 inches is acceptable for the sideslope area for pipes lengths of 240 feet and shorter. A pipe size of 6 inches is acceptable for pipe lengths between 225 and 700 feet. A pipe size of 8 inches is acceptable for pipe lengths between 700 and 1500 feet.

A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

2. **Topslope**

2.1 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - single-sided 250 mil geonet with 6 oz/sy geotextile.

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness =	0.250	in
Unit Weight of Erosion Layer Soil =	120	pcf
Thickness of Erosion Layer =	1	ft

Table 2.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (topslope)	6	1.002	120	0.250	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.
[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.
[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart shown above in Step 1.2 adapted from Reference 7.

Reduction Factors for Strength and Environmental Conditions:

Table 2.2 - Factors of Safety

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.
[2] The Total Reduction Factor is the product of all the reduction factors.
[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick single-sided geocomposite is shown on Sheet IIIE-A-15.

Calculate the Design Transmissivity (T_{DES}) and permeability of the final cover geocomposite drainage layer:

Table 2.3 - Required Transmissivity

Fill Condition	P[1] (psf)	t[2] (in)	T[3] (m^2/s)	ORF[4]	T_{DES}[5] (m^2/s)	k[6] (cm/s)
Closed (topslope)	120	0.250	1.57E-03	5.28	2.97E-04	4.67

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 2.1.

[2] t is the drainage layer thickness from Table 2.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy polypropylene geotextile) as shown on Sheet IIIE-A-15.

[4] ORF is the Overall Reduction Factor obtained from Table 2.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (ORF)$$

[6] k is the hydraulic conductivity and calculated using the following equation:

$$k = T_{DES} / t$$

2.2 Use HELP to demonstrate that the proposed pipe spacing and single-sided drainage geocomposite are adequate to prevent the erosion layer from becoming completely saturated. The scenario analyzed in the HELP model used a model area of 3.2 acres which represents the largest estimated area that would contribute to a particular drainage collection pipe. The maximum pipe spacing ($L_{s\text{-}max}$) for this closed 6% topslope scenario is 180 feet. Refer to pages IIIE-A-19 through IIIE-A-26 for the HELP model analysis. Additionally, based on this maximum spacing and as shown in the HELP model results, the maximum head on the final cover geomembrane is 4.33 inches. In this situation, the 12-inch erosion layer above the geocomposite/liner does not become entirely saturated. Final cover stability calculations are provided in Appendix IIIM.

Verify that the erosion layer will not be impacted by uplift.

Uplift may occur if the depth of water in the geocomposite exceeds the thickness of the geocomposite. As noted above, the maximum water depth on the geomembrane is 4.33 inches. If this occurs, the potential for uplift exists. Therefore to prevent uplift, the weight of erosion layer must be higher than the uplift exerted by the maximum head in drainage geocomposite.

Maximum Head Estimated by HELP Model, h_{max}=	4.33	inches (refer to page IIIE-A-25)
Unit Weight of Erosion Layer, γ_{EL}=	120	pcf (refer to Appendix IIIM - Geotechnical Report)
Unit Weight of Water, γ_W=	62.4	pcf
Thickness of Erosion Layer, h_{EL}=	12	inches

Uplift Force, UF=	$h_{max} \times \gamma_W$	psf
Weight of Erosion Layer, W_{EL}=	$h_{EL} \times \gamma_{EL}$	psf
UF=	(4.33/12)*62.4	(psf)
W_{EL}=	1 ft x 120 pcf	(psf)
UF=	22.5	psf
W_{EL}=	120	psf
Factor of Safety, FS=	W_{EL} / UF	
FS=	120 / 22.5	
FS=	5.3	

Conclusion:
A factor of safety of more than one indicates that the erosion layer will not be impacted by uplift force caused by the maximum head in the geocomposite estimated by the HELP Model. Therefore, the erosion layer is stable as designed. As shown on page IIIE-A-24, under normal conditions the head in the geocomposite is 0.010 inches which is less than the thickness of the geocomposite. Therefore, the thickness of the water on the geomembrane will not exceed the thickness of the geocomposite under normal conditions.

2.3 Determine pipe size.

Maximum flow to a collection pipe has been estimated by using the HELP model.
From the HELP model, the lateral drainage collected from the geocomposite is:

HELP Model Area=	3.2	acres, Largest area draining to a pipe
Maximum Daily Flow=	20,200	cf/day
Q_{max}=	0.234	cfs

Collection Pipe Size:

Use Manning Equation to determine the pipe size.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:
Q_{pc}: Full Flow Pipe Capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe diameter
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross Section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity for Different Pipe Sizes

d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
5	0.14	1.31	0.10	0.005	0.010	0.318
6	0.20	1.57	0.13	0.005	0.010	0.517
8	0.35	2.09	0.17	0.005	0.010	1.114

Fullness Ratio of Pipe (f):

$f = Q_{max}/Q_{pc}$

Fullness ratio of pipe (f)

Fill Condition	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (topslope)	5	0.234	0.318	0.74
	6	0.234	0.517	0.45
	8	0.234	1.114	0.21

Conclusion: A pipe size of 5 inches or more is acceptable for the topslope area.
A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

3. Topslope/Sideslope Transition

3.1 Estimate the percolation into the drainage geocomposite from the erosion layer.

Calculate the flow entering the geocomposite from unit area of erosion layer (q_f):

k_{cover} = 1.2E-04 cm/s

q_f = k_{cover} * i (i is the gradient of water percolating within the drainage layer, and it is equal to 1 for vertical percolation.)

q_f = 1.2E-4 cm/s * 1 / (30.48 cm/ 1 ft)

q_f = 3.94E-06 cfs/sf

4H:1V Sideslope

Calculate the maximum flow in drainage geocomposite on 4H:1V sideslope.
Consider the flow coming from the topdeck:

L (4H:1V)= 120 ft
L (6%)= 7 ft, topdeck length between the topdeck drain pipe and the grade break
L (total)= 127 ft
q_p = q_f * L (total)
q_p = 0.00050 sf/s

3.5H:1V Sideslope

Calculate the maximum flow in drainage geocomposite on 3.5H:1V sideslope.
Consider the flow coming from the topdeck:

L (3.5H:1V)= 95 ft
L (6%)= 6 ft, topdeck length between the topdeck drain pipe and the grade break
L (total)= 101 ft
q_p = q_f * L (total)
q_p = 0.00040 sf/s

Maximum topslope/sideslope transition percolation, q_p: 0.00050 sf/s

3.2 Determine the transmissivity of the specified drainage geocomposite.

Final Cover Drainage Layer Thickness:

Specified Design:
Drainage layer consists of geocomposite drainage layer - double-sided 250 mil geonet with 6 oz/sy geotextiles on sideslopes and single-sided on topslopes.

Assume the final cover drainage layer will undergo compression due to the weight of soil (erosion layer).

Unloaded Geocomposite Drainage Layer Thickness = 0.250 in
Unit Weight of Erosion Layer Soil = 120 pcf
Thickness of Erosion Layer = 1 ft

Table 3.1 - Final Cover Drainage Layer Thickness

Fill Condition	Slope %	d_S[1] (ft)	P[2] (psf)	t[3] (in)	t[3] (m)
Closed (4H:1V)	25	1.03	124	0.250	0.006
Closed (3.5H:1V)	28.6	1.04	125	0.250	0.006

[1] d_S is the vertical thickness of soil above the final cover drainage layer.
[2] P is the pressure on the final cover drainage layer due to the weight of the erosion layer soil.
[3] t is the thickness of the final cover drainage layer after being subjected to compression based on the chart shown above in Step 1.2 adapted from Reference 7.

Reduction Factors for Strength and Environmental Conditions:

Table 3.2 - Reduction Factors

Reduction Factors		Closed Condition
RF_{IN}	Delayed Intrusion	1.1
RF_{CC}	Chemical Clogging	1.2
RF_{BC}	Biological Clogging	2.0
Total Reduction Factor[2]		2.64

Overall Factor of Safety to Account For Uncertainties	2.0
Overall Reduction Factor (ORF)[3]	5.28

[1] Values are obtained from References 1, 5, and 6.

[2] The Total Reduction Factor is the product of all the reduction factors.

[3] The Overall Reduction Factor is the product of the Total Reduction Factor and Overall Factor of Safety to Account For Uncertainties.

Required Transmissivity Data:

The required minimum transmissivity for the 250-mil-thick double-sided and single-sided geocomposite is shown on Sheets IIIE-A-14 and IIIE-A-15, respectively.

Calculate the Design Transmissivity (T_{DES}) of the final cover geocomposite drainage layer:

Table 3.3 - Transmissivity of the Specified Geocomposite Material

Fill Condition	P[1] (psf)	t[2] (in)	T[3] (m^2/s)	FS Factor[4]	T_{DES}[5] (m^2/s)	T_{DES}[5] (sf/s)
Closed (4H:1V)	124	0.250	5.77E-04	5.28	1.09E-04	1.18E-03
Closed (3.5H:1V)	125	0.250	4.87E-04	5.28	9.22E-05	9.93E-04

[1] P is the pressure on the final cover drainage layer due to the weight of erosion layer from Table 3.1.

[2] t is the drainage layer thickness from Table 3.1.

[3] T is obtained from the specified transmissivity values for a representative geocomposite drainage layer (250-mil-thick geonet with 6 oz/sy polypropylene geotextiles) as shown on Sheets IIIE-A-14 and IIIJ-A-A-15 (double-sided and single-sided, respectively).

[4] ORF is the Overall Reduction Factor obtained from Table 3.2.

[5] T_{DES} is the design transmissivity value calculated using the following equation:

$$T_{DES} = T / (ORF)$$

Determine the capacity of the drainage geocomposite based on the estimated transmissivity and compare to the estimated flow rate that occurs due to infiltration.

The maximum required design transmissivity (T_{DES}) is: 0.00118 sf/s

T_{DES}	>	q_p
(flow capacity of the drainage geocomposite per unit width)		(estimated flow in the drainage geocomposite per unit width)
0.00118 sf/s	>	0.00050 sf/s

Since the capacity of the drainage geocomposite is greater than the estimated flow in the geocomposite, the actual flow depth is contained within the geocomposite and the design is acceptable. Therefore, the maximum spacing between the pipe located just below the grade break on the 3.5H:1V or 4H:1V slope and the pipe located just above the grade break on the topdeck is 127 feet. As shown on Sheet IIIE-A-16, the distance between these two pipes is equal to no more than 127 feet.

3.3 Determine pipe size required to convey the design flow for the specified pipe length and pipe outlet spacing.

Maximum Flow to Collection Pipe for Various Pipe Lengths:

$Q_{max} = L_{p\text{-}max} \times q_p$

Pipe Length, $L_{p\text{-}max}$ (ft)	Flow per Unit Length of Pipe, q_p (cfs/ft)	Maximum Pipe Flow, Q_{max}[1] (cfs)
< 325	0.00050	0.163
325 - 600	0.00050	0.300
600 - 1000	0.00050	0.500

[1] Maximum pipe flow is calculated using the maximum pipe length in each range.

Capacity of the collection pipe:

Use Manning Equation to determine the pipe capacity.

Pipe Capacity (Q_{pc}):

$$Q_{pc} = \frac{1.49AR^{2/3}S^{1/2}}{n}$$ (from Chapter 10 of Ref 2)

where:

Q_{pc}: Full Flow Pipe Capacity (cfs)
d: Diameter (inches), HDPE ADS collection pipe
A: Flow area (sf), Cross section of pipe
P: Perimeter (ft)
R: Hydraulic radius (ft) = Cross section (A) / Perimeter (P)
S: Pipe slope (ft/ft)
n: Manning roughness coefficient

Pipe Capacity						
d (inches)	A (sf)	P (ft)	R (ft)	S (ft/ft)	n	Q_{pc} (cfs)
4	0.09	1.05	0.08	0.005	0.01	0.175
5	0.14	1.31	0.10	0.005	0.01	0.318
6	0.20	1.57	0.13	0.005	0.010	0.517

Fullness Ratio of Pipe (f):

$f = Q_{max}/Q_{pc}$

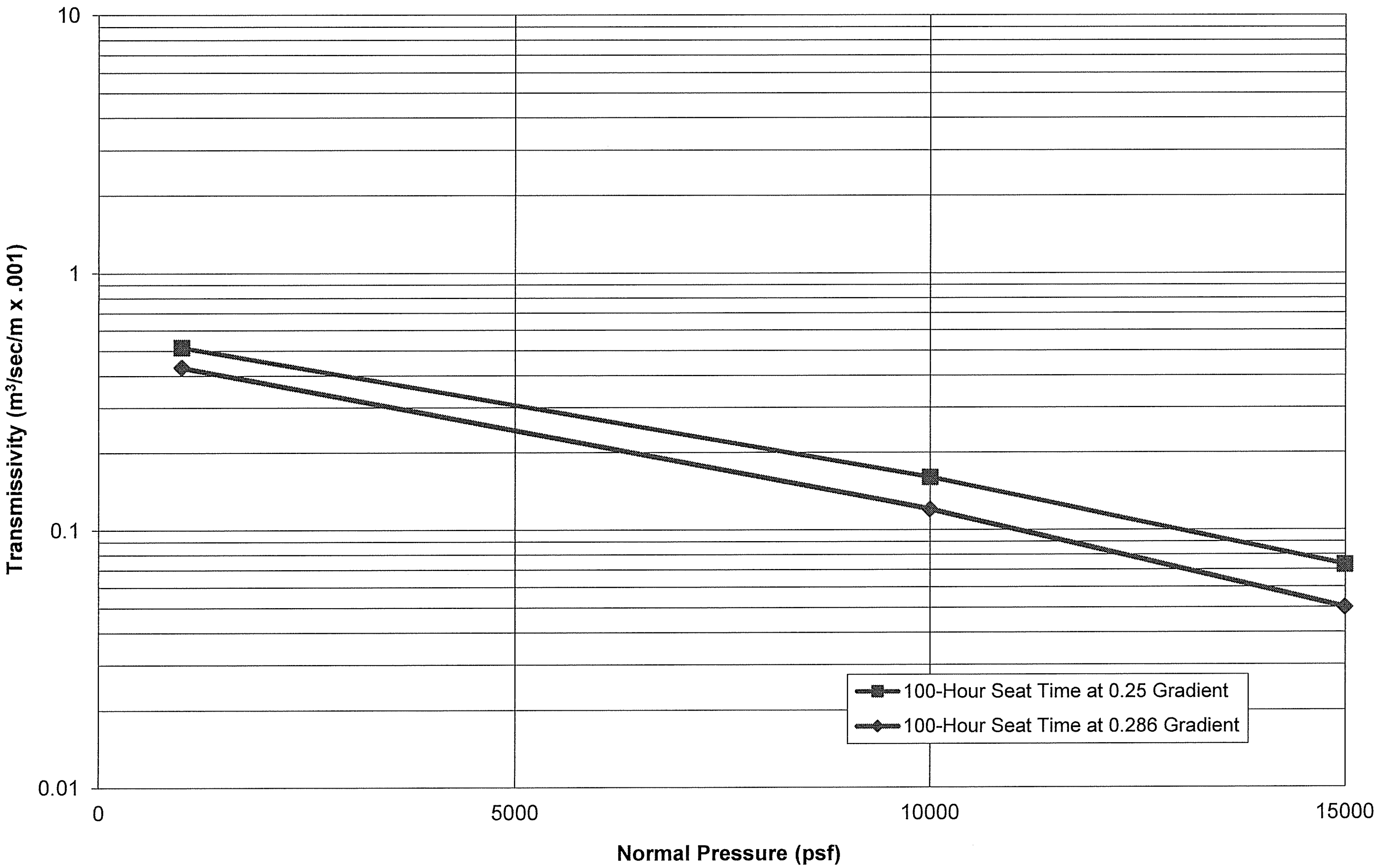
Fullness Ratio of Pipe (f)					
Fill Condition	Pipe Length (ft)	d (inches)	Q_{max} (cfs)	Q_{pc} (cfs)	f
Closed (transition)	< 325	6	0.163	0.175	0.93
	325 - 600	8	0.300	0.318	0.94
	600 - 1000	10	0.500	0.517	0.97

Conclusion: A pipe size of 4 inches is acceptable for the transition area for pipes lengths of 325 feet and shorter. A pipe size of 5 inches is acceptable for pipe lengths between 325 and 600 feet. A pipe size of 6 inches is acceptable for pipe lengths between 600 and 1000 feet.

