March 30, 2020

Mr. David Rettell
Waste Management
7227 NE 55th Ave
Portland, Oregon 97218

Dear Mr. Rettell:

Subject: Engineering Design Report
L14 Expansion Application
Chemical Waste Management of the Northwest
Arlington, Oregon
CEC Project 194-991

Civil & Environmental Consultants, Inc. (CEC) has prepared this Engineering Design Report to address select engineered components for the Landfill L14 Expansion Application at Chemical Waste Management of the Northwest (CWM) in Arlington, Oregon. In addition to select design components, CEC prepared a Permit Drawing Set included with this report. The design of these components was based on the attached Permit Drawing Set and previously submitted design report[1].

The L14 Expansion footprint does change or modify the following items:

- The top elevation of the landfill still remains unchanged at elevation 1,150;
- The waste thickness at the deepest part of the landfill remains the same at 205-feet;
- The sideslope of the landfill remains the same at 3H:1V;
- The liner system remains unchanged;
- The leachate collection system, including the leachate collection pipe, sump size, and riser pipes remain unchanged; and
- The final cover system remains unchanged.

The scope of this Engineering Design Report was based on a review of the existing design of the L14 Landfill. The design of the items in this report was requested by CWM because the previously prepared designs of these items were no longer valid for the proposed layout of the L14 Expansion footprint. This Engineering Design Report includes the following:

[1] "Landfill Design and Operations Plan for Chemical Waste Management of the Northwest, Inc." Standalone Document No. 14, Issued by Oregon Department of Environmental Quality, December 2015.

- Anchor Trench Design;
- Leachate Generation Analysis;
- Leachate Collection System Sump Sizing Calculations;
- Protective Cover Flow Capacity;
- Collection Pipe Flow Capacity;
- Leachate Collection System Pipe Strength Calculations;
- Response Action Plan (RAP);
- Site Capacity and Soil Balance Calculations; and
- Permit Drawing Set.

Detailed calculation briefs for the Anchor Trench Design, Leachate Generation Analysis, LCS Calculations, and Site Capacity and Soil Balance Calculations are included as attachments to this report. Also included as an attachment is a revised RAP narrative and associated calculations. This Engineering Design Report summarizes the methodology and results for the design of each of the above listed items. A more detailed explanation of the design of each item is provided in the respective attachments.

1.0 ANCHOR TRENCH DESIGN

A calculation brief for the design of the anchor trench was prepared to determine the size of the anchor trench required to provide sufficient frictional resistance to pull out of the geosynthetic components of the L14 base liner system. The design utilized published manufacturer data sheets to estimate the maximum allowable tension of the geomembrane, published references for the geosynthetic interface shear strengths, and the previously submitted geotechnical properties of soil components.

The previously permitted anchor trench design utilized a 3-foot (ft) by 3-ft anchor trench to stabilize the base liner system geosynthetics. For simplicity, CEC performed this analysis to determine if the continuation of a 3-ft by 3-ft anchor trench is suitable for the L14 expansion footprint. Based on the calculations in Attachment Number (No.) 1, a 3-ft by 3-ft anchor provides more than twice the frictional resistance required to resist pull out of the base liner geosynthetics and is suitable for use at the L14 Expansion.

2.0 LEACHATE GENERATION ANALYSIS

CEC utilized the Hydrologic Evaluation of Landfill Performance (HELP) Version 3.07 software to estimate the future leachate generation and maximum hydraulic head above the geomembrane for the L14 Expansion. To estimate future leachate volumes, HELP models were developed for three distinct conditions: an "open" condition, an "intermediate" condition, and a "final" condition. Open condition simply means the model possesses a limited thickness or volume of waste and would be capable of generating significant volumes of leachate, representing the daily working face during initial cell filling. Interim condition means the cell possesses a greater thickness or volume of waste relative to the open condition, and due to the thickness and absorptive capacity of the waste, generates substantially less leachate. Final condition means the cell is capped with the final cover system, and the underlying waste is dewatering and produces little, if any, additional leachate through cap geomembrane leakage.

The HELP model utilizes climatological data, soil/geosynthetic data, and design data concerning the geometry of the landfill to simulate leachate generation. Climatological data from the weather station at Pendleton, Oregon was used to generate synthetic precipitation, temperature and solar radiation data for a time period of 100 years. The precipitation data was modified so the peak precipitation included the 25-year (yr)/24-hour (hr) rain fall event for Arlington, Oregon. The soil/geosynthetic data were selected to be consistent with values utilized in the previously permitted HELP modeling[2]. The design data was selected based on the waste thickness, top of waste, and base grade orientations shown on the Permit Drawing Set.

The output from the HELP model analyses are included with the calculation brief in Attachment No. 2. The results of this analysis are summarized in the table below.

Condition	Peak Leachate Volume (in/ac/day)	Maximum Hydraulic Head above Geomembrane (in)
Open Condition	0.04213	0.021
Interim Condition	0.00014	0.005
Closed Condition	0.01152	0.070

[2] Attachment G-10 Leachate Generation Analysis L14 Landfill, prepared by Rust Environment & Infrastructure, Inc., February 1998.

The peak daily leachate volume of 0.04213 in/ac/day was utilized during the design of the leachate collection system (LCS) components for the L14 Expansion. Also, the maximum hydraulic head is less than the allowable head of 12 in.

3.0 LEACHATE COLLECTION SYSTEM SUMP SIZING CALCULATIONS

The minimum required sump volume was determined based on the peak daily leachate storage requirement and the minimum sump volume required for efficient pump operation. The leachate storage and pump requirements were estimated using the results of the above-described leachate generation analysis and the static and dynamic head requirements for a submersible pump operating at the base of the sump and discharging at the top of the slope (see Permit Drawing Set for Sump Locations).

Based on the calculations in Attachment No. 3, the sump volume should be greater than approximately 2,676 cubic feet (ft^3) in order to adequately store the anticipated leachate volume from the design storm event and maintain the efficient pumping cycles that will result in optimal longevity and performance of the pump.

4.0 PROTECTIVE COVER FLOW CAPACITY

The leachate collection system for the L14 Expansion (Cells 5 through 8) will consist of a double-sided drainage geocomposite along with 18-in thick protective cover layer along cell floor. The cell floors have a herringbone configuration with an 8-inch diameter perforated leachate collection pipe running through the center for the cells to the primary leachate collection sumps. The vertical and horizontal flow capacity of the 18-inch thick protective cover layer was estimated using Darcy's Law, typical values for the hydraulic conductivity/transmissivity of protective cover, and the cell base grade configuration. The flow capacity of the protective cover layer was compared to the leachate generation rate to determine if the protective cover layer will allow free and continuous flow of leachate from the waste to the collection pipe/sump. Based on the attached calculations, the flow capacity of the protective cover layer greatly exceeds the incoming peak leachate generation rate. A calculation brief for the Protective Cover Flow Capacity is included in Attachment No. 4

5.0 COLLECTION PIPE FLOW CAPACITY

The leachate collection system piping will be 8-inch nominal diameter Standard Dimension Ratio (SDR) 11 high density polyethylene (HDPE). Perforations will be 3/4-in diameter, spaced every 6 inches along the pipe at the 4 and 8 o'clock positions. CEC analyzed the flow capacity of the 3/4-inch diameter pipe perforations and of the 8-inch diameter collection pipe. Additionally, CEC used the American Association of State Highway and Transportation Officials (AASHTO) gradations to determine the aggregate classification that is suitable for use in the protective cover layer to prevent migration of the aggregate particles through the leachate collection pipe perforations. Based on the attached calculations, the pipe perforations and collection pipe provide adequate flow capacity to allow free flow of leachate to the primary leachate collection sump. Additionally, AASHTO No. 3 gradation aggregate is suitable for use in the protective cover layer. A calculation briefs for the Collection Pipe Flow Capacity is included in Attachment No. 5

6.0 LEACHATE COLLECTION SYSTEM PIPE STRENGTH CALCULATIONS

The leachate collection pipe will be located throughout the base of the L14 Expansion cells. Each of these components must be able to withstand the anticipated loads and stresses that will be exerted on them during site development. The proposed 8-inch diameter SDR 11 HDPE leachate collection pipe was analyzed for three possible modes of failure, including: Ring Deflection, Ring Compression (i.e., Pipe Crushing), and Ring Buckling in accordance with the Plastic Pipe Institute's[3] design methodology for deep fill installation. For the purpose of this analysis, the critical loading condition for the leachate collection pipes occurs when the maximum thickness of waste is in place.

Per the calculations included in Attachment No. 6, the L14 Expansion leachate collection system piping will be able to withstand anticipated loads, stresses, and disturbances from overlying waste and cover materials.

[3] "Handbook of Polyethylene Pipe;" Second Edition; Plastic Pipe Institute.

7.0 RESPONSE ACTION PLAN

CEC revised the RAP to include the L14 Expansion footprint (Cells 5, 6, 7, and 8). This RAP addresses: (1) the requirements of CFR Part 264.301; (2) identification and quantification of potential sources of liquids within the Leak Detection System (LDS) on a cell- specific basis; (3) the criteria to be used to detect, evaluate, and respond to liquids in the LDS;(4) the proposed response actions which may be triggered by detection of liquids within the LDS; and (5) the reporting procedures to state and federal agencies.

For continuity, CEC utilized the same design methodology in previous version of the RAP to estimate leak detection time, leakage rates through the liner system, and to determine the Action Leakage Rate (ALR) for each individual cell. The leak detection time for the cell is based on the longest flow path through the drainage geocomposite, the slope of the cell floor, and the minimum required transmissivity of drainage geocomposite. Based on these criteria, CEC identified that the critical (i.e., longest) leak detection time will occur in cell 1, 4, 7, or 8. The leak detection time calculations for these cells have been included in Appendix A of the revised RAP and the results have been summarized in the follow table.

CELL SPECIFIC LEAK DETECTION TIMES

Cell	Leak Detection Time (days)	Leak Detection Time (hours)
1	0.8	19.4
4	0.4	8.9
7	0.6	13.2
8	0.5	12.2

Based on the results, the critical leak detection time occurs in existing Cell 1 and the new expansion cells will not increase the maximum leak detection time for the L14 landfill. Based on the minimum required transmissivity and the cell floor width and slope, the maximum drainage capacities of the LDS and thus ALRs are as follows.

CELL SPECIFIC ACTION LEAKAGE RATES (ALRs)

Cell	Cell Floor Width (ft)[1]	Minimum Cell Floor Slope (%)	Max Drainage Capacity (gpd)
1	210	1.0	438
2	214	1.0	447
3	214	1.5	670
4	120	1.5	376
5	134[(2)]	1.5	419
6	134[(2)]	1.5	419
7	134[(2)]	1.5	419
8	134[(2)]	1.5	419

Note:

1. Due to the herringbone configurations of Cells 4, 5, 6, 7, and 8 the maximum drainage capacity of these cells was based on the perimeter length of the sump rather than the width of the cell floor.
2. Per the detail in the permit drawing set, sumps in Cells 5, 6, 7, and 8 are 41 ft. long by 26 ft. wide.

The use of these action leakage rates enables the owner/operator to take action before large releases into the LDS begin to occur. Additionally, CEC verified that the Secondary LCS Sump has adequate storage capacity to allow for the time required for a typical pump to remove leachate from the LDS sump. The revised RAP has been included as Attachment No. 7 to this Engineering Design Report.