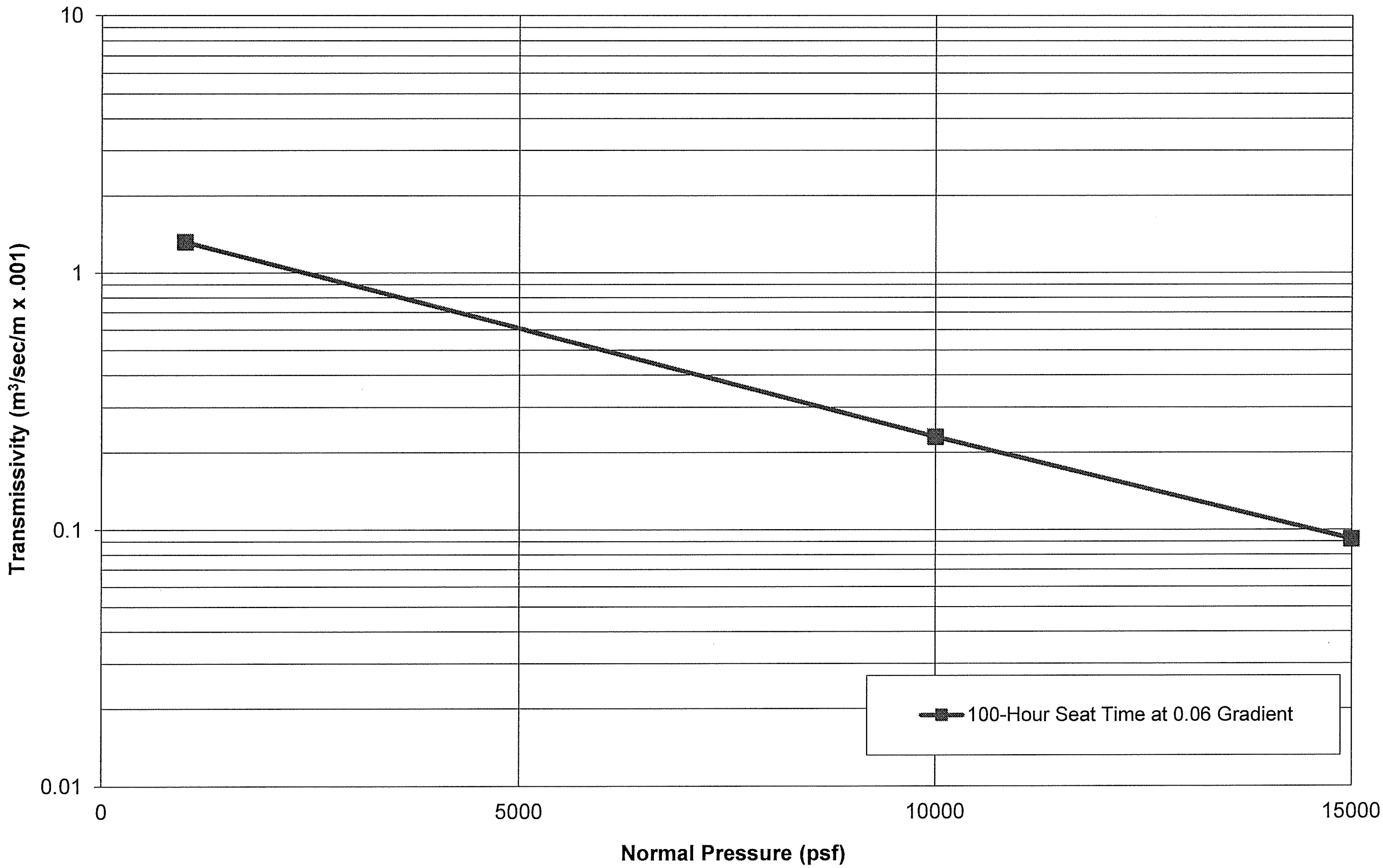
A minimum open area of 1 square inch per foot of drainage pipe is recommended by the U.S. Soil Conservation Service and the U.S. Bureau of Reclamation. Therefore, the number of 0.5 in diameter holes per foot will be 6 and total slot area provided by the manufacturer will provide documentation that minimum of 1 square inch of total slot area is provided per linear foot of pipe.

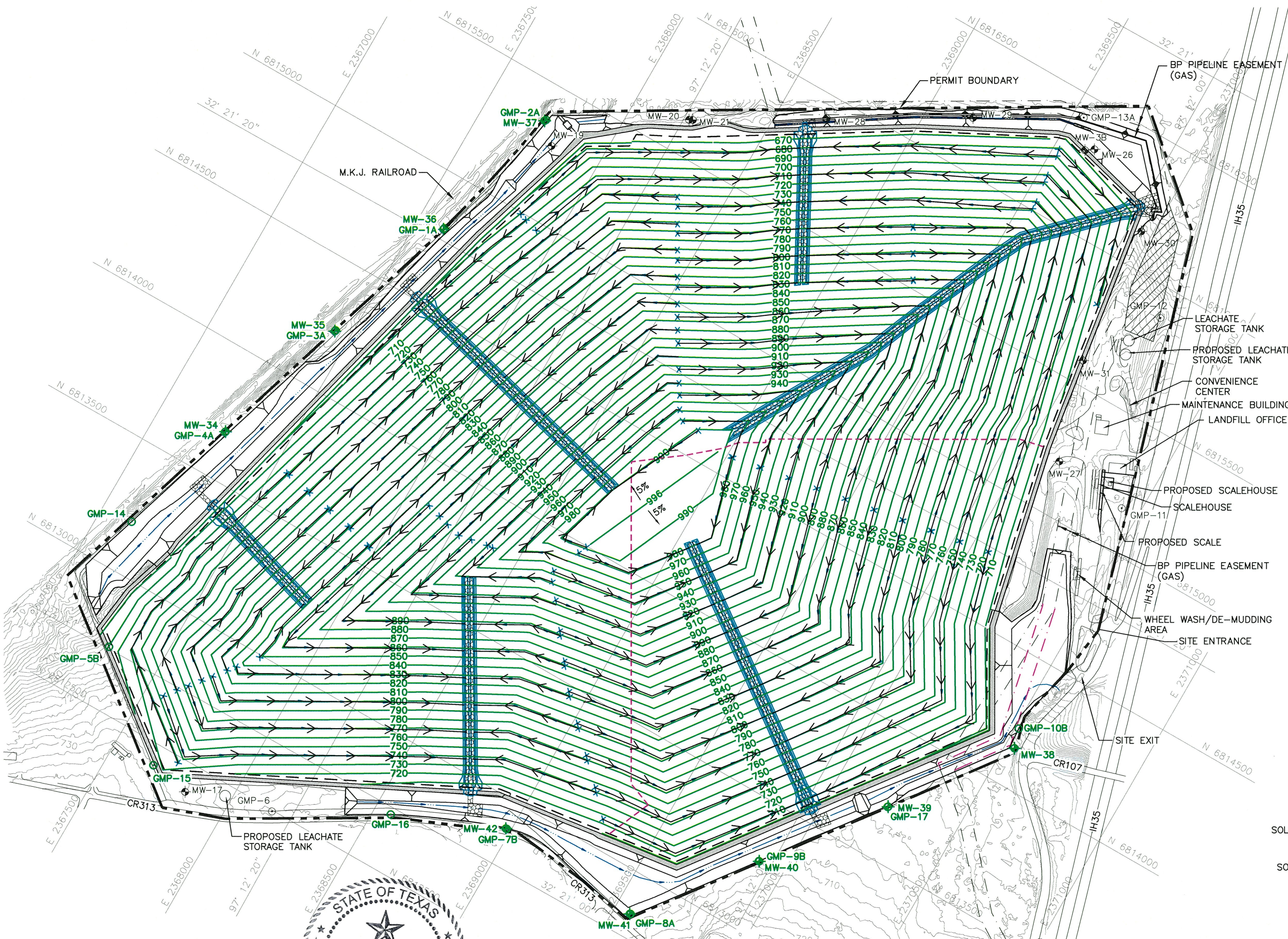
TRANSMISSIVITY OF DOUBLE-SIDED GEOCOMPOSITE

6 oz/sy Polypropylene Geotextiles with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)



TRANSMISSIVITY OF SINGLE-SIDED GEOCOMPOSITE
6 oz/sy Polypropylene Geotextile with 250 mil Drainage Net
(Soil/Geocomposite/Geomembrane)





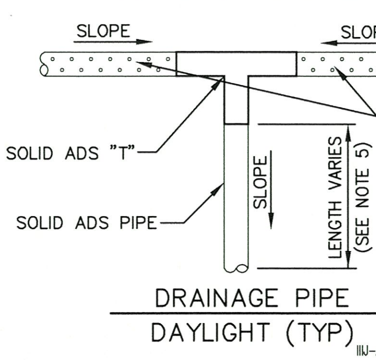
LEGEND

SCALE IN FEET: 0, 200, 400

- PERMIT BOUNDARY
- LIMITS OF WASTE
- EXISTING CONTOUR (750)
- STATE PLANE COORDINATE (N 6816000)
- GEODETIC COORDINATE (32° 21' 20")
- EASEMENT
- RELOCATED EASEMENT
- FINAL COVER CONTOUR (800)
- LIMIT OF CLASS 1 WASTE DISPOSAL AREA
- DRAINAGE LETDOWN
- DRAINAGE SWALE
- GABIONS
- EXISTING GROUNDWATER MONITORING WELL (MW-7)
- EXISTING GAS MONITORING PROBE (GMP-12)
- PROPOSED GROUNDWATER MONITORING WELL (MW-7)
- PROPOSED GAS MONITORING PROBE (GMP-17)
- PERFORATED DRAINAGE PIPE
- FUTURE LFGTE FACILITY LOCATION

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. REFER TO APPENDIX IIIF-SURFACE WATER DRAINAGE PLAN FOR DRAINAGE DESIGN INFORMATION.
3. MAXIMUM FINAL COVER ELEVATION IS 996.0 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 992.5 FT-MSL.
4. TYPICAL SIDESLOPES ARE 4H:1V IN THE CLASS 1 AREA AND 3.5H:1V IN THE MSW AREA, TYPICAL TOPSLOPE IS 6%.
5. DRAINAGE PIPE WILL BE PLACED WITH A 0.5% FLOW LINE SLOPE PARALLEL TO THE SWALES ON THE TOPSLOPES AND SIDESLOPES OF THE FILL. THE PIPE WILL BE PLACED WITH A 0.5% FLOW SLOPE AT THE TOE OF THE FINAL COVER (NO MORE THAN 500 FEET ON THE FLAT AREAS) AND DAYLIGHTED IN DRAINAGE LETDOWNS AND AS NECESSARY AT THE TOE OF FINAL COVER TO THE PERIMETER DRAINAGE STRUCTURES WITH A SOLID PIPE TEE CONNECTION.



REFER TO APPENDIX IIIF, DRAWING IIIF.11, DETAILS D1 AND D2 FOR DETAILS THAT SHOW HOW THE TEE CONNECTS TO LETDOWN.

DRAINAGE PIPE DAYLIGHT (TYP) — IIIE-A-16

TEE — IIIE-A-16

STATE OF TEXAS — DAVID E. POE — 81734 — LICENSED PROFESSIONAL ENGINEER

02-22-2022

☐ DRAFT	PREPARED FOR
☒ FOR PERMITTING PURPOSES ONLY	TEXAS REGIONAL LANDFILL COMPANY, LP
☐ ISSUED FOR CONSTRUCTION	

DATE: 02/2022	DRAWN BY: JDW
FILE: 0771-368-11	DESIGN BY: CAM
CAD: IIIE-A-16_DRAINAGE PIPE LAYOUT.DWG	REVIEWED BY: DEP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT
FINAL COVER DRAINAGE PIPE LAYOUT

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

WWW.WCGRP.COM — SHEET IIIE-A-16

O:\0771\368\EXPANSION 2021\PART III\IIIE\IIIE-A-16 PIPE PLAN.dwg, jwilson, 1:2

HELP MODEL FOR FINAL COVER

INTRODUCTION

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 was used to estimate the head on final cover geomembrane. This HELP analysis was used to demonstrate that the proposed pipe spacing and single-sided drainage geocomposite are adequate to keep potential uplift forces from adversely impacting the erosion layer.

The closed landfill conditions were modeled for a 30-year period. The evaporative zone depth was selected to be 12 inches and the leaf area index was selected to be 4.5. These parameters are consistent with the parameters shown in Appendix IIIC-A. The curve number for the closed topslope condition is 81.4 and the percent runoff area is 100, which corresponds to "good" ground cover. This is representative of the final cover, which will have a minimum 90 percent vegetation coverage.

The final cover over the Subtitle D areas consist of a 12-inch erosion layer with the top 6 inches capable of sustaining growth of vegetation, a geocomposite drainage layer, a 40-mil LLDPE geomembrane liner, and an 18-inch infiltration layer. The geomembrane liner was modeled for good installation quality. The infiltration layer consists of compacted soil with a hydraulic conductivity of $1x10^{-5}$ cm/s. Default values for the moisture content, porosity, field capacity, and wilting point for each layer were selected.

The scenario analyzed in the HELP model used a model area of 1.08 acres, which represents the largest estimated topdeck area that would contribute to a particular drainage collection pipe. The maximum pipe spacing for this area is 115 feet.

Refer to page IIIE-A-19 for a summary of the HELP analysis. The HELP model output for the closed 5 percent top slope is included on pages IIIE-A-20 through IIIE-A-26.

TURKEY CREEK LANDFILL
0771-368-11-123
HELP VERSION 3.07 SUMMARY SHEET

		CLOSED 5% TOPSLOPE
GENERAL INFORMATION	Case No.	1
	No. of Years	30
	Ground Cover	GOOD
	SCS Runoff Curve No.	81.8
	Model Area (acre)	1.08
	Runoff Area (%)	100
	Maximum Leaf Area Index	4.5
	Evaporative Zone Depth (inch)	12
EROSION LAYER (Texture = 10)	Thickness (in)	12
	Porosity (vol/vol)	0.3980
	Field Capacity (vol/vol)	0.2440
	Wilting Point (vol/vol)	0.1360
	Init. Moisture Content (vol/vol)	0.1750
	Hyd. Conductivity (cm/s)	1.2E-04
DRAINAGE LAYER (Texture = 0)	Thickness (in)	0.250
	Porosity (vol/vol)	0.8500
	Field Capacity (vol/vol)	0.0100
	Wilting Point (vol/vol)	0.0050
	Init. Moisture Content (vol/vol)	0.0100
	Hyd. Conductivity (cm/s)	4.67
	Slope (%)	5
	Slope Length (ft)	115
FLEXIBLE MEMBRANE LINER (Texture = 36)	Thickness (in)	0.04
	Hyd. Conductivity (cm/s)	4.0E-13
	Pinhole Density (holes/acre)	0
	Install. Defects (holes/acre)	0
	Placement Quality	GOOD
INFILTRATION LAYER (Texture = 0)	Thickness (in)	18
	Porosity (vol/vol)	0.4270
	Field Capacity (vol/vol)	0.4180
	Wilting Point (vol/vol)	0.3670
	Init. Moisture Content (vol/vol)	0.4270
	Hyd. Conductivity (cm/s)	1.0E-05
PRECIPITATION	Average Annual (in)	37.85
RUNOFF	Average Annual (in)	1.87
EVAPOTRANSPIRATION	Average Annual (in)	26.61
LATERAL DRAINAGE COLLECTED[1]	Average Annual (cf/year)	36,739
	Peak Daily (cf/day)	7,545
HEAD ON FINAL COVER GEOMEMBRANE	Average Annual (in)	0.006
	Peak Daily (in)	3.32

[1] This is the lateral drainage collected in the drainage geocomposite in the final cover system.

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:     C:\TC\J\CL\DATA4.D4
TEMPERATURE DATA FILE:       C:\TC\J\CL\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\TC\J\CL\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\TC\J\CL\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\TC\J\CL\DATA10.D10
OUTPUT DATA FILE:            C:\TC\J\CL\OUTPUT1.OUT


TIME:   9:46     DATE:  10/ 1/2021


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

     TITLE:  TURKEY CREEK - FC PIPE DESIGN -CLOSED CASE

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
          THICKNESS                      =     12.00   INCHES
```

```
   POROSITY                        =      0.3980 VOL/VOL
   FIELD CAPACITY                  =      0.2440 VOL/VOL
   WILTING POINT                   =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT      =      0.1750 VOL/VOL
   EFFECTIVE SAT. HYD. COND.       =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                           LAYER  2
                           --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
   THICKNESS                       =      0.25    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.       =   4.67000008000      CM/SEC
   SLOPE                           =      5.00    PERCENT
   DRAINAGE LENGTH                 =    115.0     FEET


                           LAYER  3
                           --------

               TYPE 4 - FLEXIBLE MEMBRANE LINER
                 MATERIAL TEXTURE NUMBER  36
   THICKNESS                       =      0.04    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.       =  0.399999993000E-12 CM/SEC
   FML PINHOLE DENSITY             =      0.00    HOLES/ACRE
   FML INSTALLATION DEFECTS        =      0.00    HOLES/ACRE
   FML PLACEMENT QUALITY           =  3 - GOOD


                           LAYER  4
                           --------

                 TYPE 3 - BARRIER SOIL LINER
```

MATERIAL TEXTURE NUMBER 0

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.	=	0.999999975000E-05 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 5.% AND A SLOPE LENGTH OF 115. FEET.

SCS RUNOFF CURVE NUMBER	=	81.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.080	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.100	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.776	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.632	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.788	INCHES
TOTAL INITIAL WATER	=	9.788	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	=	4.50
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	12.0 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
2.56	2.60	3.64	3.28	4.30	3.34
2.56	2.17	3.43	4.59	2.81	2.89

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
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

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

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.00	2.42	3.32	3.16	3.86	3.38
	3.53	2.06	3.86	4.64	2.58	3.04
STD. DEVIATIONS	1.37	1.39	1.99	1.94	1.81	2.19

```
                    2.81     1.53     2.12     3.85     1.97     2.18

RUNOFF
------
  TOTALS            0.022    0.043    0.112    0.120    0.143    0.171
                    0.288    0.040    0.155    0.575    0.106    0.097

  STD. DEVIATIONS   0.050    0.101    0.246    0.274    0.352    0.280
                    0.553    0.085    0.214    0.983    0.254    0.185

EVAPOTRANSPIRATION
------------------
  TOTALS            1.563    1.686    2.508    2.639    3.279    2.775
                    2.718    1.854    2.716    2.084    1.268    1.521

  STD. DEVIATIONS   0.488    0.683    0.996    1.241    1.088    1.466
                    1.537    1.325    1.218    0.964    0.505    0.491

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
  TOTALS            0.6989   0.5934   0.8363   0.5028   0.4501   0.6324
                    0.5759   0.1454   0.6032   1.8532   0.9745   1.5051

  STD. DEVIATIONS   0.9596   0.6823   1.2321   0.7659   0.6759   0.7233
                    0.9979   0.3085   0.7276   2.1303   1.3288   1.5829

PERCOLATION/LEAKAGE THROUGH LAYER  4
------------------------------------
  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          0.0030   0.0030   0.0064   0.0038   0.0036   0.0038
                    0.0056   0.0007   0.0034   0.0269   0.0061   0.0076

  STD. DEVIATIONS   0.0048   0.0044   0.0116   0.0083   0.0088   0.0053
                    0.0126   0.0019   0.0054   0.0450   0.0113   0.0104