8.0 SITE CAPACITY AND SOIL BALANCE CALCULATIONS

CEC prepared Site Capacity and Soil Balance calculations to estimate the total Waste Volume Capacity of the L14 Expansion (Cells 1 through 8) and the soil balance for site soils required to construct the remaining cells (Cells 4C - 8) and close the entire L14 Expansion.

Per the calculations in Attachment No. 8, the L14 Expansion has a site capacity of 10,105,000 cubic yards (cy) with an excess of approximately 1,003,000 cy of site soils available after construction of the remaining cells (Cells 4C - 8) and closure of the entire Landfill L14 Area.

9.0 PERMIT DRAWING SET

The L14 Permit Drawing Set consists of the drawings listed below and has been included with this Engineering Design Report:

Drawing No.	Drawing Title
P-000	Title Sheet
P-300	Subgrade Plan
P-301	Top of Protective Cover
P-302	Top of Waste Grading Plan
P-303	Landfill Cross Sections
P-304	Landfill Cross Sections
P-800	Liner System and Anchor Trench Details
P-801	Riser Pipe Details
P-802	Sump and Leachate Collection System Details
P-803	Sump and Sideslope Riser Pipe Layout
P-804	Sump Layout Details
P-805	Liner Termination Details

9.0 OTHER CONSIDERATIONS

CEC notes that this Permit Drawing Set are in fact permit drawings and are not suitable to be used for construction. The information conveyed in the Permit Drawing Set was limited in scope and only reflects the results of the design calculations included with this Engineering Design Report. CEC understands that the following calculations are being completed by others. CEC recommends that these calculations be completed prior to construction of the expansion area of Landfill L-14:

- Bearing Capacity Analysis;
- Settlement Analysis;
- Overall and Interim Slope Stability; and
- Veneer Stability of Base and Final Cover Liner Systems.

10.0 CLOSING REMARKS

CEC trusts the information in this Engineering Design Report is sufficient for your needs at this time. Please contact us if you have questions or require additional information.

Very truly yours,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

David V. Spang
Assistant Project Manager

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Senior Project Manager

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Principal

REGISTERED PROFESSIONAL ENGINEER
92360PE
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
03/30/2020
EXPIRES: 06-30-2020

Attachments

ATTACHMENT NO. 1

ANCHOR TRENCH DESIGN CALCULAIONS

OBJECTIVE: **Analyze the proposed anchor trench design to determine if it provides approximately 1,008 pounds per foot (ppf) (maximum allowable liner tension as calculated in Attachment A) of short term pull-out resistance.**

REFERENCES:

1. Koerner, Robert. Designing with Geosynthetics, Second Edition, Prentice Hall, 1990.

2. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces, GRI Report #30, Geosynthetic Research Institute, June 14, 2005.

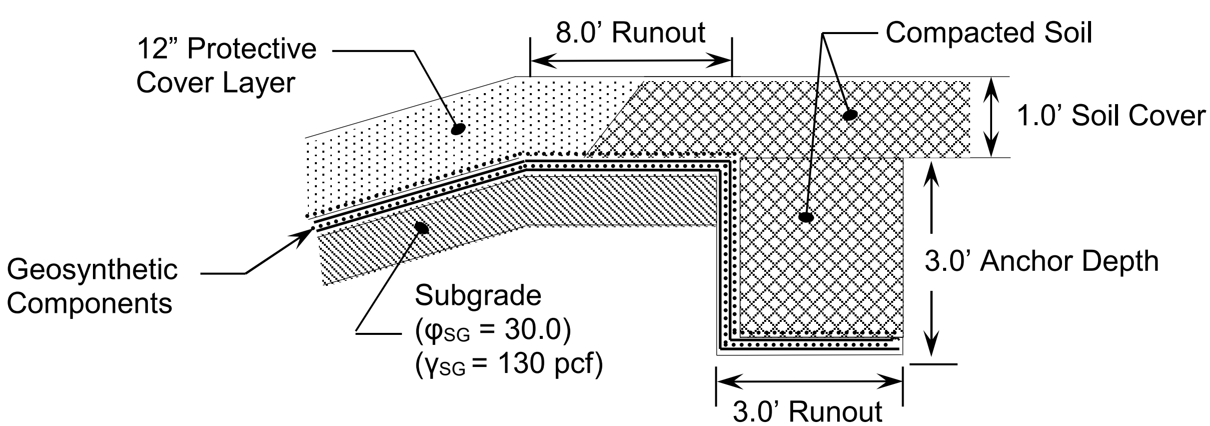
3. "Landfill Design and Operations Plan for Chemical Waste Management of the Northwest, Inc." Standalone Document No. 14, Issued by Oregon Department of Environmental Quality, December 2015.

ANALYSIS:

The proposed sideslope liner system cross-section consists of the following components listed with their friction angle of the layer below (in descending order). Friction angles for each interface were determined using Reference Number 2. Soil properties were taken from the stability analyses included in Reference Number 3.

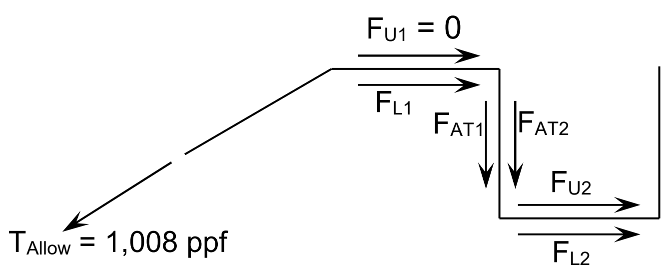
1. 12 inches of protective cover stone (27.0°);
2. Primary Double-Sided Drainage Composite (26.0°);
3. 60-mil textured HDPE primary geomembrane (26°);
5. Secondary Double-sided drainage composite (26.0);
6. 60-mil textured HDPE secondary geomembrane (23.0°);
7. Geosynthetic clay liner (GCL) (nonwoven side up) (29.0°);
8. Subgrade.

The proposed anchor trench design is shown below:



d_{sc} = 1.0' (soil cover depth)
γ_{SC} = 130 pcf
δ_1 = 23.0°
δ_2 = 26.0°
L_{RO1} = 8.0' (berm runout)
L_{RO2} = 3.0' (trench runout)
d_{AT} = 3.0' (trench depth)
$d_{AT'}$ = 4.0' (effective depth)

The frictional resistance mobilized by the anchor trench geometry shown above is resolved as follows:



$F_{L1} = \gamma_{SC}\, d_{SC} \tan \delta_1\, L_{RO1}$
$F_{AT1} = (1\text{-}\sin \varphi_{SG})\, \gamma_{SG}\, H_{Avg} \tan \delta_1\, d_{AT}$
$F_{AT2} = (1\text{-}\sin \varphi_{SG})\, \gamma_{SG}\, H_{Avg} \tan \delta_2\, d_{AT}$
$F_{U1} = 0$
$F_{U2} = \gamma_{SC}\, d_{AT'} \tan \delta_2\, L_{RO2}$
$F_{L2} = \gamma_{SC}\, d_{AT'} \tan \delta_1\, L_{RO2}$

$$H_{Avg} = \text{Average Anchor Trench Depth} = \frac{3.0' + 1.0'}{2} = 2.0'$$

Thus, for static equilibrium conditions:

$$T_{Allow} = F_{L1} + F_{AT1} + F_{AT2} + F_{U2} + F_{L2}$$

1,008 ppf ≤ (130.0 pcf • 1.0' • tan 23.0° • 8.0') + [(1-sin 30.0) • 130.0 pcf • 2.0' • tan 23.0° • 3.0'] + [(1-sin 30°) • 130.0 pcf • 2.0' • tan 26.0° • 3.0'] + (130.0 pcf • 4.0' • tan 26.0° • 3.0') + (130.0 pcf • 4.0' • tan 23.0° • 3.0')

1,008 ppf ≤ 441 ppf + 166 ppf + 190 ppf + 761 ppf + 662 ppf

1,008 ppf ≤ 2,220 ppf OK

CONCLUSION:	The proposed anchor trench will provide sufficient frictional resistance to avoid pull-out at an applied force of 1,008 ppf.

ATTACHMENT A

MAXIMUM ALLOWABLE GEOMEMBRANE STRESS

CALCULATION BRIEF

MAXIMUM ALLOWABLE GEOMEMBRANE STRESS
L14 EXPANSION
WASTE MANAGEMENT – CWM LANDFILL

OBJECTIVE: Determine the maximum allowable tensile force in the 60-mil high density polyethylene (HDPE) geomembrane. The calculated maximum tension will then be used to determine the allowable length of incremental protective cover placement and to design the liner system anchor trench.

ANALYSIS:

The maximum allowable tensile force in the HDPE geomembrane to be used will be based on the yield strengths of typical HDPE geomembranes.

The liner system design calls for the use of a 60-mil textured HDPE geomembrane liner. Assuming that potential suppliers of this material will be GSE, Poly-Flex, Inc. (Poly-Flex), Agru/America, Inc. (Agru), or SKAPS Industries (SKAPS), the yield strengths and strains for 60-mil textured HDPE geomembranes in the following table were obtained from the manufacturers. The manufacturer's data sheets have been included in Exhibit 1.

HDPE Geomembrane	Yield Strength (pounds per inch (ppi))	Yield Strain (%)
GSE 60-mil	126	12
Poly-Flex 60-mil	126	12
Agru 60-mil	132	12
SKAPS 60-mil	132	13

Using the minimum reported yield strength of 126 ppi and applying a Factor of Safety Against Yield (FS_{yield}) of 1.5 to this yield strength, results in a Preliminary Allowable Tensile Force (T_{allow}) of:

$$T_{allow} = \frac{\text{Yield Strength}}{FS_{yield}} = \frac{126\text{ppi}}{1.5} = 84 \text{ ppi} = 1{,}008 \text{ pounds per foot (ppf)}$$

The evaluation of the maximum allowable tensile force is based on maintaining strain and stress to within tolerable or allowable limits for the HDPE geomembranes. Specifically, the primary and secondary HDPE geomembranes will possess yield strains of at least 12 percent with a yield strength of at least 126 pounds per inch (ppi) as stated above. Applying a factor of safety to 1.5 to the yield strain results in the allowable tensile strain, as follows:

$$\text{Allowable Tensile Strain} = \frac{12\%}{1.5} = 8.0\%$$

CONCLUSION: The maximum allowable HDPE geomembrane tensile load in the HDPE geomembrane is approximately 1,000 pounds per foot, with a maximum allowable strain of 8.0%.