*******************************************************************************
```

****

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.85	(7.081)	148381.9	100.00
RUNOFF	1.871	(1.1373)	7336.44	4.944
EVAPOTRANSPIRATION	26.613	(3.5103)	104332.94	70.314
LATERAL DRAINAGE COLLECTED FROM LAYER 2	9.37125	(3.95542)	36739.055	24.75979
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.007	0.00000
AVERAGE HEAD ON TOP OF LAYER 3	0.006	(0.004)		
CHANGE IN WATER STORAGE	-0.007	(0.5716)	-26.51	-0.018

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	5.70	22346.279
RUNOFF	1.984	7779.4390
DRAINAGE COLLECTED FROM LAYER 2	1.92450	7544.80566
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000001	0.00376
AVERAGE HEAD ON TOP OF LAYER 3	2.800	
MAXIMUM HEAD ON TOP OF LAYER 3	3.323	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	13.0 FEET	

SNOW WATER	1.51	5925.7603

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3367
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

*** 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.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.8971	0.1581
2	0.0025	0.0100
3	0.0000	0.0000
4	7.6860	0.4270
SNOW WATER	0.000	

****
****

GEOTEXTILE DESIGN

TURKEY CREEK LANDFILL
0771-368-11-123
FINAL COVER GEOTEXTILE DESIGN

REQUIRED: Determine the required properties for the geotextile used as the top component of the drainage geocomposite.

METHOD: Design geotextiles and determine material property requirements.

REFERENCES:

1. MIRAFI, *Geotextile Filter Design, Application, and Product Selection Guide*, 1991, http://www.tcmirafi.com/pdf/brochures/ef_guidelines.pdf.
2. Koerner, R.M., *Designing With Geosynthetics*, Fifth Edition, 2005.
3. AASHTO Designation: M288-17.
4. GRI White Paper #4, *Reduction Factors (RFs) Used in Geosynthetic Design,* Feb. 3, 2005, revised Mar. 1, 2007.

SOLUTION:

Geotextile Used as Top Component of Drainage Geocomposite

The design calculations assume the erosion layer soil will consist of soils with a hydraulic conductivity less than 1.2×10^{-4} cm/s and percent fines (passing #200 sieve) greater than 20 percent.

If the erosion layer material contains less than 20 percent fines, these geotextile calculations will be revised and included in the GLER for a specific cell to demonstrate adequacy of the material used.

Retention:

Based on Chart 1 - "Soil Retention Criteria," given on page IIIE-A-31, the apparent opening size (O_{95}) may be determined.

$O_{95} <$ 0.21 mm

Permeability:

The required permeability is determined by comparing the permeability of the erosion layer (1.2×10^{-4} cm/s) with the permeability of the geotextile after the appropriate reduction factors are applied to the laboratory permeability of the geotextile.

Minimum Laboratory Permeability Specified (k_{ult}) = 0.2 cm/s

To determine the allowable permeability (k_{allow}) of the geotextile, the following reduction factors are used:

Table 2 - Reduction Factors[1]

RF_{SCB} =	Reduction factor for soil clogging and blinding	2.0
RF_{CR} =	Reduction factor for creep reduction of void space	2.0
RF_{IN} =	Reduction factor for adjacent materials intruding into void spaces	1.2
RF_{CC} =	Reduction factor for chemical clogging	1.0
RF_{BC} =	Reduction factor for biological clogging	2.0
	Overall Reduction Factor (ORF) =	9.6

[1] Reduction factors obtained from Ref. 4.

$k_{allow} = k_{ult} / ORF = (0.2\ cm/s) / 9.6$

$k_{allow} =$ 2.1E-02 cm/s

$k_{allow} >> k_{erosion\ layer}$ (1.2×10^{-4} cm/s).

Specification: Geotextile component of geocomposite permeability shall be equal to or greater than 0.2 cm/s as determined by ASTM D 4491.

Survivability:

Geotextile properties should be selected considering Class 2 survivability (refer to Sheet IIIE-A-32).

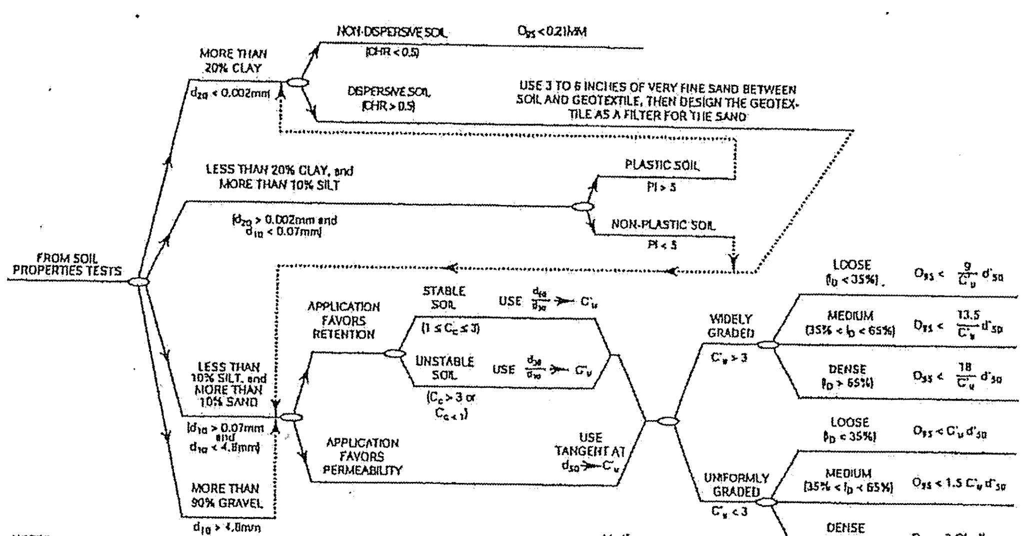
Durability:

Chemical compatibility with leachate will be considered during the selection process for the specific geotextile.

Summary of required properties for geotextile component of drainage geocomposite:

Apparent opening size	<	0.21	mm
Grab tensile strength	>	157	lb
Elongation	>=	50	%
Puncture strength	>	309	lb
Trapezoid tear	>	56	lb
Permeability	>=	0.2	cm/s

Chart 1. *Soil Retention Criteria of Steady-State Flow Conditions*



NOTES:

d_x = particle diameter of which size *x* percent is smaller

$C'_u = \sqrt{\frac{d'_{100}}{d'_0}}$ where: d'_{100} and d'_0 are the extremeties of a straight line drawn through the particle-size distribution, as directed above and d'_{50} is the midpoint of this line

$C_c = \frac{(d_{30})^2}{d_{60} \times d_{10}}$

I_D = relative density of the soil
PI = plasticity index of the soil
DHR = double-hydrometer ratio of the soil
O_{95} = geotextile opening size

Table 1—Geotextile Strength Property Requirements

	Test Methods	Units	Geotextile Class[a,b]						
			Class 1A	Class 1		Class 2		Class 3	
			Elongation <50%	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]	Elongation <50%[c]	Elongation ≥50%[c]
Grab strength	ASTM D4632/ D4632M	N	[e]	1400	900	1100	700	800	500
Sewn seam strength[d]	ASTM D4632/ D4632M	N	[e]	1260	810	990	630	720	450
Tear strength	ASTM D4533/ D4533M	N	[e]	500	350	400[f]	250	300	180
Puncture strength	ASTM D6241	N	[e]	2750	1925	2200	1375	1650	990
Permittivity	ASTM D4491	sec^{-1}	Refer to Table 6.	Minimum property values for permittivity, AOS, and UV stability are based on geotextile application. Refer to Table 2 for subsurface drainage; Table 3 and Table 4 for separation, Table 5 for stabilization, and Table 7 for permanent erosion control.					
Apparent opening size	ASTM D4751	mm	Refer to Table 6.						
Ultraviolet stability (retained strength)	ASTM D4355/ D4355M	%	Refer to Table 6.	T					

[a] Required geotextile class is designated in Table 2, 3, 4, 5, 6, or 7 for the indicated application. The severity of installation conditions for the application generally dictates the required geotextile class. Class 1A and Class 1 are specified for more severe or harsh installation conditions where there is a greater potential for geotextile damage, and Classes 2 and 3 are specified for less severe conditions.

[b] All numeric values represent MARV in the weaker principal direction. (See Section 8.1.2.)

[c] As measured in accordance with ASTM D4632/D4632M.

[d] When sewn seams are required. Refer to Appendix X1 for overlap seam requirements.

[e] Property requirement not applicable to Class 1A. Refer to Table 6 for enhancement for wide width tensile property requirement.

[f] The required MARV tear strength for woven monofilament geotextiles is 250 N.

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIE-B
WATER BALANCE FINAL COVER SYSTEM
QUALITY CONTROL PLAN

Prepared for

Texas Regional Landfill Company, LP

February 2022

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
02-22-2022

Prepared by

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WCG Project No. 0771-368-11-123

CONTENTS

STATE OF TEXAS
DAVID E. POE
81734
LICENSED PROFESSIONAL ENGINEER

02-22-2022

LIST OF TABLES

1 INTRODUCTION

Purpose

This Water Balance Final Cover System Quality Control Plan (WBFCSQCP) has been prepared to provide the Owner, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality of the water balance (WB) final cover system and to satisfy the environmental protection requirements under the Texas Commission on Environmental Quality (TCEQ) regulations. More specifically, the WBFCSQCP addresses the required procedures to construct the WB cover, including the establishment of vegetation.

This WBFCSQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Earthwork
- Section 3 – Vegetation Planting Plan
- Section 4 – Documentation

This WBFCSQCP ensures that the WB final cover will be constructed consistent with the conditions set forth in Appendix IIIJ-A as well as the requirements of the TCEQ guidance document titled, "Guidance for Requesting a Water Balance Alternative Final Cover for A Municipal Solid Waste Landfill," dated March 2017. The Professional of Record (POR) will verify that the WB final cover is constructed consistent with the conditions, parameters, and assumptions used in the WB final cover model and design. This WBFCSQCP has also been developed to ensure that vegetation will be established consistent with the vegetation parameters used in the WB final cover model and design.

Additionally, a Performance Verification Plan for Option 2 WB Cover is included in Appendix IIIE-B-1. This plan sets forth the design and monitoring procedures that will be used to verify the percolation rate for the 10-acre test plot. Soil moisture and basal percolation information will be collected using automatic data acquisition systems. The actual percolation rate will be compared to the required performance criteria to verify that the constructed WB final cover is performing as designed before additional WB final cover is constructed at the site.

Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

American Society for Testing and Materials.

Construction Quality Assurance (CQA)

A planned system of activities that provides the Owner and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Owner and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer in Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitors working under the POR's direction.

The POR may also be known in applicable regulations as the CQA Engineer or Resident Project Representative.

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily quality assurance/quality control observation and testing must be NICET-certified in geotechnical engineering technology at level two or higher for soils testing; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) on behalf of the POR.

Additional CQA monitors may be used if they work under the direction of a qualified CQA monitor who is onsite full-time.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Owner, and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction specifications and Section 2 of this plan.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

This is the organization that operates the disposal unit.

Operator's Representative

This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor.

Vegetation Establishment Contractor

This is a person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Owner and who is qualified in the establishment of vegetation similar to vegetation required by this plan.

Water Balance Final Cover System Evaluation Report (WBFCSER)

Upon completion of the installation of final cover, the certification will be in the form of the WBFCSER which will be signed by the POR and include all documentation necessary for certification for final cover installation.

2 CONSTRUCTION QUALITY ASSURANCE FOR EARTHWORK

2.1 Introduction

This section of the WBFCSQCP Plan addresses the construction of the soil components of the WB final cover system and outlines the program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements and treatment of problems. Two WB Final cover options are developed for the site. Option 1 (refer to Appendix IIIJ-C) is applicable to both side slopes and top slopes of the MSW area. Option 2 is only applicable to MSW sideslope areas. Class 1 liner area will not receive WB final cover. This plan is applicable for both options.

The scope of earthwork and related construction quality assurance includes the following elements:

- Installation of Storage Layer
- Vegetation Topsoil Layer

2.2 Earthwork Construction

The following paragraphs describe general construction procedures to be used for various earthwork components of the final cover system. The testing requirements set forth in the following sections must be met at the time of construction. If soils with different characteristics for the WB final construction are proposed to be used, a prior written authorization from the TCEQ will be obtained under the provisions of Title 30 TAC §305.70, as a non-noticed permit modification.

2.2.1 Storage Layer

After the landfill reaches the permitted bottom of final cover grades in each area to receive final cover, operational cover soils will be placed according to the facility operation plan. During each WB final cover construction event, the storage layer (i.e. foundation layer) that has a minimum thickness of 3 ft-10-inch for Option 1 and 30 inches for Option 2 measured from the top of the waste will be installed in accordance with this WBFCSQCP.

The contractor may re-work any existing operational cover to meet the requirements of the storage layer. The POR may partially remove any existing operational cover before installing the storage layer. The storage layer soils will be tested in accordance with Section 2.4 and will be approved by the POR prior to placement of the vegetation topsoil layer. Rock particles will only exist in incidental amounts in the soil used for this layer.