EXHIBIT 1

GEOMEMBRANE MANUFACTURER'S DATA SHEETS

Table 2.1: GSE HD Textured Geomembrane (English)

			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mil Lowest individual reading	ASTM D 5994	every roll	30 27	40 36	60 54	80 72	100 90
Density, g/cm^3 , (min.)	ASTM D 1505	200,000 lbs	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lbs	 45 63 100 12	 60 84 100 12	 90 126 100 12	 120 168 100 12	 150 210 100 12
Tear Resistance, lb	ASTM D 1004	45,000 lbs	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	45,000 lbs	45	60	90	120	150
Carbon Black Content, % (Range)	ASTM D 1603*/4218	20,000 lbs	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lbs	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Asperity Height, mil	ASTM D 7466	second roll	16	18	18	18	18
Notch Constant Tensile Load(2), hr	ASTM D 5397, Appendix	200,000 lbs	300	300	300	300	300
Oxidative Induction Time, min	ASTM D 3895, 200°C; O_2, 1 atm	200,000 lbs	>100	>100	>100	>100	>100
Typical Roll Dimensions							
Roll Length(3), ft	Double-Sided Textured Single-Sided Textured		830 1,010	700 780	520 540	400 410	330 330
Roll Width(3), ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft^2	Double-Sided Textured Single-Sided Textured		18,675 22,725	15,750 17,550	11,700 12,150	9,000 9,225	7,425 7,425

NOTES:
- (1)Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)NCTL for GSE HD Textured is conducted on representative smooth geomembrane samples.
- (3)Roll lengths and widths have a tolerance of ± 1%.
- GSE HD Textured is available in rolls weighing approximately 4,000 lb.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

TEXTURED HDPE GEOMEMBRANE
ENGLISH UNITS

POLY-FLEX®
POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values 40 mil	60 mil	80 mil	100 mil
Thickness, mils	ASTM D 5994				
minimum average		38	57	76	95
lowest individual of 8 of 10 readings		36	54	72	90
lowest individual of 10 readings		34	51	68	85
Asperity Height[1], mils	ASTM D 7466	10	10	10	10
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, lb/in		84	126	168	210
2. Break Strength, lb/in		60	90	120	150
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, lb	ASTM D 1004	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	60	90	120	150
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	--Note 5--			
Oxidative Induction Time (OIT)					
Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80
UV Resistance[6]	ASTM D 7238				
High Pressure OIT[7] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet)		750	500	375	300
3. Area (square feet):		17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,500	3,500	3,470	3,470

1 Of 10 readings; 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

These data are provided for informational purposes only and are not intended as a warranty or guarantee. Poly-America, L.P. assumes no responsibility in connection with the use of these data. Suitablility for a particular use shall be determined by and is the sole responsibility of the end user. These values are subject to change without notice. REV. 03/14

MicroSpike® Liner

HIGH DENSITY POLYETHYLENE

AGRU America's structured geomembranes are manufactured on state-of-the-art manufacturing equipment using the flat die calender manufacturing process, a method that produces the most consistent texturing across the roll along with a more consistent core thickness than other processes, such as the blown film extrusion process. AGRU uses only the highest-grade HDPE and LLDPE resins manufactured in North America.

PRODUCT DATA

Property	Test Method	Frequency	Minimum Average Values				
Thickness (nominal), mil (mm)	ASTM D5994	Per Roll	30 (0.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min avg), mil (mm)			29 (0.71)	38 (0.95)	57 (1.43)	76 (1.9)	95 (2.38)
Thickness (min 8 of 10), mil (mm)			27 (0.68)	36 (0.90)	54 (1.35)	72 (1.8)	90 (2.25)
Thickness (lowest individual), mil (mm)			26 (0.64)	34 (0.85)	51 (1.28)	68 (1.7)	85 (2.13)
Asperity Height mils, (mm)	ASTM D7466	2nd Roll	20 (0.51)	20 (0.51)	20 (0.51)	18 (0.46)	18 (0.46)
Density, g/cc, minimum	ASTM D792, Method B	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (both directions)	ASTM D6693, Type IV						
Strength @ Yield, lb/in width (N/mm)	2 in/minute	20,000 lb	66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Yield, % (GL=1.3in)			12	12	12	12	12
Strength @ Break, lb/in width (N/mm)			66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Break, % (GL=2.0in)			350	350	350	350	350
Tear Resistance, lb,s. (N)	ASTM D1004	45,000 lb	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance, lbs. (N)	ASTM D4833	45,000 lb	60 (267)	90 (400)	120 (534)	150 (667)	180 (801)
Carbon Black Content, % (range)	ASTM D4218	20,000 lb	2-3	2-3	2-3	2-3	2-3
Carbon Black Dispersion (Category)	ASTM D5596	45,000 lb	Only near spherical agglomerates: 10 views in Cat. 1 or 2				
Stress Crack Resistance (SP-NCTL), hrs.	ASTM D5397 Appendix	200,000 lb	500	500	500	500	500
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	200,000 lb	≥140	≥140	≥140	≥140	≥140

AGRU America's geomembranes are certified to pass Low Temp. Brittleness via ASTM D746 (-80°C), Dimensional Stability via ASTM D1204 (±2% @ 100°C). Oven Aging and UV Resistance are tested per GRI GM 13. These product specifications meet or exceed GRI's GM13.

SUPPLY INFORMATION (STANDARD ROLL DIMENSIONS)

THICKNESS mil	THICKNESS mm	WIDTH ft	WIDTH m		LENGTH ft	LENGTH m	AREA (APPROX.) ft²	AREA (APPROX.) m²
30	0.75	23	7	Double-Sided	980	299	22,540	2,094
				Single-Sided	1050	320	24,150	2,244
40	1.0	23	7	Double-Sided	750	229	17,250	1,603
				Single-Sided	800	244	18,400	1,709
60	1.5	23	7	Double-Sided	540	165	12,420	1,154
				Single-Sided	560	171	12,880	1,197
80	2.0	23	7	Double-Sided	410	125	9,430	876
				Single-Sided	425	130	9,775	908
100	2.5	23	7	Double-Sided	335	102	7,705	716
				Single-Sided	340	104	7,820	726

Note:

Average roll weight is 3,900 lbs (1,770 kg). All rolls are supplied with two slings. Rolls are wound on a 6" core. Special length available upon request. Roll length and width have a tolerance of ±1%. The weight and length values may change due to project specifications (i.e. average or absolute minimum thickness) or shipping requirements (i.e. international containerized shipments). All information, recommendations and suggestions appearing in this literature concerning the use of our products are based upon tests and data believed to be reliable; however, it is the users responsibility to determine the suitability for their own use of the products described herein. Since the actual use by others is beyond our control, no guarantee or warranty of any kind, expressed or implied, is made by AGRU America as to the effects of such use or the results to be obtained, nor does AGRU America assume any liability in connection herewith. Any statement made herein may not be absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations. Nothing herein is to be construed as permission or as a recommendation to infringe any patent.

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Revision Date: October 29, 2018

HDPE GEOMEMBRANE
Textured Single & Double Sided

SKAPS INDUSTRIES
571 Industrial Pkwy,
Commerce, GA 30529
Phone: (706) 336-7000
Fax: (706) 336-7007
E-Mail: contact@skaps.com

SKAPS HDPE Single and Double Textured Geomembranes are manufactured utilizing the highest quality standards to provide the greatest durability in geomembrane applications. The geomembrane is formulated to meet the requirements of GRI GM13 specifications.

PROPERTY	TEST METHOD	FREQUENCY	30 mil	40 mil	60 mil	80 mil	QUALIFIER
Thickness (minimum avg), mil	ASTM D 5994	Per Roll	28.5	38	57	76	MAV[1]
Thickness (min 8 of 10), mil			27	36	54	72	MIN
Thickness (minimum), mil			25.5	34	51	68	MIN
Asperity Height, mils	ASTM D 7466	2nd Roll	18	18	18	18	MAV
Density, g/cc	ASTM D 1505	200,000 lb	0.940	0.940	0.940	0.940	MIN
Tensile Properties (both directions)	ASTM D6693 Type IV Specimen, 2 in/min	20,000 lb					
Strength at Yield, lb/in width			66	88	132	176	MAV
Elongation at Yield, % (1.3 in. GL)			13	13	13	13	MAV
Strength at Break, lb/in width			66	88	132	176	MAV
Elongation at Break, % (2 in. GL)			150	150	150	150	MAV
Tear Resistance, lb	ASTM D 1004	45,000 lb	23	30	45	60	MAV
Puncture Resistance, lb	ASTM D 4833	45,000 lb	60	90	120	150	MAV
Carbon Black Content, %	ASTM D 4218	20,000 lb	2-3				Range
Carbon Black Dispersion (Category)	ASTM D 5596	45,000 lb	Note (2)				Category
Stress Crack Resistance, hr.	ASTM D 5397, Appendix	200,000 lb	500				MIN
Oxidative Induction Time, minutes	ASTM D 3895 200°C, 1 atm O_2	200,000 lb	100				MIN
ROLL DIMENSIONS (Double-Sided)							
Roll Length, ft			870	730	510	400	NOM
Roll Width, ft			23.5	23.5	23.5	23.5	
Roll Area, sf			20,445	17,155	11,985	9,400	
ROLL DIMENSIONS (Single-Sided)							
Roll Length, ft			1,010	800	540	410	NOM
Roll Width, ft			23.5	23.5	23.5	23.5	
Roll Area, sf			23,735	18,800	12,690	9,635	

Notes:

(1) Minimum average value.

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

ATTACHMENT NO. 2

LEACHATE GENERATION ANALYSIS

CALCULATION BRIEF

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
L14 EXPANSION; CELLS 5-8
LEACHATE GENERATION

OBJECTIVE: Estimate the peak daily leachate volume and hydraulic head above the primary geomembrane for a one-acre (ac) area of the the L14 Landfill Cells 5, 6, 7, and 8 during various stages of development at the Chemical Waste Management of the Northwest (CWM). CEC modeled three stages using the Hydrologic Evaluation of Landfill Performance (HELP) Version 3.07 software (Reference Number One (Ref. No. 1)) based on the expansion footprint base grades (Ref. No. 2) and the previously prepared Leachate Generation analysis (Ref. No. 3).

REFERENCES:

1. Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07, United States Environmental Protection Agency (USEPA), November 1, 1997.

2. L14 Landfill Expansion Permit Drawing Set at Chemical Waste Management of the Northwest L14 prepared by Civil & Environmental Consultants, Inc., January 2020.

3. Attachment G-10 Leachate Generation Analysis L14 Landfill, prepared by Rust Environment & Infrastructure, Inc., February 1998.

4. NOAA Atlas 2 Precipitation- Frequency Atlas of the Western United States, Volume X – Oregon, prepared for U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, 1973.

ANALYSIS:

To estimate future leachate generation volumes, HELP models were developed for three distinct conditions, as follows:

1. "Open" condition

   - "Open" condition means the model possesses a limited thickness or volume of waste and would be capable of generating significant volumes of leachate, representing the daily working face during initial cell filling.

   - Waste mass thickness of 5 feet (ft) with 6 inches (in) of daily cover soil;

2. "Intermediate" condition

   - "Interim" condition means the cell possesses a greater thickness or volume of waste relative to the open condition, and due to the thickness and absorptive capacity of the waste, generates substantially less leachate.

   - Waste mass thickness of 63 ft with 6 in of daily cover soil.

3. "Final" condition

   - "Final" condition means the cell is capped with the final cover system, and the underlying waste is dewatering and produces little, if any, additional leachate through cap geomembrane leakage.

   - Waste mass thickness of 126 ft with 6 in of daily cover soil.

The HELP model is a mathematical simulation that routes precipitation along various flow paths that can exist within the landfill. These flow paths include surface runoff, evapotranspiration, lateral drainage, soil moisture storage, and vertical percolation through and out of the landfill. Essentially, three types of data are required by the HELP model including climatological data, soil/geosynthetic data, and design data concerning the geometry of the landfill.

Climatological Data

Climitalogical data selected for the nearest weather station location available in HELP. HELP used climatological data from the weather station at Pendleton, Oregon was used to generate synthetic precipitation, temperature and solar radiation data. The precipitation data was modified so the peak precipitation matched the 25-year (yr)/24-hour (hr) rain fall event. Per Ref. No. 4, the 25-yr/24-hr rainfall for Arlington, Oregon is 1.8 inches (See attachment No. 2). Note, for consistency with the modeling performed in Ref No. 3, the 25-yr/24-hr rainfall event was doubled during the interim analysis (i.e. 3.6 inches).