If existing operational cover soil is incorporated into the storage layer, Quality Assurance/Quality Control (QA/QC) for this portion of the storage layer will be performed under the supervision of the POR. QA/QC procedures to be performed during preparation of the storage layer will include all of the requirements of the storage layer. QA/AC procedures for the installation of the storage layer will include continuous observation of soil being placed for color and texture as well as testing in accordance with Section 2.4. During the observation of the storage layer placement, the CQA monitor may require additional testing in accordance with Section 2.4 if any change in soil physical properties (e.g., color, texture) is observed. Upon completion of the rework, the POR will determine that the layer meets all the storage layer requirements set forth in this plan. If the existing operational cover is vegetated, the vegetated soil will be scraped off and possibly used as vegetation topsoil layer as described in Section 2.2.2 – Vegetation Topsoil Layer. If the existing soils are removed (for re-use as a vegetative topsoil layer or disqualified by POR), a storage layer of soil meeting the requirements of the storage layer will be placed over the area prior to the installation of the vegetation topsoil layer. The bottom of the storage layer will be re-worked to provide a firm base for the placement of this layer.

The storage layer will consist of a minimum 3 ft-10-inch-thick layer (measured perpendicular to the surface of the storage layer) for Option 1 or a 30-inch-thick soil layer for Option 2 that will extend along the top and side slopes of the landfill except for the Class 1 areas. Material used for the storage layer will be tested in accordance with Table 2-1 (for Option 1) or Table 2-2 (for Option 2). The soil will be inspected as placed by the CQA monitor to be free of debris and rocks greater than 2 inches in diameter. Rock particles will only exist in incidental amounts in the soil used for this layer.

The storage layer material should be placed in no more than 12 inch lifts given that the compaction requirements presented in Tables 2-1 and 2-2 will be met. The storage layer will be placed in no more than 12 inch lifts and compacted to a density of 95 percent of the maximum dry density determined by Standard Proctor (ASTM D 698) at a moisture content less than the optimum moisture content.

The storage layer construction will be conducted in a systematic and timely fashion. Delays will be avoided in completion of the storage layer and construction of the overlying vegetation topsoil layer.

Placement of the storage layer will cease during rainfall events to prevent over saturation. After a rainfall event greater than 0.5 inches, the contractor will proceed with construction by installing at a minimum, a 10-foot by 10-foot initial area. The

POR will verify that compaction efforts can continue based on the proctor by taking at least two field density tests and allowing the contractor to continue with the construction if the test results are acceptable. The field density results will be reported in the Water Balance Final Cover System Evaluation Report (WBFCSER).

Surveying will be performed to verify that the completed storage layer meets the minimum required storage layer thickness. The storage layer will be surveyed on a 100-foot grid to ensure that a minimum storage soil layer thickness is in place at each survey location. Surveying will be performed by a State of Texas registered professional land surveyor using an instrument survey method to verify that the completed storage layer has the required minimum thickness.

2.2.2 Vegetation Topsoil Layer

The vegetation topsoil layer will be placed over the storage layer. The soil is placed in one lift (6-inch or 12-inch minimum thickness) over the entire surface of the vegetation topsoil layer and is compacted in place with a dozer or similar compaction equipment. The following portion of this section is only applicable to Option 2. At a minimum, one moisture/density relationship test (standard Proctor) for Option 2 will be performed for each source of soil borrow material to be used for the vegetation topsoil layer. The vegetation topsoil layer will meet the requirements set forth in Table 2-2. The vegetation topsoil layer will be placed as a single lift and compacted to 90 percent of the maximum dry density determined by Standard Proctor (ASTM D 698) at a moisture content less than the optimum moisture content. The installed vegetation topsoil layer density testing will be in accordance with Section 2.4. The installed vegetation topsoil layer will be tested for saturated hydraulic conductivity to verify that the requirements listed in Table 2-2 are met. The surface of the soil cover will be graded to achieve the desired final grades and disked parallel to the proposed contours, in preparation for seeding and to prevent excessive loss due to heavy rainfall.

The soil cover for both WB final cover options will be placed under the continuous observation of QA/QC personnel to determine that the minimum thickness is applied and that no damage occurs to other structures (e.g., gas system components) installed in the final cover.

Placement of the vegetation topsoil layer will cease during rainfall events to prevent over compaction of the vegetation topsoil layer. This layer will not be reworked after a rainfall event until the CQA monitor confirms that the soil can be effectively disked. To prevent erosion, the CQA monitor will ensure that the procedures detailed in the Vegetation Planting Plan (refer to Section 3) are followed.

Surveying will be performed to verify that the completed vegetation topsoil layer has the required thickness at each measurement location. This layer will be surveyed on a 100-foot grid to verify that a minimum 12-inch-thick vegetation topsoil layer is in place. Surveying will be performed by a State of Texas registered professional land surveyor using an instrument survey method to verify that the complete vegetation topsoil layer has the required minimum thickness.

Final cover drainage structures (e.g., swales) will be constructed by hauling soil with low ground pressure trucks and compacting berms with dozers or similar equipment. The vegetation topsoil layer may be disked as deemed necessary after the placement of the final cover drainage structure and prior to vegetation seeding.

2.3 Survey and Final Topography

Upon completion of the installation of the final cover, a final topographic survey of the cover is to be completed by a qualified land surveyor. The final topographic map will be included in the final cover certification report and will include as-built final contours for the certification area, location of gas vents, gas monitoring wells, groundwater monitoring wells, drainage structures, fences and gates, access roads and all other pertinent site features as applicable.

A cover thickness drawing showing thicknesses for each layer (i.e., storage layer and vegetation topsoil layer) placed in accordance with Subsections 2.2.1 and 2.2.2 and thickness of each layer at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the final cover will be called out on one of the final drawings.

2.4 Construction Testing

2.4.1 Procedures

CQA monitors will perform field and laboratory tests in accordance with this WB Final Cover System Quality Control Plan. The following test standards apply as called out in this manual and in the technical specifications:

Standard Test	Test Description
ASTM D 448	Sieve Analysis (determine percent (vol/vol) of rock between 1 inch and 2-inches in borrow soil)
ASTM D 698	Moisture-density relationship of soils and soil-aggregate mixtures, using 5-½ lb hammer and 12-inch drop
ASTM D 6398	Density of soil and soil-aggregate in place by nuclear methods (shallow depth)
ASTM D 2487	Classification of soils for engineering purposes
ASTM D 2488	Description and identification of soils (visual-manual procedure)

Standard Test	Test Description
ASTM D 2216	Laboratory determination of water (moisture) content of soil, rock, and soil-aggregate mixtures (not applicable if nuclear gauge reads both density and moisture)
EM 1110-2-1906 Appendix VII	U.S. Army Corps of Engineers test method for measurement of hydraulic conductivity of saturated porous materials
ASTM D 6836	Test method for determination of the soil water characteristic curve
ASTM D 9084	Test methods for measurement of hydraulic conductivity of saturated porous materials using flexible wall permeameter
ASTM D 5856	Test method for measurement of hydraulic conductivity of porous materials using a rigid-wall, compaction-mold permeameter

2.4.2 Test Frequencies

The test frequencies for the storage layer and vegetation topsoil layer are listed in Table 2-1 (for Option 1) and Table 2-2 (for Option 2). Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Additional testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

2.5 Reporting

The POR on behalf of the Owner will submit to the TCEQ a WBFCSER for approval of the constructed final cover system. Section 4 describes the documentation requirements.

Table 2-1
Option 1 – Minimum Tests and Observations for Storage Layer and Vegetation Topsoil Layer for Preconstruction and During Construction

Soil Parameter	Testing Method	Storage Layer		Vegetation Topsoil Layer	
		Testing Frequency	Passing Criteria	Testing Frequency	Passing Criteria
Soil classification (borrow source testing)	ASTM D 2488	Each 1,000 cy	CH, CL, ML, or SC[3]	Each 1,000 cy	The top 6 inches of the WB final cover will consist of soils that can sustain vegetative growth (refer to Appendix IIIF for additional information for final vegetation and soil erosion demonstrations).
Moisture density relationship (preconstruction testing – borrow source testing)	ASTM D 698	1 per soil type	Maximum 95 percent of standard proctor dry density. Standard proctor optimum moisture content or below.	1 per soil type	
Percentage (% volume) of rock particles between 1 inch and 2 inches in diameter (borrow source testing)	ASTM D 448	1 per soil type	10% or less	1 per soil type	
Saturated hydraulic conductivity[4] (cm/s), K_S (borrow source testing will also be completed as noted in footnote 4)	ASTM D 5048 or EM1110-2-1806, Appendix VII	1 per each 10,000 cy borrow soil placed (samples to be obtained from installed material)	$K_s \leq 1x10^{-8}$ cm/s	1 per each 10,000 cy borrow soil placed (samples to be obtained from installed material)	
Saturated water content (% volume), MC_S	ASTM D 2216 and ASTM D 6836	1 per soil type	The passing criterion for Option 1 is based on the statewide design tables presented in the TCEQ Guidance document.	1 per soil type	
Residual water content (% volume), MC_R	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Coefficient "α" of the van Genuchten function (1/cm), α	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Coefficient "n" of the van Genuchten function, n	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Field density and moisture	ASTM D 6398	Each 10,000 sf	Maximum 95 percent of standard proctor dry density. Standard proctor optimum moisture content or below.	Each 10,000 sf	
Thickness verification (minimum)	Instrument survey methods	Each 10,000 sf	46 inches	Each 10,000 sf	6 inches

1 If recompaction of the storage layer is required by the POR, then a moisture density relationship test and field density measurements will be required. If this condition occurs then saturated hydraulic conductivity and soil moisture characteristic tests will also be performed on the recompacted soil; otherwise, testing will be performed on undisturbed samples from the installed cover.
2 All surveying will be performed by a State of Texas registered professional land surveyor using an instrument survey method. The method, such as those utilizing thickness measurement plates, must be able to determine the lift thickness of the surveyed layer.
3 Soils will be classified in accordance with the Unified Soil Classification System (USCS) to verify consistency of soil used in the storage layer or soils that will be obtained from the soil borrow area.
4 Unless otherwise indicated, the laboratory testing will be performed on undisturbed samples recovered from the installed layers. The frequency of sampling area for the installed cover will be determined for the installed thickness. For example, for a 1-foot-thick vegetation topsoil layer, 10,000 cy corresponds to 6.2 acres; for a 46-inch-thick storage layer, frequency will be 1.6 acres. A saturated hydraulic conductivity test will also be performed on the borrow soil (1 per soil type). The borrow soil material will be recompacted to meet the compaction specification listed in Section 2.2.
5 The POR will determine the number of different soil types for the installed storage layer. For each determined soil type, one soil moisture characteristic curve test will be performed. The POR will perform the test to represent the condition of the storage layer ready for vegetation topsoil layer placement (e.g., if rework of the storage layer is planned, the soil sample will represent the reworked condition).
6 One soil moisture characteristic curve test will be performed for each soil borrow material. A soil sample will be prepared using the compaction specifications set forth in this section to prepare the soil for testing.
7 Option 1 WB final cover design information is presented in Appendix IIIJ-A.

Table 2-2
Option 2 – Minimum Tests and Observations for Storage Layer and Vegetation Topsoil Layer for Preconstruction and During Construction

Soil Parameter	Testing Method	Storage Layer		Vegetation Topsoil Layer	
		Testing Frequency	Passing Criteria	Testing Frequency	Passing Criteria
Soil classification (borrow source testing)	ASTM D 2488	Each 1,000 cy	CH, CL, ML, or SC[3]	Each 1,000 cy	CH, CL, ML, or SC[3]
Moisture density relationship (preconstruction testing – borrow source testing)	ASTM D 698	1 per soil type	Maximum 95 percent of standard proctor dry density. Standard proctor optimum moisture content or below.	1 per soil type	Maximum 90 percent of standard proctor dry density. Standard proctor optimum moisture content or below.