Soil/Geosynthetic Data

Soil/geosynthetic data accounts for the largest amount of input required by the HELP model. Input data required for each layer of the landfill that is modeled include: porosity, field capacity, wilting point, saturated hydraulic conductivity, and thickness. The HELP model assumes that each of these layers is homogeneous and isotropic with respect to each of these soil properties. A summary of the characteristics for the cap system, waste, and liner system used in the HELP model simulations follows. The properties for each component were selected to match Ref. No. 3 for consistency.

Cap System and Waste

Liner Component	Thickness	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated k (cm/sec)
Final Cover	18 inches	0.419	0.307	0.180	1.899×10^{-5}
Drainage Composite	0.20 inches	0.850	0.010	0.005	10.0
Geomembrane	0.04 inches	0	0	0	2.0×10^{-13}
Intermediate Cover	18 inches	0.427	0.418	0.367	1.0×10^{-7}
Waste	5 feet (Open) 62.5 feet (Int.) (1) 125 feet (Final) (1)	0.398	0.244	0.136	1.119×10^{-4}

Notes:

1. The L14 waste thickness will range from 0 to 200 feet, with an average of 125 feet (1,500 inches).

Base Liner System

Liner Component	Thickness (inches)	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated k (cm/sec)
Protective Cover	18	0.457	0.131	0.058	1.0×10^{-3}
Leachate Collection Geocomposite	0.20	0.850	0.010	0.005	8.39(1) 1.79(1) 1.0×10^{-3}(1)
Primary Geomembrane	0.06	0	0	0	2.0×10^{-13}
Geosynthetic Clay Liner(4)	0.20	0.750	0.747	0.400	3.0×10^{-9}

Notes:

1. The hydraulic conductivity of the leachate collection geocomposite was reduced to account for the increased normal loads associated with the increasing waste thickness.

Design Data

Ref. No. 2 was used to provide lateral drainage slopes and lengths and waste thicknesses. The lateral drainage slopes used in the model were dictated by the proposed landfill configuration. Inspection of the top of protective cover plan shown on the L14 permit drawings shows a maximum drainage distance of approximately 230 feet along a 2.0% base slope, and inspection of the final cover system plan shown on the permit drawings shows a maximum drainage distance of approximately 250 feet along a 5% slope between benches.

RESULTS:

The output from the HELP model analyses are included with this calculation brief in Attachment No. 1. The results of this analysis are summarized in the table below.

Condition	Peak Leachate Volume (in/ac/day)	Maximum Hydraulic Head above Geomembrane (in)
Open Condition	0.04213	0.021
Interim Condition	0.00014	0.005
Closed Condition	0.01152	0.070

CONCLUSION: A peak daily leachate volume of 0.04213 in/ac/day and a maximum hydraulic head of 0.070 in are estimated to occur throughout operation and closure of Cells 5 through 8 at CWM's L14 landfill.

ATTACHMENT 1

HELP MODEL OUTPUT

OPEN CONDITION

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

OPEN CONDITION

```
 PRECIPITATION DATA FILE:    \CWM\OPDATA4.D4
 TEMPERATURE DATA FILE:      \CWM\OPDATA7.D7
 SOLAR RADIATION DATA FILE:  \CWM\OPDATA13.D13
 EVAPOTRANSPIRATION DATA:    \CWM\OPDATA11.D11
 SOIL AND DESIGN DATA FILE:  \CWM\OPDATA10.D10
 OUTPUT DATA FILE:           \CWM\OPOUT.OUT


 TIME:  14: 6     DATE:   1/20/2020
```

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

      TITLE:  Landfill L-14

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


      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   9
            THICKNESS                    =      6.00   INCHES
            POROSITY                     =      0.5010 VOL/VOL
            FIELD CAPACITY               =      0.2840 VOL/VOL
            WILTING POINT                =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT   =      0.1650 VOL/VOL
            EFFECTIVE SAT. HYD. COND.    =  0.190000006000E-03 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER  10
            THICKNESS                    =     60.00   INCHES
            POROSITY                     =      0.3980 VOL/VOL
            FIELD CAPACITY               =      0.2440 VOL/VOL
            WILTING POINT                =      0.1360 VOL/VOL
            INITIAL SOIL WATER CONTENT   =      0.1500 VOL/VOL
            EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC


                                  LAYER  3
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   5
            THICKNESS                    =     18.00   INCHES
            POROSITY                     =      0.4570 VOL/VOL
```

```
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0667 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 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.   =   8.39999962000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    230.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   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                   =      0.20   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 USER-SPECIFIED.

```
SCS RUNOFF CURVE NUMBER            =     84.00
FRACTION OF AREA ALLOWING RUNOFF    =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      0.990  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      3.006  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.810  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     11.343  INCHES
TOTAL INITIAL WATER                 =     11.343  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PENDLETON OREGON

```
STATION LATITUDE                         =  45.41 DEGREES
MAXIMUM LEAF AREA INDEX                  =   0.00
START OF GROWING SEASON (JULIAN DATE)    =    115
END OF GROWING SEASON (JULIAN DATE)      =    288
EVAPORATIVE ZONE DEPTH                   =   6.0  INCHES
AVERAGE ANNUAL WIND SPEED                =   9.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  52.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  41.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.73	1.11	1.06	0.99	1.09	0.70
0.30	0.55	0.58	0.95	1.48	1.66

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.80	39.40	43.90	50.30	58.40	66.20
73.80	71.70	63.60	52.50	41.10	36.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

AND STATION LATITUDE = 45.41 DEGREES

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ANNUAL TOTALS FOR YEAR 1

-

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.34	44794.195	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.538	38253.016	85.40
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		

CHANGE IN WATER STORAGE	1.802	6541.174	14.60
SOIL WATER AT START OF YEAR	11.343	41173.531	
SOIL WATER AT END OF YEAR	13.145	47714.703	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.05	43741.508	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.589	38437.758	87.87
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	1.461	5303.778	12.13
SOIL WATER AT START OF YEAR	13.145	47714.703	
SOIL WATER AT END OF YEAR	14.606	53018.480	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	-0.028	0.00

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ANNUAL TOTALS FOR YEAR 3

-

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.41	52308.305	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.037	36433.414	69.65
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	4.373	15874.887	30.35
SOIL WATER AT START OF YEAR	14.606	53018.480	
SOIL WATER AT END OF YEAR	18.979	68893.367	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 4

-

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.70	49731.016	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.802	35582.844	71.55
DRAINAGE COLLECTED FROM LAYER 4	2.0237	7345.913	14.77
PERC./LEAKAGE THROUGH LAYER 6	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0013		
CHANGE IN WATER STORAGE	1.874	6802.224	13.68
SOIL WATER AT START OF YEAR	18.979	68893.367	
SOIL WATER AT END OF YEAR	20.782	75436.961	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.071	258.630	0.52
ANNUAL WATER BUDGET BALANCE	0.0000	0.028	0.00

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ANNUAL TOTALS FOR YEAR 5

-

	INCHES	CU. FEET	PERCENT

PRECIPITATION	11.13	40401.910	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.138	29542.074	73.12
DRAINAGE COLLECTED FROM LAYER 4	3.6543	13265.253	32.83
PERC./LEAKAGE THROUGH LAYER 6	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0024		
CHANGE IN WATER STORAGE	-0.663	-2405.441	-5.95
SOIL WATER AT START OF YEAR	20.782	75436.961	
SOIL WATER AT END OF YEAR	20.190	73290.148	
SNOW WATER AT START OF YEAR	0.071	258.630	0.64
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

-

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.88	0.95	0.83	1.46	1.02	1.02
	0.21	0.22	0.65	1.15	1.69	1.65
STD. DEVIATIONS	0.61	0.42	0.25	0.62	0.57	1.16
	0.20	0.17	0.31	0.55	0.38	0.89

```
   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                 0.817    1.028    1.055    1.209    0.964    1.097
                            0.398    0.200    0.273    0.724    1.039    1.018

     STD. DEVIATIONS        0.192    0.568    0.544    0.663    0.680    0.854
                            0.268    0.083    0.114    0.542    0.268    0.138

   LATERAL DRAINAGE COLLECTED FROM LAYER  4
   ----------------------------------------
     TOTALS                 0.0100   0.0374   0.1204   0.2456   0.2327
0.1481
                            0.1452   0.0785   0.0454   0.0311   0.0206
0.0206

     STD. DEVIATIONS        0.0223   0.0836   0.2692   0.3860   0.3207
0.2033
                            0.1989   0.1084   0.0623   0.0428   0.0300
0.0283

   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)

------------------------------------------------------------------------------
-
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DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES 0.0001 0.0003 0.0009 0.0020 0.0018
0.0012
0.0011 0.0006 0.0004 0.0002 0.0002
0.0002

STD. DEVIATIONS 0.0002 0.0007 0.0021 0.0031 0.0025
0.0016
0.0016 0.0008 0.0005 0.0003 0.0002
0.0002

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*

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*

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

-

	INCHES		CU. FEET	PERCENT
PRECIPITATION	12.73	(1.317)	46195.4	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	9.821	(0.9978)	35649.82	77.172
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.13560	(1.65842)	4122.233	8.92347
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.003	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.001	(0.001)		
CHANGE IN WATER STORAGE	1.770	(1.7890)	6423.32	13.905

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	1.80	6534.000
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.04213	152.93448
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 5	0.010	
MAXIMUM HEAD ON TOP OF LAYER 5	0.021	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.87	3160.5120

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5010

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1350

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

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

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.2979	0.2163
2	15.8000	0.2633
3	2.9398	0.1633
4	0.0024	0.0119
5	0.0000	0.0000
6	0.1500	0.7500
SNOW WATER	0.000	

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INTERIM CONDITION

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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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INTERIM CONDITION

```
 PRECIPITATION DATA FILE:    \CWM\INDATA4.D4

 TEMPERATURE DATA FILE:      \CWM\INDATA7.D7

 SOLAR RADIATION DATA FILE:  \CWM\INDATA13.D13

 EVAPOTRANSPIRATION DATA:    \CWM\INDATA11.D11

 SOIL AND DESIGN DATA FILE:  \CWM\INDATA10.D10

 OUTPUT DATA FILE:           \CWM\INOUT.OUT


 TIME:  12:35     DATE:   1/21/2020
```

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

      TITLE:  Landfill L-14

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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   9
            THICKNESS                   =     6.00   INCHES
            POROSITY                    =     0.5010 VOL/VOL
            FIELD CAPACITY              =     0.2840 VOL/VOL
            WILTING POINT               =     0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.1650 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC


                                  LAYER  2
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  10
            THICKNESS                   =   750.00   INCHES
            POROSITY                    =     0.3980 VOL/VOL
            FIELD CAPACITY              =     0.2440 VOL/VOL
            WILTING POINT               =     0.1360 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.1500 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC


                                  LAYER  3
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   5
            THICKNESS                   =    18.00   INCHES
            POROSITY                    =     0.4570 VOL/VOL
```

```
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0667 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 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  =      0.0110 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   1.79999995000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    230.0    FEET


                        LAYER  5
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   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                   =      0.20   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 USER-SPECIFIED.