Percentage (% volume) of rock particles between 1 inch and 2 inches in diameter (borrow source testing)	ASTM D 448	1 per soil type	10% or less	1 per soil type	10% or less
Saturated hydraulic conductivity[4] (cm/s), K_S (borrow source testing will also be completed as noted in footnote 4)	ASTM D 5048 or EM1110-2-1806, Appendix VII	1 per each 10,000 cy borrow soil placed (samples to be obtained from installed material)	$K_s \leq 1\text{x}10^{-5}$ cm/s	1 per each 10,000 cy borrow soil placed (samples to be obtained from installed material)	$K_s \leq 1\text{x}10^{-4}$ cm/s
Saturated water content (% volume), MC_S	ASTM D 2216 and ASTM D 6836	1 per soil type	For each WB final cover construction event, the POR will perform a soil testing to verify soil parameters used in the UNSAT-H model. The POR may repeat the UNSAT-H simulation using the soil testing results. Under no circumstances will soil parameters that do not provide a maximum of 4 mm/yr of percolation using the UNSAT-H model be allowed.	1 per soil type	For each WB final cover construction event, the POR will perform a soil testing to verify soil parameters used in the UNSAT-H model. The POR may repeat the UNSAT-H simulation using the soil testing results. Under no circumstances will soil parameters that do not provide a maximum of 4 mm/yr of percolation using the UNSAT-H model be allowed.
Residual water content (% volume), MC_R	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Coefficient "α" of the van Genuchten function (1/cm), α	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Coefficient "n" of the van Genuchten function, n	ASTM D 2216 and ASTM D 6836	1 per soil type		1 per soil type	
Field density and moisture	ASTM D 6398	Each 10,000 sf	Maximum 95 percent of standard proctor dry density. Standard proctor optimum moisture content or below.	Each 10,000 sf	Maximum 90 percent of standard proctor dry density. Standard proctor optimum moisture content or below.
Thickness verification (minimum)	Instrument survey methods	Each 10,000 sf	30 inches	Each 10,000 sf	12 inches

1 If recompaction of the storage layer is required by the POR, then a moisture density relationship test and field density measurements will be required. If this condition occurs then saturated hydraulic conductivity and soil moisture characteristic tests will also be performed on the recompacted soil; otherwise, testing will be performed on undisturbed samples from the installed cover.
2 All surveying will be performed by a State of Texas registered professional land surveyor using an instrument survey method. The method, such as those utilizing thickness measurement plates, must be able to determine the lift thickness of the surveyed layer.
3 Soils will be classified in accordance with the Unified Soil Classification System (USCS) to verify consistency of soil used in the storage layer or soils that will be obtained from the soil borrow area.
4 Unless otherwise indicated, the laboratory testing will be performed on undisturbed samples recovered from the installed layers. The frequency of sampling area for the installed cover will be determined for the installed thickness. For example, for a 1-foot-thick vegetation topsoil layer, 10,000 cy corresponds to 6.2 acres; for a 2-foot-thick storage layer, frequency will be 3.1 acres. A saturated hydraulic conductivity test will also be performed on the borrow soil (1 per soil type). The borrow soil material will be recompacted to meet the compaction specification listed in Section 2.2.
5 The POR will determine the number of different soil types for the installed storage layer. For each determined soil type, one soil moisture characteristic curve test will be performed. The POR will perform the test to represent the condition of the storage layer ready for vegetation topsoil layer placement (e.g., if rework of the storage layer is planned, the soil sample will represent the reworked condition).
6 One soil moisture characteristic curve test will be performed for each soil borrow material. A soil sample will be prepared using the compaction specifications set forth in this section to prepare the soil for testing.

3 VEGETATION PLANTING PLAN

The purpose of this plan is to detail the procedures to be used for the initial planting on the WB final cover system. This plan sets forth a specific seed mix that will meet the vegetation performance specification included in Section 1.4 of Appendix IIIJ-B-1-B as part of Appendix IIIJ-B. Although this section is mainly developed for Option 2 WB final cover, it may be used as a guidance for initial establishment of vegetation if Option 1 is utilized.

3.1 Soil Preparation and Seeding

All seeds must conform to the requirements of the U.S. Department of Agriculture rules and regulations set forth in the Federal Seed Act and Texas seed law. Cultivation area preparation will start as soon as practicable after completion of the vegetation topsoil layer to the lines and grades specified in the construction plans which will be developed based on the TCEQ permitted final completion plans for the site. Unless otherwise requested by the vegetation establishment contractor and approved by the POR to ensure required ground cover and root penetration, the vegetated area will be cultivated to a typical depth of 4 inches before placement of seed or seed mixture. If temporary seeding is utilized, the area covered with temporary grass will be cultivated to a typical depth of 4 inches before placement of permanent seeds.

Table 3-1 includes the schedule for seeding. Table 3-2 includes the seed application rate of pure live seed (PLS) per acre.

Table 3-1
Schedule for Vegetation Establishment

Dates	Seed Mix to Use
February 1 – May 1	Perennial
May 1 – August 31	Warm Season (Summer)
September 1 – November 30	Cool Season (Winter)

Table 3-2
Seed Mix for Vegetation Establishment

Seed Mix	Species and Rates (lb Pure Live Seed/ac)	
Perennial	Green Sprangletop	1.5
	Sideoats Grama (Haskell)	4.5
	Bermudagrass	4.5
	Illinois Bundleflower	3.5
	Switchgrass	3.0
	Indiangrass	3.0
	Big Bluestem	1.5
	Little Bluestem (Native)	3.0
Cool Season (Winter)	Tall Fescue	4.5
	Oats	24
	Wheat	34
	Black-eyed Susan	1.0
Warm Season (Summer)	Foxtail Millet	34

Unless otherwise requested by the POR for meeting the performance specifications, plant seeding may utilize one or a combination of the following methods, as suggested by the Texas Department of Transportation in its "Specifications Book."

1. **Broadcast Seeding.** Distribute the seed or seed mixture uniformly over the areas shown on the plans using hand or mechanical distribution or hydro-seeding on top of the soil. When seed and water are to be distributed as a slurry during hydro-seeding, apply the mixture to the area to be seeded within 30 min. of placement of components in the equipment. Roll the planted area with a light roller or other suitable equipment. Roll sloped areas along the contour of the slope.
2. **Straw or Hay Mulch Seeding**. Plant seed using broadcast seeding. Immediately after planting the seed or seed mixture, apply straw or hay mulch uniformly over the seeded area. Apply straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.
3. **Cellulose Fiber Mulch Seeding.** Plant seed using broadcast seeding. Immediately after planting the seed or seed mixture, apply cellulose fiber mulch uniformly over the seeded area at the following rates:
   - Sandy Soils with slopes of 3:1 or less—2500 lb per acre
   - Sandy Soils with slopes greater than 3:1—3000 lb per acre
   - Clay Soils with slopes of 3:1 or less—2000 lb per acre
   - Clay Soils with slopes greater than 3:1—2300 lb per acre

Cellulose fiber mulch rates are based on dry weight of mulch per acre. Mix cellulose fiber mulch and water to make slurry and apply uniformly over the seeded area using suitable equipment.

4. **Drill Seeding.** Plant seed or seed mixture uniformly over the area at a depth of 1/4 in. to 1/3 in. using a pasture or rangeland type drill. Plant seed along the contour of the slopes.
5. **Straw or Hay Mulching.** Apply straw or hay mulch uniformly over the area as indicated on the plans. Apply straw at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

3.2 Fertilizer Recommendations

The installed vegetation topsoil layer will be tested for fertilizer need prior to seeding. Initial fertilization will occur prior to seeding (except broadcast seeding). Fertilizer needs for the installed vegetation topsoil layer will be determined by collecting one soil sample per every 10 acres of installed vegetation topsoil layer. Soil nutrient needs will be tested by a qualified agronomic testing laboratory (e.g., Texas A&M University Soil, Water, and Forage Testing Laboratory). The laboratory testing report will determine macro and micro nutrient needs and may also contain suggestions for soil inoculants, organic matter, etc. for the installed vegetation topsoil layer. Unless higher rates required by the agronomics laboratory testing results, nitrogen (N), phosphoric acid (P) and potash (K) ratio is 2:1:1, and will be applied at a rate of 100 pounds of nitrogen, 50 pounds of phosphoric acid, and 50 pounds of potash per acre. At a minimum, micro nutrients will be applied at a rate of 1 pound per acre of boron, 1 pound per acre of magnesium and 1 pound per acre of calcium. Seed and fertilizer may be distributed simultaneously during "Broadcast Seeding" operations, provided each component is applied at the specified rate. When temporary and permanent seeding are both specified for the same area, apply half of the required fertilizer during the temporary seeding operation and the other half during the permanent seeding operation. Fertilization will occur at intervals of no more than six weeks after initial seeding and until vegetation is established. Fertilizer will be applied to areas with established vegetation using turf type line equipment to prevent damage.

Use a fertilizer containing nitrogen (N), phosphoric acid (P), and potash (K) nutrients unless otherwise specified on the plans. Unless otherwise dictated by the soils laboratory, at least 50 percent of the nitrogen component must be of a slow-release formulation such as urea-based and plastic resin-coated fertilizers. The vegetation establishment contractor will ensure that fertilizer is in an acceptable condition for distribution in containers labeled with the analysis. Fertilizer is subject to testing by the Texas A&M Feed and Fertilizer Control Service (or other agencies approved by POR) in accordance with the Texas Fertilizer Law.

4 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports (if necessary), progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the WBFCSER. Standard report forms will be provided by the POR prior to construction.

4.1 Preparation of WBFCSER

The POR, on behalf of the Owner, will submit to the TCEQ a WBFCSER for approval after each increment of the final cover system constructed. During the active life of the landfill, a portion of the site (or "increment") may receive the WB final cover. The WBFCSER will be submitted upon completion of the WB final cover construction for that increment. However, the area that received the WB final cover will not be certified closed until the Vegetation Establishment Verification Plan is approved by TCEQ for this increment. After construction of the final cover for the last increment, a WBFCSER will be submitted along with other required certification for closure and, upon TCEQ approval, the site will be closed. The last increment must still obtain Vegetation Establishment Verification approval from the TCEQ; however, the site can still be certified closed during this time. Final cover QA/QC testing will be performed in accordance with this WBFCSQCP and should be part of the WBFCSER which will be prepared in accordance with this WBFCSQCP.

At a minimum, the WBFCSER will contain:

- A summary of construction activities.
- A summary of the initial installation of vegetation.
- Laboratory and field test results.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings.
- A statement of compliance with the permit WBFCSQCP and construction plans.

- The reports will be signed and sealed by a professional engineer(s) licensed in the state of Texas.

The as-built record drawings will accurately site the constructed location of work items. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the WBFCSER.

4.2 Reporting Requirements

The WBFCSER will be signed and sealed by the POR and signed by the site operator and submitted to the MSW Permits Section of Waste Permits Division of the TCEQ for approval. Upon approval of the WBFCSER, the vegetation establishment period will begin as noted in Appendix IIIE-B-1-B. After the approval of the final WBFCSER and during the vegetation establishment period, the applicant will request closure of the site in accordance with Appendices IIIJ and IIIK. Since the vegetation establishment period timeframe is 3 years, and is actually part of the postclosure plan, closure of the site will occur prior to the completion of the vegetation establishment period. At the end of the vegetation establishment period, a Vegetation Establishment Verification Report will be completed as noted in Appendix IIIE-B-1-B.