```
SCS RUNOFF CURVE NUMBER            =    84.00
FRACTION OF AREA ALLOWING RUNOFF   =     0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
EVAPORATIVE ZONE DEPTH             =     6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =     0.990  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =     3.006  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =     0.810  INCHES
INITIAL SNOW WATER                 =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =   114.843  INCHES
TOTAL INITIAL WATER                =   114.843  INCHES
TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PENDLETON OREGON

```
STATION LATITUDE                        =  45.41 DEGREES
MAXIMUM LEAF AREA INDEX                 =   0.00
START OF GROWING SEASON (JULIAN DATE)   =    115
END OF GROWING SEASON (JULIAN DATE)     =    288
EVAPORATIVE ZONE DEPTH                  =   6.0  INCHES
AVERAGE ANNUAL WIND SPEED               =   9.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  52.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  41.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  72.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.73	1.11	1.06	0.99	1.09	0.70
0.30	0.55	0.58	0.95	1.48	1.66

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.80	39.40	43.90	50.30	58.40	66.20
73.80	71.70	63.60	52.50	41.10	36.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

AND STATION LATITUDE = 45.41 DEGREES

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ANNUAL TOTALS FOR YEAR 1

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.34	44794.195	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.548	38290.898	85.48
DRAINAGE COLLECTED FROM LAYER 4	0.0002	0.726	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		

CHANGE IN WATER STORAGE	1.791	6502.550	14.52
SOIL WATER AT START OF YEAR	114.843	416879.281	
SOIL WATER AT END OF YEAR	116.634	423381.844	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

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ANNUAL TOTALS FOR YEAR 2

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.05	43741.508	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.579	38400.156	87.79
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	1.471	5341.366	12.21
SOIL WATER AT START OF YEAR	116.634	423381.844	
SOIL WATER AT END OF YEAR	118.106	428723.219	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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ANNUAL TOTALS FOR YEAR 3

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.21	58842.309	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.970	36190.766	61.50
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	6.240	22651.525	38.50
SOIL WATER AT START OF YEAR	118.106	428723.219	
SOIL WATER AT END OF YEAR	124.346	451374.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 4

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.70	49731.016	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.736	35341.906	71.07
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	3.964	14389.077	28.93
SOIL WATER AT START OF YEAR	124.346	451374.750	
SOIL WATER AT END OF YEAR	128.238	465505.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.071	258.630	0.52
ANNUAL WATER BUDGET BALANCE	0.0000	0.035	0.00

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ANNUAL TOTALS FOR YEAR 5

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	INCHES	CU. FEET	PERCENT

PRECIPITATION	11.13	40401.910	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.092	29373.977	72.70
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	3.038	11027.902	27.30
SOIL WATER AT START OF YEAR	128.238	465505.187	
SOIL WATER AT END OF YEAR	131.348	476791.719	
SNOW WATER AT START OF YEAR	0.071	258.630	0.64
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.031	0.00

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ANNUAL TOTALS FOR YEAR 6

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.25	37207.504	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.632	27705.514	74.46
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00

AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	2.618	9501.997	25.54
SOIL WATER AT START OF YEAR	131.348	476791.719	
SOIL WATER AT END OF YEAR	133.965	486293.719	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 7

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.83	46572.906	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.399	30488.385	65.46
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	4.431	16084.474	34.54
SOIL WATER AT START OF YEAR	133.965	486293.719	
SOIL WATER AT END OF YEAR	138.396	502378.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.048	0.00

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ANNUAL TOTALS FOR YEAR 8

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.27	40910.105	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	9.226	33489.012	81.86
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	2.044	7421.128	18.14
SOIL WATER AT START OF YEAR	138.396	502378.187	
SOIL WATER AT END OF YEAR	140.441	509799.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.035	0.00

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ANNUAL TOTALS FOR YEAR 9

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.30	48279.012	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.641	27736.590	57.45
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	5.659	20542.371	42.55
SOIL WATER AT START OF YEAR	140.441	509799.312	
SOIL WATER AT END OF YEAR	145.708	528921.312	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.391	1420.397	2.94
ANNUAL WATER BUDGET BALANCE	0.0000	0.050	0.00

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ANNUAL TOTALS FOR YEAR 10

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	INCHES	CU. FEET	PERCENT

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PRECIPITATION	12.28	44576.406	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.395	30472.328	68.36
DRAINAGE COLLECTED FROM LAYER 4	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 6	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0000		
CHANGE IN WATER STORAGE	3.885	14104.145	31.64
SOIL WATER AT START OF YEAR	145.708	528921.312	
SOIL WATER AT END OF YEAR	149.985	544445.812	
SNOW WATER AT START OF YEAR	0.391	1420.397	3.19
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.068	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

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	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	2.17	1.03	0.90	1.16	1.06	0.83
	0.31	0.38	0.44	0.93	1.49	1.83
STD. DEVIATIONS	0.69	0.61	0.29	0.53	0.46	0.83

```
                            0.30     0.27     0.34     0.61     0.61     1.14

   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                 0.768    0.917    1.110    0.937    1.044    0.961
                            0.328    0.258    0.279    0.614    0.888    0.919

     STD. DEVIATIONS        0.317    0.483    0.515    0.569    0.559    0.714
                            0.219    0.092    0.078    0.510    0.302    0.156

   LATERAL DRAINAGE COLLECTED FROM 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        0.0001   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  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


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-
                AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

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```
   DAILY AVERAGE HEAD ON TOP OF LAYER  5
   -------------------------------------
     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    1 THROUGH   10

------------------------------------------------------------------------------
-
                                      INCHES            CU. FEET       PERCENT
                                ------------------   -------------
---------
  PRECIPITATION                 12.54    (   1.656)      45505.7     100.00

  RUNOFF                         0.000   (  0.0000)          0.00      0.000

  EVAPOTRANSPIRATION             9.022   (  1.1396)      32748.95     71.967

  LATERAL DRAINAGE COLLECTED     0.00002 (  0.00006)         0.073    0.00016
    FROM LAYER  4

  PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.000
0.00000
    LAYER  6

  AVERAGE HEAD ON TOP            0.000 (    0.000)
    OF LAYER  5

  CHANGE IN WATER STORAGE        3.514   (  1.6174)      12756.65     28.033

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	3.60	13068.000
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.00014	0.51294
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.000	
MAXIMUM HEAD ON TOP OF LAYER 5	0.005	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.23	4478.1094
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5010	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350	

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

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

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FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	1.5909	0.2652
2	147.0296	0.1960
3	1.2126	0.0674
4	0.0020	0.0100
5	0.0000	0.0000
6	0.1500	0.7500
SNOW WATER	0.000	

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CLOSED CONDITION

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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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CLOSED CONDITION

```
 PRECIPITATION DATA FILE:    \CWM\CLDATA4.D4
 TEMPERATURE DATA FILE:      \CWM\CLDATA7.D7
 SOLAR RADIATION DATA FILE:  \CWM\CLDATA13.D13
 EVAPOTRANSPIRATION DATA:    \CWM\CLDATA11.D11
 SOIL AND DESIGN DATA FILE:  \CWM\CLDATA10.D10
 OUTPUT DATA FILE:           \CWM\CLOUT.OUT


 TIME:  12:50     DATE:   1/21/2020
```

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

      TITLE:  Landfill L-14

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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  22
            THICKNESS                   =    18.00   INCHES
            POROSITY                    =     0.4190 VOL/VOL
            FIELD CAPACITY              =     0.3070 VOL/VOL
            WILTING POINT               =     0.1800 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.3200 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.189999992000E-04 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
                         MATERIAL TEXTURE NUMBER  20
            THICKNESS                   =     0.20   INCHES
            POROSITY                    =     0.8500 VOL/VOL
            FIELD CAPACITY              =     0.0100 VOL/VOL
            WILTING POINT               =     0.0050 VOL/VOL
            INITIAL SOIL WATER CONTENT  =     0.0250 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
            SLOPE                       =     5.00   PERCENT
            DRAINAGE LENGTH             =   250.0    FEET


                                  LAYER  3
                                  --------

                       TYPE 4 - FLEXIBLE MEMBRANE LINER
                         MATERIAL TEXTURE NUMBER  35
```

```
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.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

```
                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     18.00   INCHES
POROSITY                     =      0.4270 VOL/VOL
FIELD CAPACITY               =      0.4180 VOL/VOL
WILTING POINT                =      0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC
```

```
                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    750.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1260 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
```

```
                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    750.00   INCHES
POROSITY                     =      0.3980 VOL/VOL
FIELD CAPACITY               =      0.2440 VOL/VOL
```

```
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2550 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
```

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 5

```
THICKNESS                    =     18.00   INCHES
POROSITY                     =      0.4570 VOL/VOL
FIELD CAPACITY               =      0.1310 VOL/VOL
WILTING POINT                =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1860 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

LAYER 8

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  =      0.0340 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.660000026000     CM/SEC
SLOPE                        =      2.00   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          =      1.00   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                   =      0.20   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 USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER             =     84.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      6.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      1.920  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.514  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.080  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    302.706  INCHES
TOTAL INITIAL WATER                 =    302.706  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          PENDLETON             OREGON

     STATION LATITUDE                          =  45.41 DEGREES
     MAXIMUM LEAF AREA INDEX                   =   0.00
     START OF GROWING SEASON (JULIAN DATE)     =    115
```

END OF GROWING SEASON (JULIAN DATE) = 288
EVAPORATIVE ZONE DEPTH = 6.0 INCHES
AVERAGE ANNUAL WIND SPEED = 9.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 71.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 52.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 41.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.73	1.11	1.06	0.99	1.09	0.70
0.30	0.55	0.58	0.95	1.48	1.66

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
32.80	39.40	43.90	50.30	58.40	66.20
73.80	71.70	63.60	52.50	41.10	36.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PENDLETON OREGON

AND STATION LATITUDE = 45.41 DEGREES

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ANNUAL TOTALS FOR YEAR 1

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.34	44794.195	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.695	38822.121	86.67
DRAINAGE COLLECTED FROM LAYER 2	1.4339	5205.135	11.62
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0003		
DRAINAGE COLLECTED FROM LAYER 8	3.1569	11459.637	25.58
PERC./LEAKAGE THROUGH LAYER 10	0.000005	0.019	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0265		
CHANGE IN WATER STORAGE	-2.946	-10692.703	-23.87
SOIL WATER AT START OF YEAR	302.706	1098821.750	
SOIL WATER AT END OF YEAR	299.760	1088129.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

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ANNUAL TOTALS FOR YEAR 2

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.05	43741.508	100.00

RUNOFF	0.010	36.397	0.08
EVAPOTRANSPIRATION	10.353	37580.645	85.92
DRAINAGE COLLECTED FROM LAYER 2	2.8182	10230.225	23.39
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 8	2.9291	10632.788	24.31
PERC./LEAKAGE THROUGH LAYER 10	0.000005	0.018	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0247		
CHANGE IN WATER STORAGE	-4.060	-14738.566	-33.69
SOIL WATER AT START OF YEAR	299.760	1088129.000	
SOIL WATER AT END OF YEAR	295.700	1073390.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.002	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.41	52308.305	100.00
RUNOFF	1.108	4021.084	7.69
EVAPOTRANSPIRATION	9.778	35495.734	67.86

DRAINAGE COLLECTED FROM LAYER 2	2.4616	8935.763	17.08
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 8	2.3888	8671.432	16.58
PERC./LEAKAGE THROUGH LAYER 10	0.000005	0.017	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0201		
CHANGE IN WATER STORAGE	-1.327	-4815.666	-9.21
SOIL WATER AT START OF YEAR	295.700	1073390.500	
SOIL WATER AT END OF YEAR	294.373	1068574.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.063	0.00

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ANNUAL TOTALS FOR YEAR 4

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.70	49731.016	100.00
RUNOFF	1.471	5341.049	10.74
EVAPOTRANSPIRATION	9.702	35218.387	70.82
DRAINAGE COLLECTED FROM LAYER 2	2.8295	10271.183	20.65
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00

AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 8	0.4764	1729.512	3.48
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.011	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0040		
CHANGE IN WATER STORAGE	-0.779	-2829.218	-5.69
SOIL WATER AT START OF YEAR	294.373	1068574.870	
SOIL WATER AT END OF YEAR	293.523	1065487.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.071	258.630	0.52
ANNUAL WATER BUDGET BALANCE	0.0000	0.094	0.00

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ANNUAL TOTALS FOR YEAR 5

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.13	40401.910	100.00
RUNOFF	0.868	3152.590	7.80
EVAPOTRANSPIRATION	7.951	28862.262	71.44
DRAINAGE COLLECTED FROM LAYER 2	2.6918	9771.145	24.18
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0006		
DRAINAGE COLLECTED FROM LAYER 8	0.1498	543.849	1.35

PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0013		
CHANGE IN WATER STORAGE	-0.531	-1927.956	-4.77
SOIL WATER AT START OF YEAR	293.523	1065487.000	
SOIL WATER AT END OF YEAR	293.063	1063817.620	
SNOW WATER AT START OF YEAR	0.071	258.630	0.64
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 6

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.25	37207.504	100.00
RUNOFF	0.884	3209.892	8.63
EVAPOTRANSPIRATION	7.520	27296.902	73.36
DRAINAGE COLLECTED FROM LAYER 2	0.9616	3490.749	9.38
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0002		
DRAINAGE COLLECTED FROM LAYER 8	0.0883	320.457	0.86
PERC./LEAKAGE THROUGH LAYER 10	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0007		

CHANGE IN WATER STORAGE	0.796	2889.444	7.77
SOIL WATER AT START OF YEAR	293.063	1063817.620	
SOIL WATER AT END OF YEAR	293.859	1066707.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.050	0.00

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ANNUAL TOTALS FOR YEAR 7

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.83	46572.906	100.00
RUNOFF	1.790	6499.323	13.96
EVAPOTRANSPIRATION	8.313	30176.150	64.79
DRAINAGE COLLECTED FROM LAYER 2	3.0336	11011.894	23.64
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0007		
DRAINAGE COLLECTED FROM LAYER 8	0.0553	200.833	0.43
PERC./LEAKAGE THROUGH LAYER 10	0.000002	0.009	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0005		
CHANGE IN WATER STORAGE	-0.362	-1315.166	-2.82
SOIL WATER AT START OF YEAR	293.859	1066707.120	

SOIL WATER AT END OF YEAR	293.496	1065391.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.137	0.00

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ANNUAL TOTALS FOR YEAR 8

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.27	40910.105	100.00
RUNOFF	0.408	1480.255	3.62
EVAPOTRANSPIRATION	8.963	32536.127	79.53
DRAINAGE COLLECTED FROM LAYER 2	2.1737	7890.484	19.29
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.275	-996.788	-2.44
SOIL WATER AT START OF YEAR	293.496	1065391.870	
SOIL WATER AT END OF YEAR	293.222	1064395.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 9

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.30	48279.012	100.00
RUNOFF	3.289	11939.795	24.73
EVAPOTRANSPIRATION	7.554	27421.199	56.80
DRAINAGE COLLECTED FROM LAYER 2	1.7316	6285.831	13.02
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0004		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.725	2632.206	5.45
SOIL WATER AT START OF YEAR	293.222	1064395.120	
SOIL WATER AT END OF YEAR	293.556	1065607.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.391	1420.397	2.94
ANNUAL WATER BUDGET BALANCE	0.0000	-0.021	0.00

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ANNUAL TOTALS FOR YEAR 10

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	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.28	44576.406	100.00
RUNOFF	2.626	9533.630	21.39
EVAPOTRANSPIRATION	8.303	30140.189	67.61
DRAINAGE COLLECTED FROM LAYER 2	2.0397	7404.079	16.61
PERC./LEAKAGE THROUGH LAYER 4	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0005		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.689	-2501.487	-5.61
SOIL WATER AT START OF YEAR	293.556	1065607.000	
SOIL WATER AT END OF YEAR	293.258	1064525.870	
SNOW WATER AT START OF YEAR	0.391	1420.397	3.19
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.005	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

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	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.17	1.03	0.90	1.16	1.06	0.83
	0.31	0.38	0.44	0.93	1.49	1.65
STD. DEVIATIONS	0.69	0.61	0.29	0.53	0.46	0.83
	0.30	0.27	0.34	0.61	0.61	0.68
RUNOFF						
TOTALS	0.581	0.437	0.054	0.000	0.001	0.001
	0.000	0.000	0.000	0.002	0.033	0.137
STD. DEVIATIONS	0.777	0.660	0.161	0.000	0.002	0.003
	0.000	0.000	0.000	0.005	0.082	0.344
EVAPOTRANSPIRATION						
TOTALS	0.774	0.892	1.069	0.900	1.106	0.951
	0.308	0.257	0.281	0.605	0.869	0.901
STD. DEVIATIONS	0.325	0.470	0.481	0.562	0.566	0.728
	0.209	0.094	0.079	0.496	0.282	0.184
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.5552	0.2629	0.2333	0.0149	0.0149	0.0293
	0.0180	0.0016	0.0166	0.1900	0.3605	0.5202
STD. DEVIATIONS	0.4544	0.2341	0.2539	0.0247	0.0246	0.0468
	0.0570	0.0039	0.0436	0.2135	0.3780	

0.3890

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

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS 0.0748 0.0577 0.0794 0.0840 0.0861
0.0813
0.0819 0.0798 0.0754 0.0762 0.0794
0.0684

STD. DEVIATIONS 0.1022 0.0891 0.1102 0.1223 0.1277
0.1216
0.1231 0.1205 0.1143 0.1157 0.1202
0.1078

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)

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DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES 0.0016 0.0008 0.0007 0.0000 0.0000

```
0.0001
                            0.0001   0.0000   0.0000   0.0005   0.0011
0.0015

     STD. DEVIATIONS        0.0013   0.0007   0.0007   0.0001   0.0001
0.0001
                            0.0002   0.0000   0.0001   0.0006   0.0011
0.0011

   DAILY AVERAGE HEAD ON TOP OF LAYER  9
   -------------------------------------
     AVERAGES               0.0074   0.0063   0.0079   0.0086   0.0085
0.0083
                            0.0081   0.0079   0.0077   0.0076   0.0081
0.0068

     STD. DEVIATIONS        0.0101   0.0098   0.0109   0.0125   0.0127
0.0125
                            0.0122   0.0120   0.0117   0.0115   0.0123
0.0107


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

------------------------------------------------------------------------------
-
                                      INCHES           CU. FEET       PERCENT
                                ------------------   -------------
---------
  PRECIPITATION                 12.36    (   1.263)      44852.3     100.00

  RUNOFF                         1.246   (  1.0803)       4521.40     10.081

  EVAPOTRANSPIRATION             8.913   (  1.1579)      32354.97     72.137

  LATERAL DRAINAGE COLLECTED     2.21753 (  0.67879)      8049.648   17.94702
    FROM LAYER  2

  PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.006
0.00001
    LAYER  4
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  AVERAGE HEAD ON TOP              0.001 (    0.000)
    OF LAYER  3

  LATERAL DRAINAGE COLLECTED       0.92448 (  1.33193)      3355.851    7.48201
    FROM LAYER  8

  PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)         0.009
0.00002
    LAYER 10

  AVERAGE HEAD ON TOP              0.008 (    0.011)
    OF LAYER  9

  CHANGE IN WATER STORAGE        -0.945   (  1.5175)      -3429.59     -7.646

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                 PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
    ------------------------------------------------------------------------
                                                    (INCHES)      (CU. FT.)
                                                   ----------   -------------
       PRECIPITATION                                 1.80          6534.000

       RUNOFF                                        1.100         3993.6677

       DRAINAGE COLLECTED FROM LAYER  2              0.15874        576.21179

       PERCOLATION/LEAKAGE THROUGH LAYER  4          0.000000         0.00023

       AVERAGE HEAD ON TOP OF LAYER  3               0.014

       MAXIMUM HEAD ON TOP OF LAYER  3               0.025

       LOCATION OF MAXIMUM HEAD IN LAYER  2
             (DISTANCE FROM DRAIN)                  29.9 FEET

       DRAINAGE COLLECTED FROM LAYER  8              0.01152         41.82290

       PERCOLATION/LEAKAGE THROUGH LAYER 10          0.000000         0.00006

       AVERAGE HEAD ON TOP OF LAYER  9               0.035

       MAXIMUM HEAD ON TOP OF LAYER  9               0.070
```