A semi-annual report will be submitted to the TCEQ during the vegetation establishment period. This semi-annual report will include the status of vegetation establishment activities (fertilizer application, watering, reseeding, etc.) and any other activities that are related to installed final cover or vegetation. If the WB final cover is constructed, the site will submit an updated postclosure care plan cost estimate to incorporate the additional cost due to the cost associated with the initial vegetation establishment period.

In addition, if the WBFCSER is completed for an area where the final cover is placed during the active life of the site, then the Vegetation Establishment Verification Plan discussed in Appendix IIIE-B-1-B will be submitted for the completed final cover area. After the Vegetation Establishment Verification Report is approved by the TCEQ, the site may submit an updated closure and postclosure care cost estimate to incorporate the area that has received "approved final cover."

If Option 2 is utilized, then the initial final cover construction area will be 10 acres. Performance verification for this initial 10-acre area will be conducted in accordance with Appendix IIIE-B-1.

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1417D

MAJOR PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
APPENDIX IIIE-B-1
PERFORMANCE VERIFICATION PLAN FOR OPTION 2 WATER BALANCE COVER

Prepared for

Texas Regional Landfill Company, LP

February 2022

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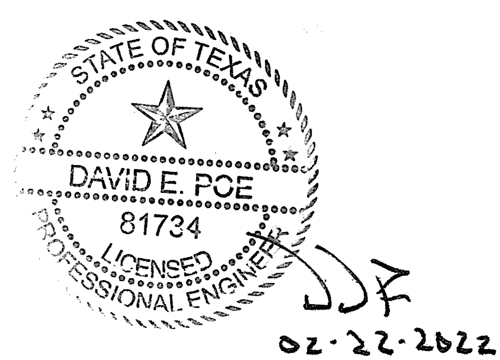

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1 INTRODUCTION

The purpose of this appendix is to set forth the design and monitoring procedures that will be used to verify the percolation rate for the water balance (WB) final cover system. As discussed in the TCEQ guidance document titled, "Guidance for Requesting a Water Balance Alternative Final Cover for a Municipal Solid Waste Landfill" (dated March 2017), a "performance verification test plot" will be installed, maintained, and monitored to verify that the WB final cover design will meet the basal percolation limits. The monitoring system design included in this appendix will provide the following data for the verification test plot.

- Weather data
- Soil temperature
- Continuous moisture content
- Basal percolation

The verification test plot will be located within the initial WB final cover construction area shown on Figure 1 (refer to Appendix IIIE-B-1-A). As discussed in Section 2, soil moisture and basal percolation information will be collected using automatic data acquisition systems. The basal percolation rate determined during the test period will be compared to the criteria listed in Table 1-1.

Table 1-1
Verification Plot Percolation Criteria

Percolation Rate	Required Action
≤ 8 mm/yr	A successful demonstration has been made and the remaining WB final cover can be constructed.
> 8 mm/yr ≤ 12 mm/yr	The remaining WB final cover will be redesigned using data from the test plot and the design will be submitted to the TCEQ as a permit modification. The permit modification will include site specific data collected from the in-service final cover (i.e., test plot area). The additional data collected will include saturated hydraulic conductivity in varying depths, vegetation root profile, and SMCC. This additional data will be collected from the area over the lysimeter and from other test plot areas. Upon approval of the permit modification by the TCEQ, the remaining WB final cover will be constructed.
> 12 mm/yr	If >12 mm percolation in a year is measured, then the remaining WB final cover would be redesigned, and the new design submitted to the TCEQ for permit modification. Upon approval, an initial phase of cover may be constructed, which would include a new test plot for cover performance verification in the same manner as the original test plot. Additional WB final cover beyond the initial maximum of 10 acres that includes the test plot should not be constructed until the TCEQ has determined that the initial phase of WB cover has been successfully demonstrated.

The following sections of this appendix provide information for the design, data collection, and reporting requirements for the proposed performance verification monitoring system that will be installed as part of the initial WB final cover construction.

2 WATER BALANCE FINAL COVER MONITORING SYSTEM DESIGN

The WB final cover performance verification test plot will be installed during the initial WB final cover construction. Figures 1 through 4 in Appendix IIIE-B-1-A show the initial WB final cover configuration and the monitoring system that will be installed. The monitoring system will consist of a lysimeter, moisture monitoring probes, and a data acquisition station.

2.1 Lysimeter Design and Basal Percolation Monitoring

Figures 1 shows the location of the initial WB cover construction area and lysimeter that will be installed as part of the monitoring system. The lysimeter has been designed to measure the basal percolation, or water that flows through the overlying WB final cover system. Details of the lysimeter are shown on Figures 2 through 4.

As shown on Figures 2 through 4, any water that flows through the WB final cover system will percolate into the lysimeter's drainage media or drainage stone. A filter geotextile separates the WB final cover soil from the drainage stone. Water that enters the lysimeter will flow to a collection sump. The collection sump consists of a 2.5-foot-diameter HDPE pipe with an end cap. The collection sump will be equipped with a pressure transducer that measures the depth of water in the sump. The pressure transducer will relay water depth information to a data logger. The depth of the water, if any, will also be measured manually (using a calibrated rod) to verify that the pressure transducer readings are accurate.

The collection sump water levels will be documented daily. The data logger will be equipped with internal memory for data storage and will be used to store water depth data until it is downloaded. As noted in Section 3.1, manufacturer information for the pressure transducer and data logger installed for this project will be documented in the FCSER. The sump water depth data will be used to determine the total volume and rate of percolation collected. In addition, the sump will be manually inspected on a weekly basis to verify that the sump is functioning as designed.

The pressure transducer and data logger will be inspected on a weekly basis. During the inspections, the water level in the sump will be manually measured and recorded to verify water depth data obtained from the pressure transducer. Any damage to the equipment will be documented and repaired. Records of the inspections and water depth information will be maintained in the Site Operating Record.

During weekly inspections, if the water depth in the sump is above 3 feet, the accumulated water will be removed from the sump using a bailer pump. The depth of water in the sump will be measured and recorded before and after pumping.

2.2 Soil Moisture Monitoring System Design

As shown on Figures 2 and 3, soil moisture monitoring probes will be in three nests (upgradient, downgradient, and over the lysimeter) with duplicate sensors at each location. As shown on Lysimeter Section B, Figure 3, the probes will continuously monitor soil conditions (e.g., soil moisture and temperature). The installed probes will be connected to a data acquisition station for data storage and retrieval.

Water content reflectometers (WCRs), time domain reflectometry (TDR), or similar probes will be used to measure soil moisture and temperature data. These sensors will be installed in three nests with duplicate sensors. A nest will contain probes placed at upper, middle, and lower portions of the installed WB final cover, with vertical spacing of no greater than one foot. The typical installation configuration of the soil probes is shown on Figure 3. As noted in Section 3.1, as-built information for the soil moisture probes will be included in the FCSER.

2.3 On-site Weather Station

Meteorological conditions will be measured at the site using data from an onsite weather station. A weather station, capable of monitoring temperature, precipitation, humidity, wind speed, and solar radiation will be utilized. The weather data will be recorded during the monitoring period. As noted in Section 3.3, the specific on-site weather station used will be documented in each Annual Performance Verification Report.

3 REPORTING REQUIREMENTS

The reporting requirements for the performance verification test plot are listed in Sections 3.1, 3.2, and 3.3.

3.1 Final Cover System Evaluation Report (FCSER)

Construction of the 10-acre WB final cover system will be documented in the FCSER. This report will include all the required field and laboratory reports, as-built drawings, summary of construction activities, and the vegetation planting details as specified in Section 3 of Appendix IIIE-B.

In addition, for this initial 10-acre WB final cover construction event over a Subtitle D area, the FCSER will also document the as-built configuration of the performance verification lysimeter. Specifically, the FCSER will include the following.

- As-built drawings of the lysimeter configuration.
- Material quality assurance information for the 40-mil LLDPE, geotextile, and drainage stone.
- Specific details and manufacturer's information for the selected moisture probes and lysimeter flow rate monitoring equipment (i.e., pressure transducer and data logger).
- Manufacturer's information for the weather station equipment that will be used during the WB final cover evaluation period.
- Verify that the cover placed over the installed lysimeter is consistent with the rest of the 10-acre initial performance verification test plot.

3.2 Vegetation Establishment Report

As discussed in Section 3 of Appendix IIIE-B-1, a Vegetation Establishment Report will be submitted semi-annually to the TCEQ during the WB final cover start-up period. This report will indicate the type and quantity of vegetation and percent vegetative cover as well as activities that took place during the reporting period and any erosion and/or cover repairs. For the initial 10-acre performance verification test plot, the area in the vicinity of the lysimeter will be specifically addressed in each report. As noted in Appendix IIIE-B-1-B, Vegetation Establishment Verification Plan, after the Vegetation Establishment Verification Report has been approved by TCEQ for the 10-acre test plot area, this area will be considered an "approved final cover area" and the closure and post closure care cost estimates may be updated to reflect that an approved final cover system exists in this area.

3.3 Annual Performance Verification Reports

After vegetation is fully established in the area of the lysimeter, as documented in the Vegetation Establishment Report (see Section 3.2), the performance verification monitoring period will begin. However, data gathering will start within six months after the installation of the lysimeter. An Annual Performance Verification Report (PVR) will be submitted to the TCEQ to document the data obtained from the monitoring system. The PVR will document the following.

- Weather data
- Soil moisture data collected by the installed moisture probes
- Basal percolation
- Observations and recommendations of the POR during the monitoring period

The POR will document in the annual PVRs if the installed WB final cover system is performing as designed and provides adequate protection from wind and water erosion. The POR will submit a PVR to the TCEQ for review and approval at the end of the monitoring period.

The POR will also assess the vegetation in the area of the lysimeter and compare the existing vegetation to the final vegetation establishment report that was submitted to the TCEQ prior to the initiation of the performance verification monitoring period. If there is a significant change to the vegetation, this change will also be documented in the PVR. If the POR suspects that any significant change in vegetation is due to a change in soil conditions, then additional soil data (e.g., soil moisture retention curves) will also be obtained.

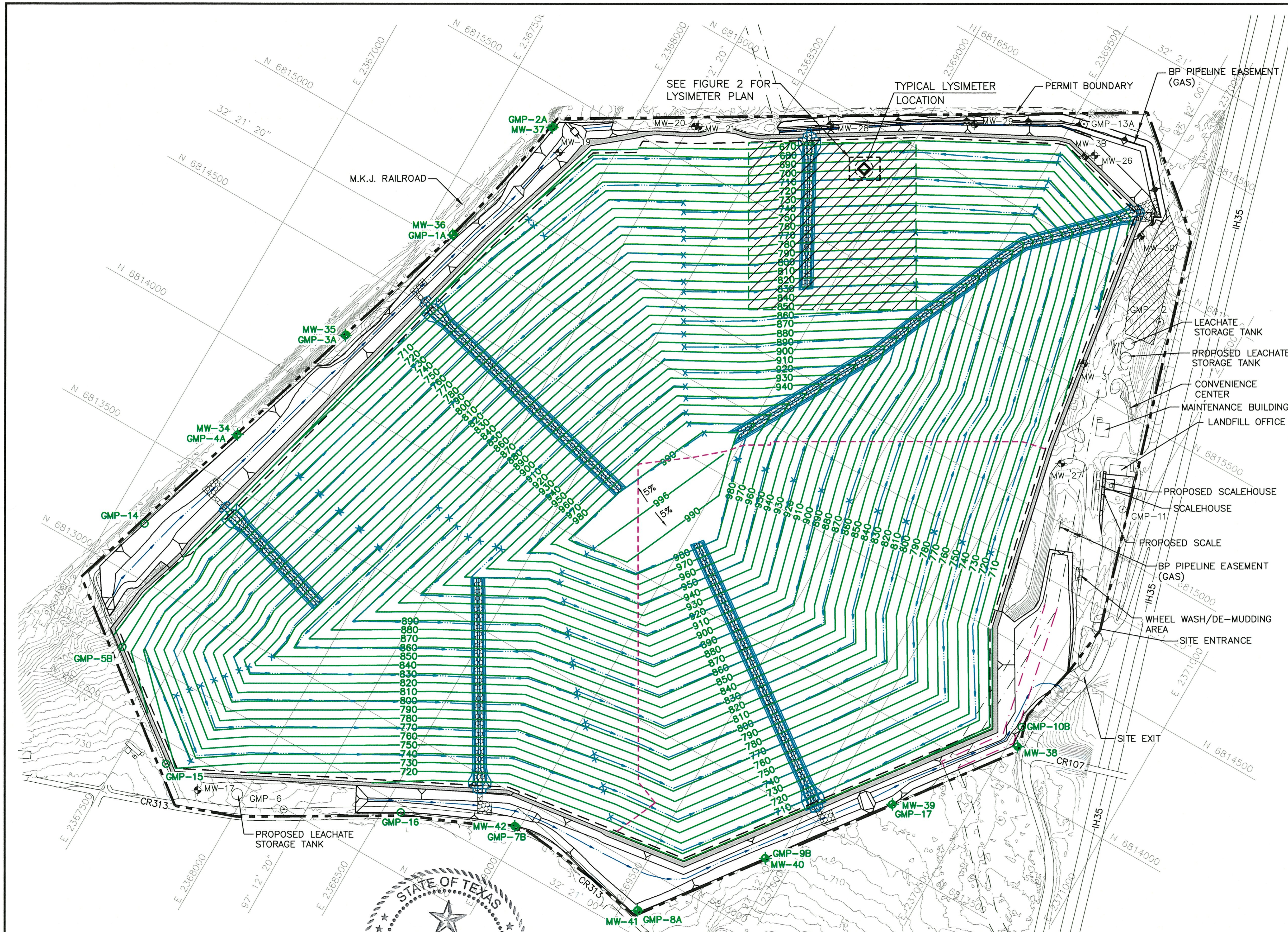
The PVR will be submitted to the TCEQ within 60 days after the 12-month monitoring period has ended. The PVR submitted after year 2 will provide a summary of the precipitation and basal percolation measured through the first two years of the performance verification period. The POR will compare the precipitation data to the WB final cover demonstration included in Appendix IIIJ-A to provide an assessment of how the actual precipitation and basal percolation values compared to the maximum modeled percolation values.

The final PVR (completed at the end of Year 3 of the monitoring period) will also include a summary of all the basal percolation data collected over the 3-year monitoring period. This data will be compared to the criteria listed in Table 1-1 to determine the required action after the conclusion of the 3-year performance verification monitoring period.

Upon approval of the final PVR by the TCEQ, the remaining portions of the WB final cover will be installed in accordance with the permitted design and WB Final Cover System Quality Control Plan (Appendix IIIE-B).

APPENDIX IIIE-B-1-A

FIGURES



STATE OF TEXAS
DAVID E. POE
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PROFESSIONAL ENGINEER
02-22-2022

LEGEND

	PERMIT BOUNDARY
	LIMITS OF WASTE
750	EXISTING CONTOUR
N 6816000	STATE PLANE COORDINATE
32° 21' 20"	GEODETIC COORDINATE
	EASEMENT
	RELOCATED EASEMENT
800	FINAL COVER CONTOUR
	LIMIT OF CLASS 1 WASTE DISPOSAL AREA
	DRAINAGE LETDOWN
	DRAINAGE SWALE
	GABIONS
MW-7	EXISTING GROUNDWATER MONITORING WELL
GMP-12	EXISTING GAS MONITORING PROBE
MW-7	PROPOSED GROUNDWATER MONITORING WELL
GMP-17	PROPOSED GAS MONITORING PROBE
	INITIAL 10-ACRE WB FINAL COVER TEST AREA (SEE NOTE 4)
	FUTURE LFGTE FACILITY LOCATION

NOTES:

1. EXISTING CONTOURS AND ELEVATIONS PROVIDED BY FIRMATEK FROM AERIAL PHOTOGRAPHY FLOWN ON 01-08-2021. THE GRID SYSTEM IS TIED TO THE TEXAS STATE PLANE COORDINATE SYSTEM NORTH CENTRAL ZONE NAD 1983.
2. TYPICAL SIDESLOPES ARE 4H:1V IN THE CLASS 1 AREA AND 3.5H:1V IN THE MSW AREA, TYPICAL TOPSLOPE IS 6%.
3. MAXIMUM FINAL COVER ELEVATION IS 946.0 FT-MSL. MAXIMUM TOP OF WASTE ELEVATION IS 942.5 FT-MSL. IF OPTION 1-WB FINAL COVER IS UTILIZED, FINAL COVER ELEVATION WILL BE AS MUCH AS 10 INCHES ABOVE SHOWN GRADES AS THE OPTION 1 WB FINAL COVER WILL BE 10 INCHES THICKER THAN SUBTITLE D FINAL COVER AND OPTION 2-WB FINAL COVER.
4. WB FINAL COVER CAN ONLY BE INSTALLED OVER THE MSW AREA (CANNOT BE INSTALLED OVER CLASS 1 AREA). TYPICAL LOCATION FOR THE INITIAL 10-ACRE WB FINAL COVER AREA IS SHOWN FOR OPTION 2 WB FINAL COVER. ACTUAL LOCATION MAY VARY; HOWEVER LYSIMETER TO BE INSTALLED AT LEAST 100 FEET BELOW THE TOP ELEVATION OF THE 10-ACRE WB COVER TO ENSURE ANY IMPACT FROM UPPER ELEVATIONS OF THE INSTALLED 10-ACRE WB COVER REPRESENTED BY THE LYSIMETER MEASUREMENTS.

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☒ FOR PERMITTING PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 02/2022
FILE: 0771-368-11
CAD: 1-LYSIMETER PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

MAJOR PERMIT AMENDMENT LYSIMETER LOCATION

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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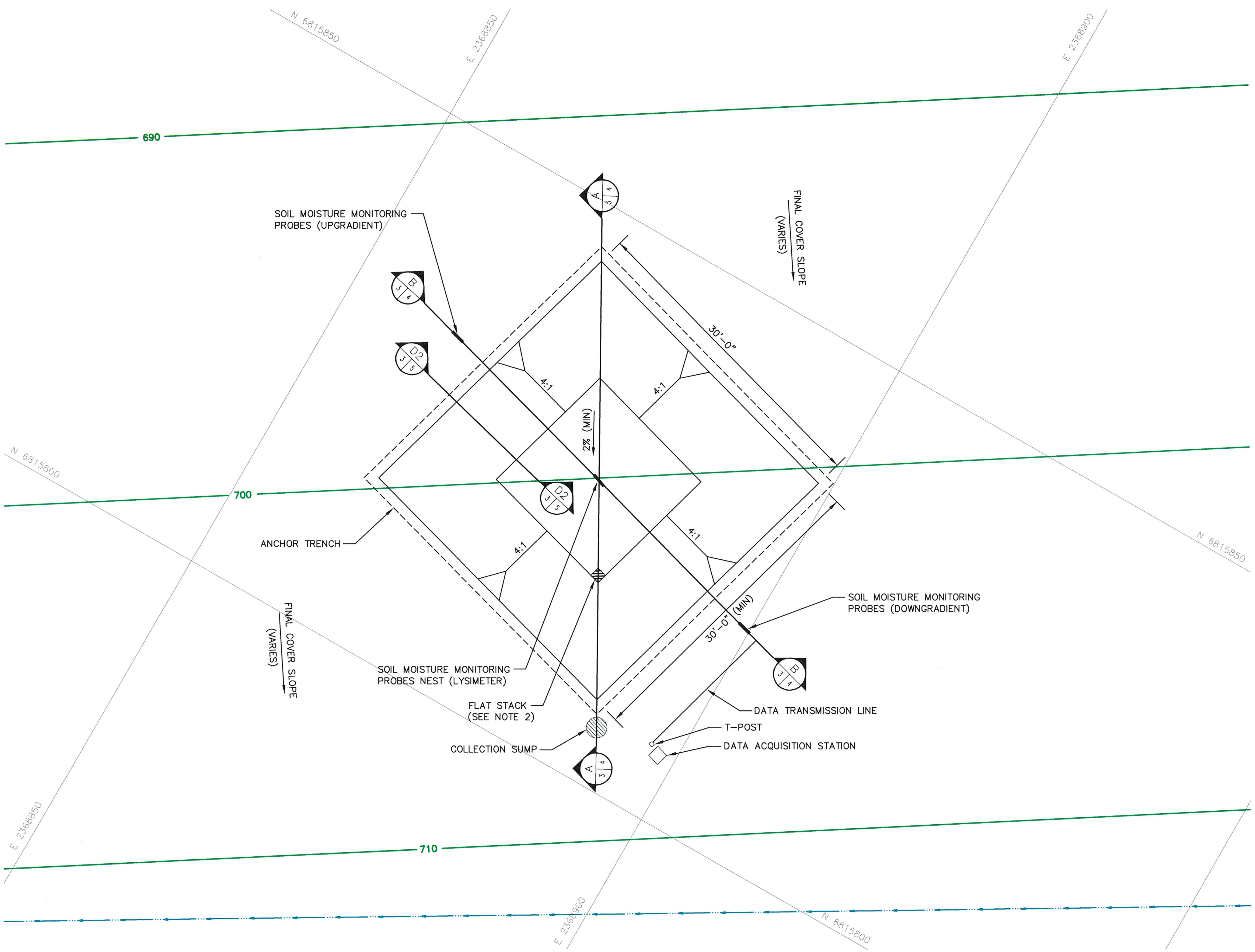
FIGURE 1

O:\0771\368\EXPANSION 2021\PART III\IIIE\IIIJ-B\1-LYSIMETER PLAN.dwg, rarrington, 1:2



LEGEND

750	EXISTING CONTOUR
N 6815800	STATE PLANE COORDINATE
700	FINAL COVER CONTOUR
	DRAINAGE SWALE

NOTES:

1. LYSIMETER SPOT ELEVATIONS ARE APPROXIMATE AND ESTIMATED BY SUBTRACTING 3.5-FOOT COVER THICKNESS FROM THE FINAL COVER ELEVATION AT EACH LOCATION. THE ACTUAL ELEVATION MAY VARY; HOWEVER, THE MINIMUM SLOPES AND DIMENSIONS WILL REMAIN CONSISTENT WITH THE LYSIMETER LAYOUT SHOWN ON THIS FIGURE.
2. THE "FLAT STACK" IS A ONE-FOOT BY ONE-FOOT HDPE MATERIAL THAT IS USED FOR REINFORCING DRAIN PIPE CONNECTION TO THE LYSIMETER DRAIN POINT. REFER TO DETAIL D2 ON FIGURE 4.

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DATE: 02/2022
FILE: 0771-368-11
CAD: 2-LYSIMETER PLAN.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

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TEXAS REGIONAL LANDFILL COMPANY, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LYSIMETER PLAN

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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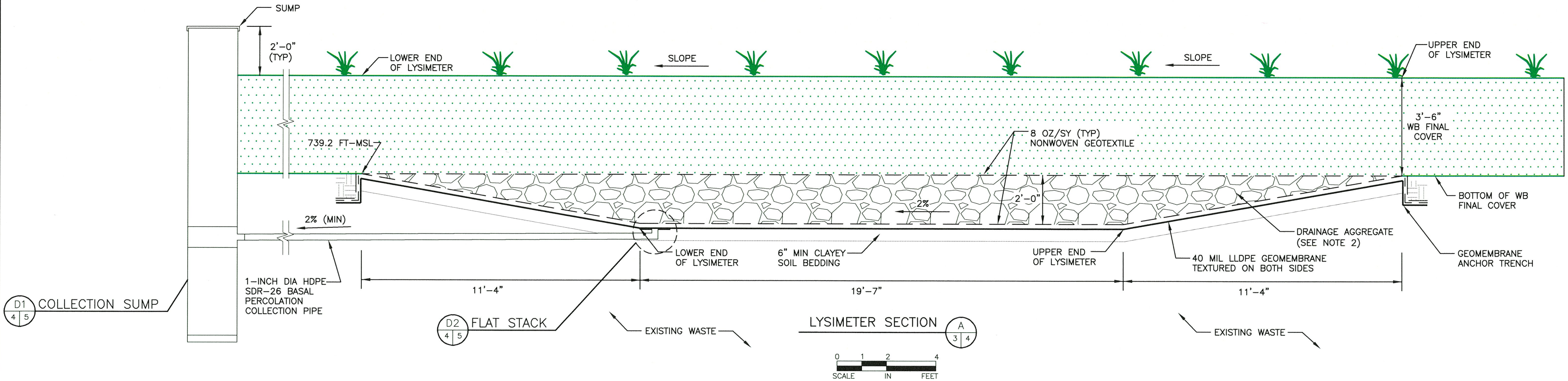
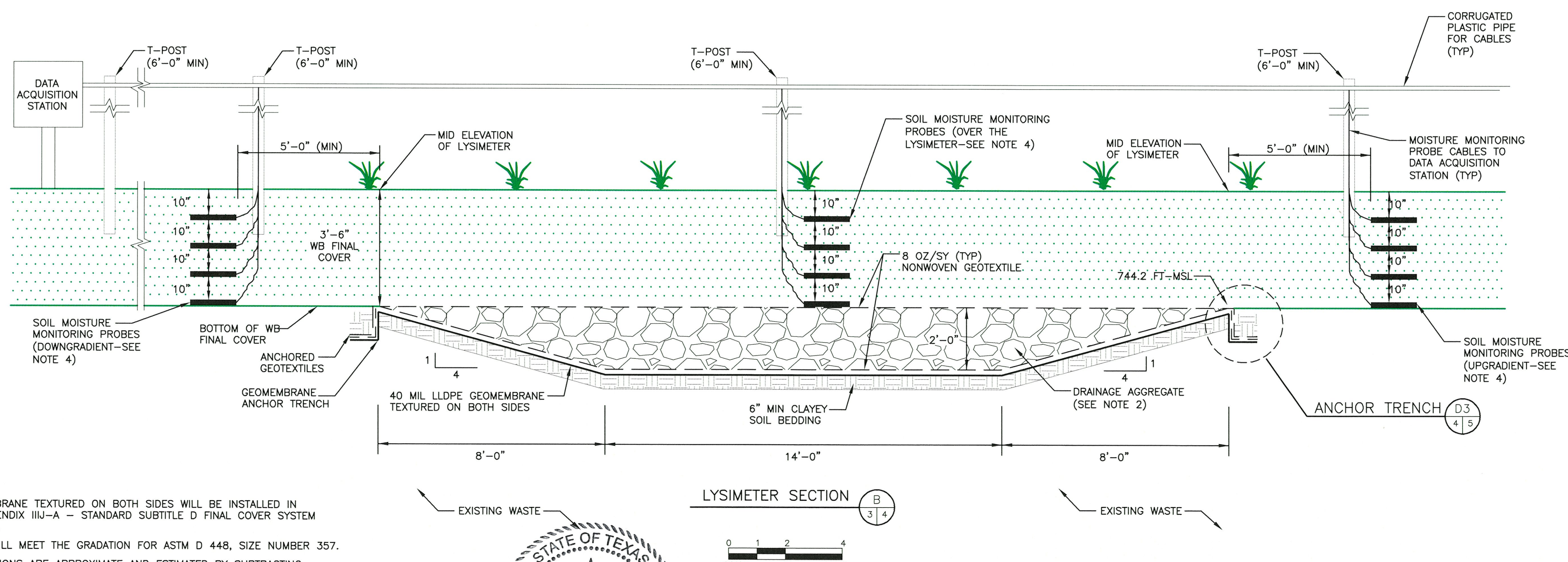
FIGURE 2

O:\0771\368\EXPANSION 2021\PART III\IIIE\IIIJ-B\2-LYSIMETER PLAN.dwg, rfarrington, 1:2





NOTES:

1. 40 MIL LLDPE GEOMEMBRANE TEXTURED ON BOTH SIDES WILL BE INSTALLED IN ACCORDANCE WITH APPENDIX IIIJ-A – STANDARD SUBTITLE D FINAL COVER SYSTEM QUALITY CONTROL PLAN.
2. DRAINAGE AGGREGATE WILL MEET THE GRADATION FOR ASTM D 448, SIZE NUMBER 357.
3. LYSIMETER SPOT ELEVATIONS ARE APPROXIMATE AND ESTIMATED BY SUBTRACTING 3.5-FOOT COVER THICKNESS FROM THE FINAL COVER ELEVATION AT EACH LOCATION. THE ACTUAL ELEVATION MAY VARY; HOWEVER, THE MINIMUM SLOPES AND DIMENSIONS WILL REMAIN CONSISTENT WITH THE LYSIMETER LAYOUT SHOWN ON THIS FIGURE.
4. EACH PROBE CLUSTER WILL CONSIST OF AT LEAST FOUR MONITORING PROBES WITH DUPLICATE SENSORS LOCATED IN THE UPPER, MIDDLE, AND LOWER PORTIONS OF THE COVER SOIL, WITH VERTICAL SPACING OF NOT GREATER THAN ONE FOOT.

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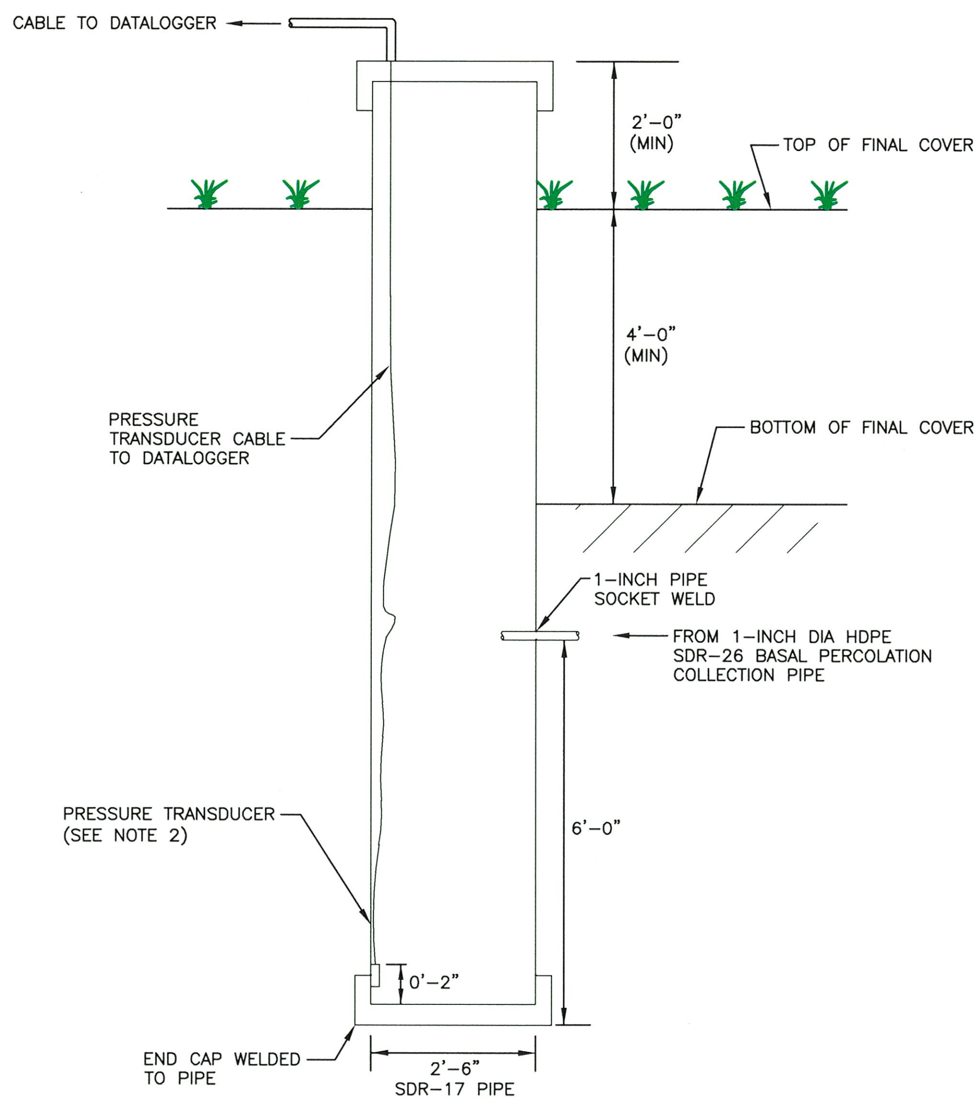
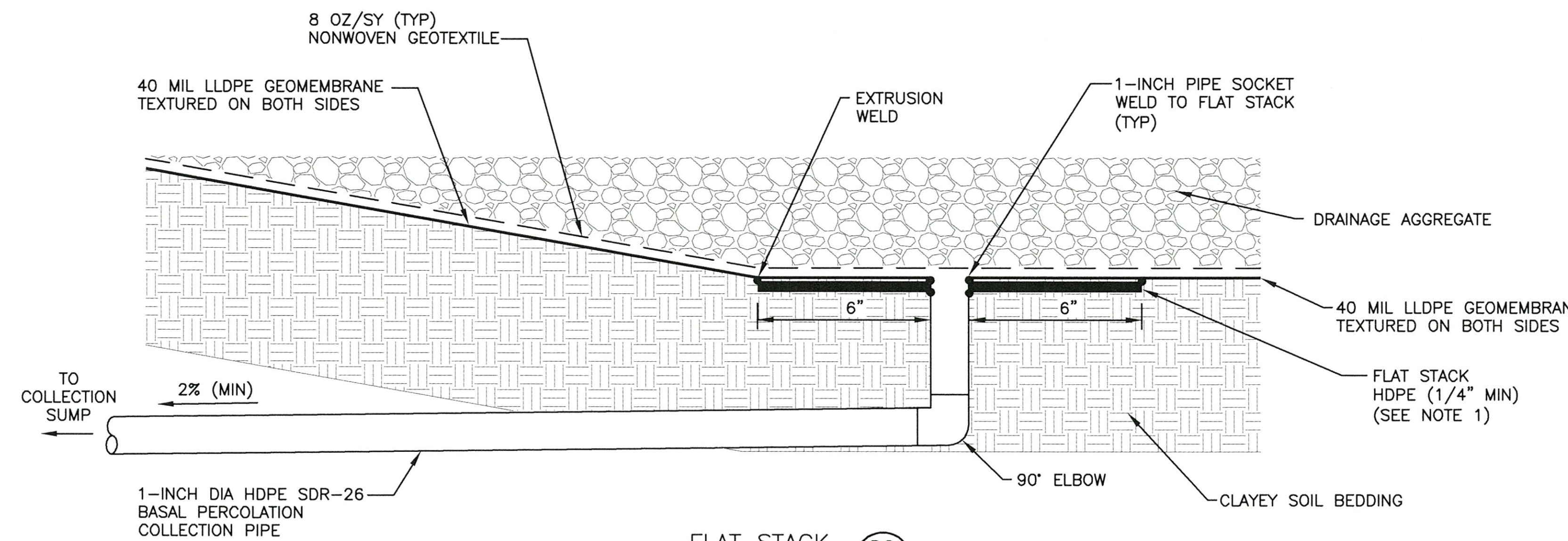
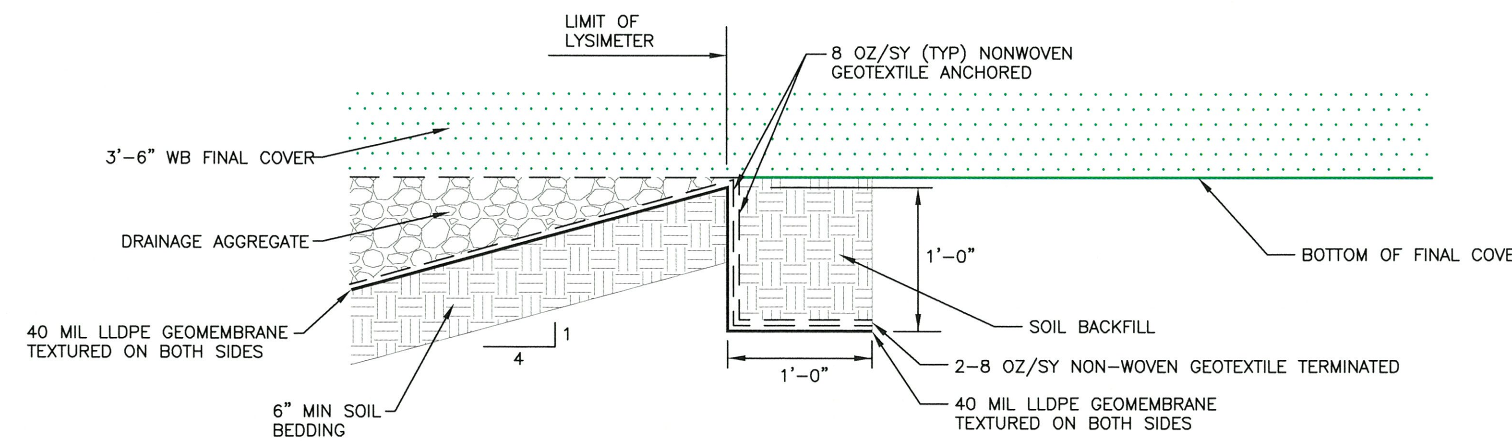
DATE: 02/2022 FILE: 0771-368-11 CAD: 3-LYSIMETER SECTIONS.DWG	DRAWN BY: JDW DESIGN BY: CAM REVIEWED BY: NT	REVISIONS NO. / DATE / DESCRIPTION	TURKEY CREEK LANDFILL JOHNSON COUNTY, TEXAS
Weaver Consultants Group TBPE REGISTRATION NO. F-3727			WWW.WCGRP.COM / FIGURE 3



COLLECTION SUMP D1 4|5
NTS



FLAT STACK D2 3|5
NTS



ANCHOR TRENCH D3 4|5
NTS

NOTES:

1. THE "FLAT STACK" IS A 1–FOOT X 1–FOOT HDPE PLASTIC MATERIAL (1/4" MIN) USED TO REINFORCE THE GEOMEMBRANE TO PIPE TRANSITION.
2. PRESSURE TRANSDUCER IS SET 2" ABOVE THE BOTTOM OF THE COLLECTION SUMP TO PROTECT FROM POTENTIAL SILTATION. THE PRESSURE TRANSDUCER DEPTH READINGS WILL BE VERIFIED BY MANUALLY MEASURING THE WATER DEPTH IN THE SUMP (REFER TO SECTION 2.1).

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DATE: 02/2022
FILE: 0771-368-11
CAD: 4-LYSIMETER DETAILS.DWG

DRAWN BY: JDW
DESIGN BY: CAM
REVIEWED BY: NT

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TBPE REGISTRATION NO. F-3727

PREPARED FOR
TEXAS REGIONAL LANDFILL COMPANY, LP

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NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT
LYSIMETER DETAILS

TURKEY CREEK LANDFILL
JOHNSON COUNTY, TEXAS

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FIGURE 4

O:\0771\368\EXPANSION 2021\PART III\IIIE\IIIJ-B\4-LYSIMETER DETAILS.dwg, rarrington, 1:2

TURKEY CREEK LANDFILL
JOHNSON, TEXAS
TCEQ PERMIT NO. MSW-1417D

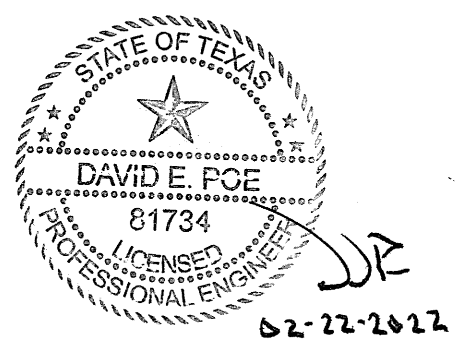
MAJOR PERMIT AMENDMENT APPLICATION
APPENDIX IIIE-B-1-B

WATER BALANCE FINAL COVER
VEGETATION ESTABLISHMENT VERIFICATION PLAN
FOR OPTION 2 WATER BALANCE FINAL COVER

Prepared for

Texas Regional Landfill Company, LP

February 2022



Prepared by

Weaver Consultants Group, LLC
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817-735-9770

Project No. 0771-368-11-123

CONTENTS

STATE OF TEXAS
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02-22-2022

1 VEGETATION ESTABLISHMENT VERIFICATION PLAN

1.1 Introduction

The purpose of this plan is to set forth the procedures that will be used to verify that the vegetation is established consistent with the parameters used in the Water Balance (WB) Final Cover Demonstration included in Appendix IIIJ (Appendix IIIJ-B – Option 2 WB Final Cover Design) as this plan is only applicable to Option 2 WB final cover option. Establishment of the vegetation topsoil layer is a critical component of the WB Final Cover System. The closure plan details the construction of the WB Final Cover System. This Vegetation Establishment Verification Plan details both the maintenance activities that will be required to establish the vegetation topsoil layer and the information that will be included in the Vegetation Establishment Verification Report that will be submitted to TCEQ to document that the vegetation has been established consistent with the WB AFC demonstration. The following subsections of this plan detail the following.

- Vegetation Establishment Period
- Maintenance activities to be completed during the Vegetation Establishment Period
- Vegetation Performance Specification
- Vegetation Establishment Verification Report

1.2 Vegetation Establishment Period

The maintenance period will start immediately after seeding and will continue until the Vegetation Establishment Verification Report is approved by the TCEQ. During this period, the specified vegetative cover will be established. Vegetative cover is considered to be established when surface coverage and root penetration values used in the UNSAT-H model simulation are achieved. The vegetation establishment period begins after the Final Cover Certification Report is approved by the TCEQ and ends when the Vegetation Establishment Report is approved by TCEQ. This time frame is anticipated to be approximately 2 to 3 years. During this period the site will work to establish the vegetation consistent with parameters used in the Alternative Final Cover Demonstration shown in Appendix IIIJ-B.

1.3 Maintenance Activities to be Completed During the Vegetation Establishment Period

The following maintenance activities will be performed to ensure that the vegetation planted during the construction of the final cover system is maintained so that it will meet the vegetation performance specification established for this project.

- The site will irrigate and fertilize the WB Final Cover area to promote vegetation growth.
- Vegetation will be maintained and mowed as appropriate, depending on the season. No mowing will be allowed until grasses establish mature seed.
- Bare areas will be over seeded to facilitate vegetation growth.
- Areas of significant differential settlement will be regraded and re-seeded.
- Areas that experience erosion will be promptly repaired.
- If it is determined that landfill gas is detrimental to any specific area of the established vegetation, the LFG extraction system will be expanded to include additional extraction wells in those areas.
- Vehicles with more than 16 psi ground pressure will not be allowed over the constructed final cover areas during the Vegetation Establishment Period, unless access by a vehicle that does not meet this requirement is required due to a critical maintenance activity or emergency. If a vehicle that does not meet this requirement is used over the cover system, the area disturbed will be evaluated and repaired, if necessary.

1.4 Vegetation Performance Specification

For the vegetation to be considered "established" a professional engineer will complete an evaluation of the vegetation topsoil layer at the end of the vegetation establishment period (typically 2 to 3 years). The performance specification for the vegetation layer is discussed in Section 3 of Appendix IIIJ, Appendix IIIJ-B, and is summarized below.

- Percent Vegetation Cover – 90 percent. This will be based upon the demonstration that a satisfactory stand of turf, defined as 90 percent ground cover and no bare areas larger than one square foot of the established species, exists in the WB final cover area.
- Root Penetration – minimum depth of 40 inches. As discussed in Section 3 of Appendix IIIJ, Appendix IIIJ-B, the minimum root depth required is 40 inches based on the UNSAT-H demonstration.

1.5 Verification of Established WB Final Cover Vegetation

At the end of the vegetation establishment period for each installed final cover section, the POR will perform field work to verify the model input parameters for the established final cover vegetation. Table 1 outlines the minimum vegetation tests and testing frequencies for the established WB cover. The testing results will be reported in the Vegetation Establishment Verification Report outlined in Section 1.6. If the verification testing results are not consistent with the original parameters used in Appendix IIIJ-B, the Vegetation Establishment Verification Report will include updated models to demonstrate that established cover meets the minimum requirements for the WB final cover.

Table 1
Vegetation and Soil Testing at End of Vegetation Establishment Period

Soil Parameters		Frequency
Variables	Required Value	
Fraction of soil surface that is bare of plants (Fraction), BARE	0.1	Visual observation of entire area
Root Penetration (Inches), P	Varies	1 test boring per acre or 1 trench per 10 acres

1.6 Vegetation Establishment Verification Report

A vegetation establishment report will be submitted semi-annually until the vegetation is established to design conditions. At the end of the vegetation establishment period (2 to 3 years), a Vegetation Establishment Verification Report will be prepared and submitted to TCEQ for approval. The report will be prepared by a Texas Licensed Professional Engineer and include the following.

- Document the percent vegetation cover in accordance with ground cover determination procedure included in this plan. This documentation will include the engineer's assessment of the vegetation cover and photographs that document compliance with the performance specification.
- Document the Root Penetration performance. At a frequency of one per acre, either a drive cylinder or hand augur will be completed to a depth of 40 inches. The excavated soil will be visually inspected to verify the target root depth has been achieved in each location. A drawing showing each sample location will also be included. The boreholes created by taking the soil cores will be backfilled with the same soils that have been removed. After the soil samples have been examined, the soil will be placed back into the borehole.

- In addition to the above, each core obtained will be examined by the certifying engineer to observe that the roots are denser in the upper portion of the soil profile and extend to 40 inches of depth. The certifying engineer will also provide a statement indicating that the vegetation layer of the WB final cover system has been maintained consistent with the parameters used in the Alternative Final Cover System Demonstration.
- If the established vegetation does not meet the minimum requirements included in Table 1 of Section 1.5, the POR will provide an updated final cover model consistent with the approved design demonstration procedures established in Appendix IIIJ-B, using the actual soil data for the installed final cover area.