LOCATION OF MAXIMUM HEAD IN LAYER 8
(DISTANCE FROM DRAIN) 2.3 FEET

SNOW WATER 1.23 4478.1094

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4092

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1800

*** 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 10

LAYER	(INCHES)	(VOL/VOL)
1	5.5591	0.3088
2	0.0027	0.0136
3	0.0000	0.0000
4	7.6860	0.4270
5	94.5000	0.1260
6	183.0000	0.2440
7	2.3580	0.1310
8	0.0020	0.0100
9	0.0000	0.0000

```
        10              0.1500          0.7500

    SNOW WATER          0.000

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

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ATTACHMENT 2

NOAA ATLAS 2
PRECIPITATION - FREQUENCY ATLAS OF THE WESTERN UNITED STATES
VOLUME X - OREGON

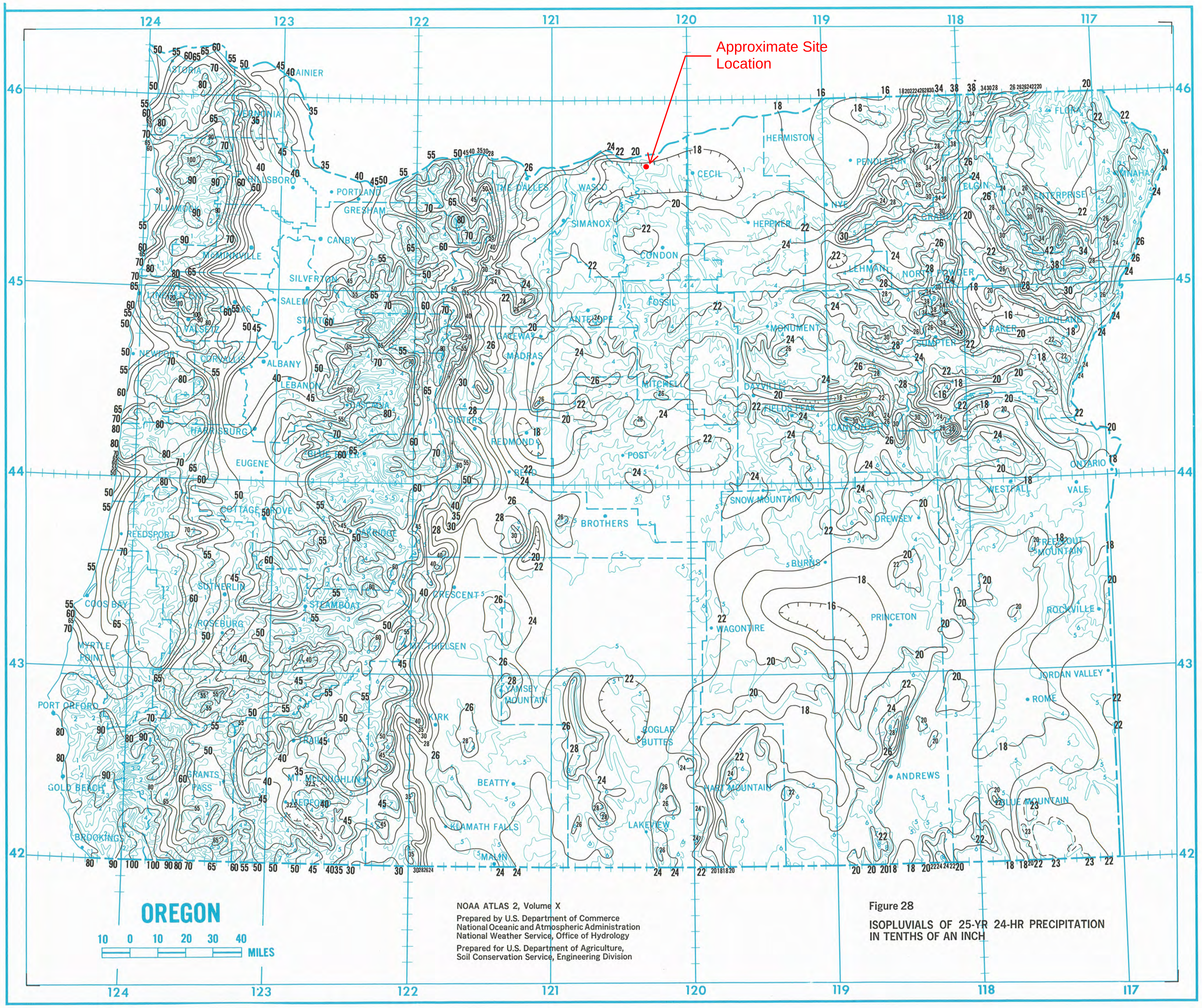


Figure 28

ISOPLUVIALS OF 25-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

ATTACHMENT NO. 3

LCS SUMP CALCULATIONS

OBJECTIVE: **Using the maximum anticipated daily leachate generation for a cell in the L14 landfill, determine the size of the primary leachate collection sump that is required to adequately store and pump leachate for the proposed L14 expansion area. Check that the calculated volume will be sufficient for optimal pump operation.**

REFERENCES:

1. Hydrologic Evaluation of Landfill Performance Analysis for the Chemical Waste Management of the Northwest (CWM) Landfill L14 Expansion, Model Verions 3.07, Prepared by Civil & Environmental Consultants, Inc. January 2020.

2. L14 Landfill Expansion Permit Drawing Set for Chemical Waste Management of the Northwest, prepared by Civil & Environmental Consultants, Inc., January 2020.

3. "Design and Operations Plan for Chemical Waste Management of the Northwest, Inc." Revision 5, Prepared by Environmental Information Logistics, LLC., October 2011.

ASSUMPTIONS:

Assume the pump used for pumping leachate from the sump will be an EPG SurePump TSP Series 2-4 submersible pump. A pump curve for this series pump is included in Attachment B.

Assume the maximum footprint of the landfill areas under open condition will be limited to 7 acres at any one time.

Assume the porosity of gravel in the sump area is approximately 40 percent.

ANALYSIS:

The minimum required sump volume was determined based on the peak daily leachate storage requirement and the minimum sump volume required for efficient pump operation. The leachate storage and pump requirements were estimated using the results of the Hydrologic Evaluation of Landfill Perfromance (HELP) analysis completed for the L14 expansion (Reference Number (Ref. No.) 1). Results for the daily leachate storage and efficient pump requirements were compared in order to determine the controlling volume requirement.

Per Ref. No. 1 the peak daily leachate generation rate was determined to be 0.04213 inches per day for a one-acre area during the 25-year 24-hour design storm event. The maximum anticipated open area for the L14 expansion is 7 acres. The peak leachate generation anticipated for entire 7 acre area is 5.56 gallons per minute (gpm). Assuming the sump gravel has a porosity of 40%, the minimum required total sump volume (includes leachate and gravel) for one day of storage is 2,676 cubic feet (ft^3). See the calculation spreadsheet in Attachment A for more details.

The minimum sump volume to ensure the pump will operate on efficient pumping cycles was estimated based on the static and dynamic head requirements for a submersible pump operating at the base of the sump and discharging at the top of the slope. The top of proctective cover grades from Ref. No. 2 were used to determine the head requirements for the submersible pump. The pump curve for an EPG SurePump TSP Series 2-4 submersible pump was selected to based on a total head requirement of 81 feet and the peak leachate generation for the 7 acre area of 5.56 gpm. As pump performance and longevity are maximized by running the pump for a set amount of time before shutting down the pump, the minimum sump volume must be calculated to allow for a sufficient leachate volume that will maintain efficient pumping cycles. The minimum efficient pump cycle time for the specified pump is assumed to be 15 minutes. Referring to the calcuations in Attachment A, it was determined that the sump should have a volume of approximately 39 ft^3 in order to adequately maintain efficient pumping cycles.

$$2{,}676\ ft^3 > 39 ft^3 \therefore \mathit{Daily\ Leachate\ Storage\ Requirement\ controls}$$

CONCLUSION:	The sump volume should be greater than approximately 2,676 ft^3 in order to adequately store the anticipated leachate volume from the design storm event and maintain the efficient pumping cycles that will result in optimal longevity and performance of the pump.

ATTACHMENT A

SUMP SIZING CALCUALTIONS

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
SUMP SIZING ANALYSIS
INPUT TABLE

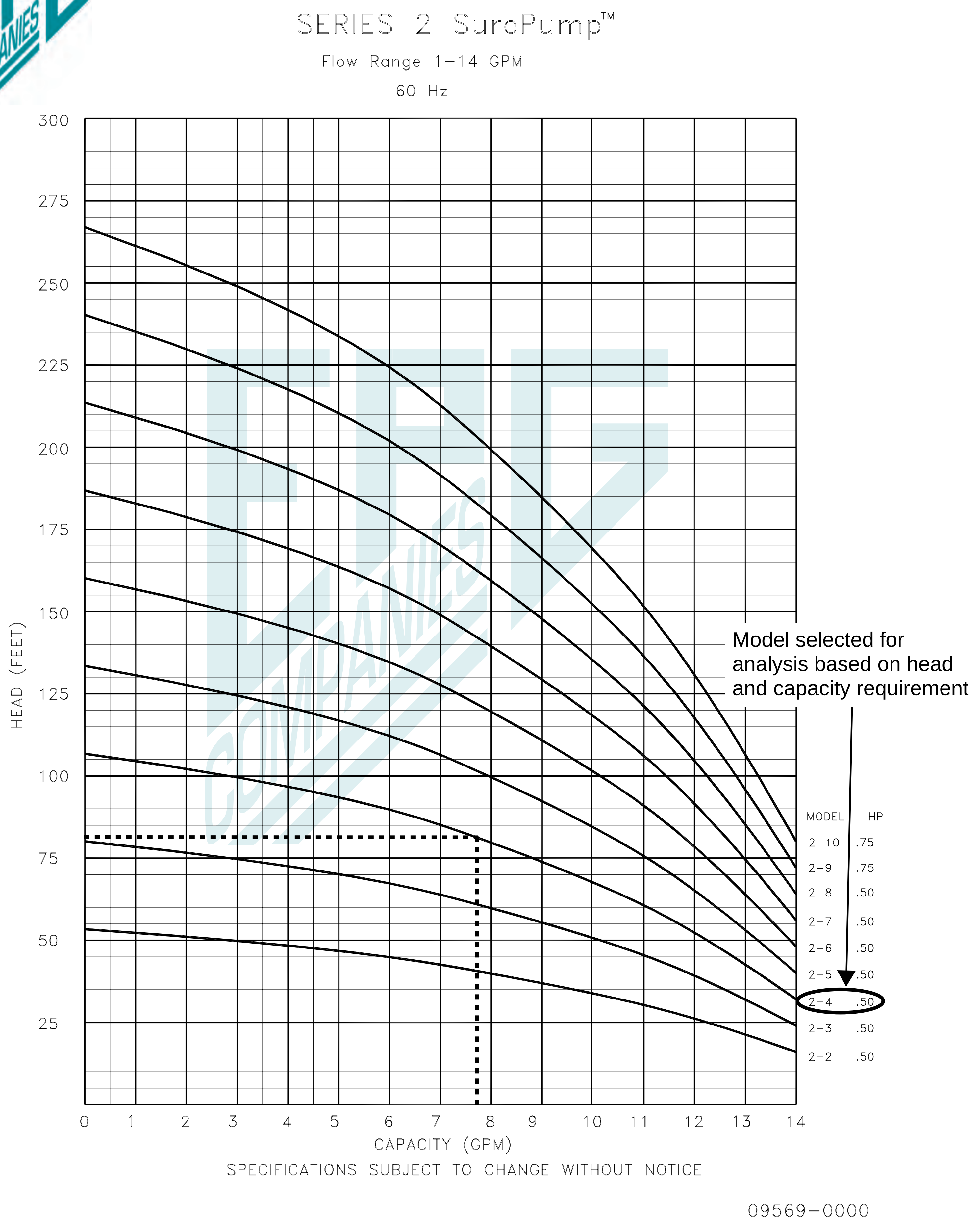
(green)	Denotes an input value
(orange)	Denotes an automatically calculated cell

MINIMUM SUMP VOLUME BASED ON LEACHATE STORAGE REQUIREMENTS						
Expansion Waste Footprint per Phase	7.00	acres				
Peak Daily Leachate Generation Rate	0.04213	inches				
Maximum Daily Leachate Generation of Cell	1,070.52	cubic feet per day	192.50	cf/day =	1	gpm
Maximum Daily Leachate Generation of Cell	5.56	gallons per minute				
Sump Gravel Porosity	40%					
Minimum Required Total Sump Volume for 1 Day Storage	2,676.31	cubic feet	(Includes volume of gravel)			
MINIMUM SUMP VOLUME BASED ON EFFICIENT PUMP OPERATION						
Approximate Bottom Elevation of Sump	938	feet				
Approximate Top of Discharge Point	1014	feet				
Elevation Head	76.00	feet				
Approximate Length of Pump Piping	238	feet				
Approximate Dynamic Head	5	feet				
Total Pump Head	81	feet				
Approximate Pump Rate	7.70	gallons per minute	(See pump curve in Attachment B)			
Maximum Daily Leachate Generation of Cell	5.56	gallons per minute				
Is Pump Rate Greater than Leachate Generation Rate?	Yes					
Minimum Time for Pump to Run Efficiently	15	minutes				
Minimum Required Liquid Storage Volume of Sump for Pump to Run for the Recommended Minimum Time Period	115.5	gallons	(Does not include leachate continuing to flow into sump while pump is running)			
Minimum Required Liquid Storage Volume of Sump for Pump to Run for the Recommended Minimum Time Period	15.44	cubic feet				
Minimum Required Total Sump Volume	38.60	cubic feet	(Includes volume of gravel)			

Calculated By:	Zach Metzler	Date:	1/17/2020
Checked By:	David Spang	Date:	1/20/2020

ATTACHMENT B

EPG SERIES 2 SUREPUMP PUMP CURVE


SERIES 2 SurePump™
Flow Range 1–14 GPM
60 Hz
HEAD (FEET)
300
275
250
225
200
175
150
125
100
75
50
25
CAPACITY (GPM)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Model selected for analysis based on head and capacity requirement
MODEL HP
2–10 .75
2–9 .75
2–8 .50
2–7 .50
2–6 .50
2–5 .50
2–4 .50
2–3 .50
2–2 .50
SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE
09569–0000

ATTACHMENT NO. 4

PROTECTIVE COVER FLOW CAPACITY CALCULATIONS

CALCULATION BRIEF

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
L14 EXPANSION; CELLS 5-8
LEACHATE COLLECTION PROTECTIVE COVER CAPACITY

OBJECTIVE: Determine if the leachate collection zone will be free draining and that leachate will continuously flow from the collection zone.

REFERENCES:

1. Hydrologic Evaluation of Landfill Performance Analysis for the Chemical Waste Management of the Northwest (CWM) Landfill L14 Expansion, Model Version 3.07, Prepared by Civil & Environmental Consultants, Inc. February 2020.

METHODOLOGY: Use Darcy's Law to estimate the flow capacity of the leachate collection zone protective cover and compare this capacity to the design leachate generation rate.

ANALYSIS: The design leachate generation rate was determined by multiplying the peak impingement rate from the HELP model analysis (0.04123 in/day/acre) in Reference Number (Ref. No.) 1 and the maximum anticipated open area (Assumed to be 7 acres) of the L14 Expansion. As design leachate generation rate is estimated as 5.56 gallons per minute (gpm).

For a unit area of 1 ft^2:

$$q_{\text{Design}} = 5.56\text{ gpm} \times \frac{1\text{ft}^3}{7.481\text{ gal}} \times \frac{1\text{ min}}{60\text{ sec}} \div \left[7\text{acres} \times \frac{43{,}560\text{ft}^2}{1\text{ acre}}\right] \times \frac{30.48\text{ cm}}{1\text{ ft}} = 1.2\text{x}10^{-6}\text{cm/sec}$$

Cross-Plane Flow Capacity of Protective Cover

- The cross-plane (vertical) flow capacity of the leachate collection zone, 18-inch thick protective cover, can be estimated using Darcy's Law

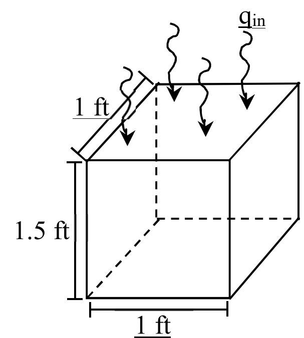
$$Q = kiA$$

Analyzing a unit area (i.e., A = 1)

$$Q = ki$$

For vertical flow, the hydraulic gradient is 1.5.

$$\text{Thus: } Q = 1.5k$$



(Cross-Plane Flow)

Therefore, the cross-plan flow capacity of the 18-inch protective cover is essentially equal to 1.5 times its hydraulic conductivity.

Per 40 CFR 264.301 the minimum hydraulic conductivity of the 18-inch protective cover will be at least 1.0 x 10^{-2} cm/s, and because the hydraulic conductivity of the AASHTO No. 3 gradation aggregate, will likely be much greater than 1.0 x 10^{-2} cm/s. Comparing the available flow capacity to the design

$$q_{available} \geq 0.01 \text{ cm/s}$$

$$q_{design} = 1.2 \times 10^{-6} \text{ cm/s}$$

$$FS = \frac{q_{available}}{q_{design}} = \frac{0.01 \text{ cm/s}}{1.2 \times 10^{-6} \text{ cm/s}} = 8{,}333$$

O.K.

In-Plane Flow Capacity of Protective Cover

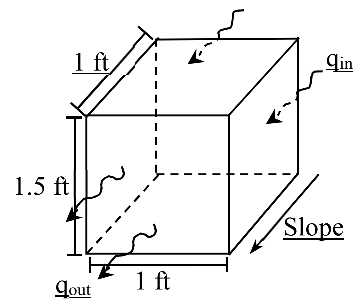
- The in-plane flow capacity (transmissivity) of the leachate collection zone, 18-inch protective cover, can be estimated using Darcy's Law

$$Q = kiA$$

In-plane flow area (A) = 1 ft^2 since regulations allow a maximum of 1 foot of leachate head on the primary liner

$$k = 0.01 \text{ cm/s}$$

$$k = 0.003 \text{ ft/s}$$



(In-Plane Flow)

- For steady-state flow, $q_{out} = q_{in}$

- For a unit area (1 ft^2), the maximum flow in (q_{in}) is:

$$q_{in} = (1\text{ft})(1\text{ft})\left(1.2 \times 10^{-6}\,\frac{\text{cm}}{\text{s}}\right)\left(\frac{1\text{ ft}}{30.48\text{ cm}}\right) = 3.9 \times 10^{-8}\ \text{ft}^3/\text{s}$$

This is the surface area of the top of the protective cover that is presented for leachate infiltration. For the various proposed slopes [i = 2.0% and 3H:1V (33%)]

Slope (i) (ft/ft)	**Slope (k) (ft/s)**	**Available Flow Capacity (q_{out} = ki) (ft^3/s)**	**Ratio of q_{out}/q_{in} (Factor of Safety)**
0.020	0.003	6.0×10^{-5}	1,538
0.33	0.003	9.9×10^{-4}	25,385

Thus, the 18-inch protective cover possesses sufficient in-plane flow capacity to allow free flow of the design maximum leachate volume.

CONCLUSION: The above calculations show that the protective cover will allow free and continuous flow of leachate from the waste to the collection sump.

ATTACHMENT NO. 5

LEACHATE COLLECTION PIPE FLOW CAPACITY CALCULATIONS

CALCULATION BRIEF

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
L14 EXPANSION; CELLS 5-8
LEACHATE COLLECTION PIPING FLOW CAPACITY

OBJECTIVE: **Determine the flow capacity of the leachate collection system piping. Additionaly, determine the aggregate particle size required to prevent clogging of the leachate collection pipe perforations.**

REFERENCES:

1. Sump Sizing Design for the Chemical Waste Management of the Northwest (CWM) Landfill L14 Expansion, Prepared by Civil & Environmental Consultants, Inc. February 2020.

2. "Handbook of Polyethylene Pipe", Second Edition, Plastic Pipe Institute.

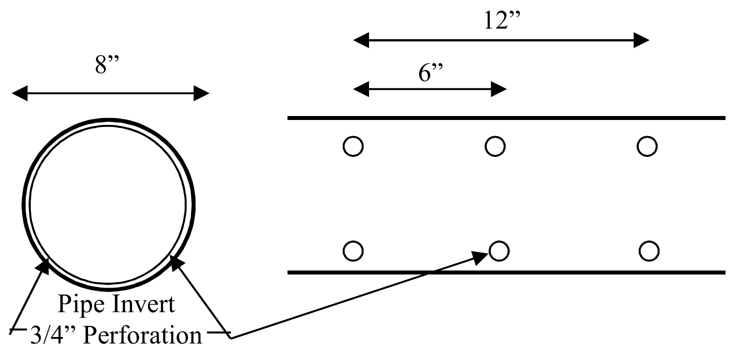
METHODOLOGY: Use the peak daily leachate volume that is anticipated for the leachate collection sumps to determine the maximum flow capacity required for the leachate collection piping for the L14 expansion area.

ANALYSIS:

Pipe Capacity

Per Reference Number (Ref. No.) 1, the peak daily leachate generation rate for an anticipated open area of 7 acres was determined to be 5.56 gallons per minute (gpm).

The leachate collection system piping will include 8-inch nominal diameter Standard Dimension Ratio (SDR) 11 high density polyethylene (HDPE). Perforations will be 3/4-inch diameter, spaced every 6 inches along the pipe at the 4 and 8 o'clock positions.



Cross-Section View Plan View of Pipe from Bottom

The estimated quantity of leachate that will flow into one pipe perforation can be determined as follows:

$$Q = 0.6a\sqrt{2hg} \qquad \text{(Equation 1)}$$

Where: Q = flow from one perforation (cfs);
0.6 = orifice coefficient for sharp-edged inlets;
a = cross-sectional area of perforation (ft^2);
g = acceleration due to gravity = 32.2 ft/s^2; and
h = head of leachate acting on perforation (ft).

The flow capacity of the pipe can be estimated using Manning's equation as follows:

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A \qquad \text{(Equation 2)}$$

Where: Q = flow rate of pipe (cfs);
R = hydraulic radius (ft);
S = minimum slope (ft/ft); and
A = area of pipe (ft^2).

Flow Capacity of Pipe Perforations

1. For a 3/4-inch diameter perforation the area is 3.1×10^{-3} ft^2.

2. Using Equation 1 with a maximum allowable leachate head of 1.0-foot, the flow rate into one pipe perforation is:

$$Q_{perf} = 0.6 \times (3.1 \times 10^{-3} ft^2) \times (2 \times 32.2\ ft/s^2 \times 1.0\ ft)^{1/2}$$

$$Q_{perf} = 0.0148\ cfs = 6.6\ gpm$$

3. Thus, for a 1-foot head of leachate, a 3/4-inch diameter pipe perforation will allow approximately 6.6 gpm to enter the leachate collection pipe.

4. There are 4 pipe perforations per foot of pipe, thus each foot of pipe allows 26.4 gpm to enter under a 1-foot head of leachate.

5. To allow the maximum leachate flow of 5.56 gpm to enter the sump, the minimum length of pipe needed is:

$$L_{min} = 5.56 \text{ gpm}/26.4 \text{ gpm/ft} = 0.21 \text{ ft}$$

6. Obviously, the length of piping within the base area leading to the sump is greater than 0.21 feet. Therefore, the pipe perforations are sufficiently sized to allow the maximum leachate flow to enter the leachate collection pipe under free flow conditions (i.e., pipe perforations will not back-up leachate on the primary liner).

Flow Capacity of Leachate Collection Pipe

1. The leachate collection piping will be nominal 8-inch diameter IPS SDR 11 HDPE. For this pipe, the following applies:

   - Inside Diameter = 6.96 inches (Ref No. 2);
   - Full Flow Area (A) = 0.26 ft^2;
   - Full Flow Hydraulic Radius (R) = 0.143 ft;
   - Minimum Pipe Slope = 0.015 ft/ft (along base slopes); and
   - Manning's n = 0.015 (for aged HDPE pipe).

2. Based on the above values, the maximum flow capacity of the leachate collection piping is:

$$Q_{pipe} = (1.49 / 0.015) \text{ x } (0.143 \text{ ft})^{2/3} \text{ x } (0.015)^{1/2} \text{ x } (0.26 \text{ ft}^2)$$

$$Q_{pipe} = 0.86 \text{ cfs} = 386 \text{ gpm}$$

3. Thus, the maximum available flow capacity of the leachate collection pipe is 386 gpm, which is adequate to convey the maximum leachate flow quantity of 5.56 gpm.

Perforation Clogging

The holes in the pipes must be small enough to prevent particles of the coarse aggregate in contact with the pipes from penetrating into the pipes. Calculations to verify the suitability of the specified pipe perforation size follows.

The maximum allowable size of pipe perforations to provide retention of coarse aggregate particles can be determined as follows (U.S. EPA, 1983):

$$D_{max} = \frac{D_{85}}{F}$$

Where:	D_{max}	=	maximum allowable pipe hole size (inches)
	D_{85}	=	aggregate particle size for which 85 percent, by weight, of the particles are finer
	F	=	factor ranging from 1 to 1.2

Coarse aggregate surrounding the leachate collection pipes will possess an AASHTO No. 3 gradation. From the chart below, which shows a typical AASHTO No. 3 gradation range, the particle-size distribution for which 85 percent by weight of the particles are finer (D_{85}) is approximately 1.75 inches (see gradation chart below). The leachate collection pipe perforation design diameter is 0.75 inches, which results in a ratio of 2.3, using the above formula. This ratio is substantially greater than the most conservative ratio value of 1.2. Therefore, clogging of the leachate collection pipe by aggregate particles should not occur.

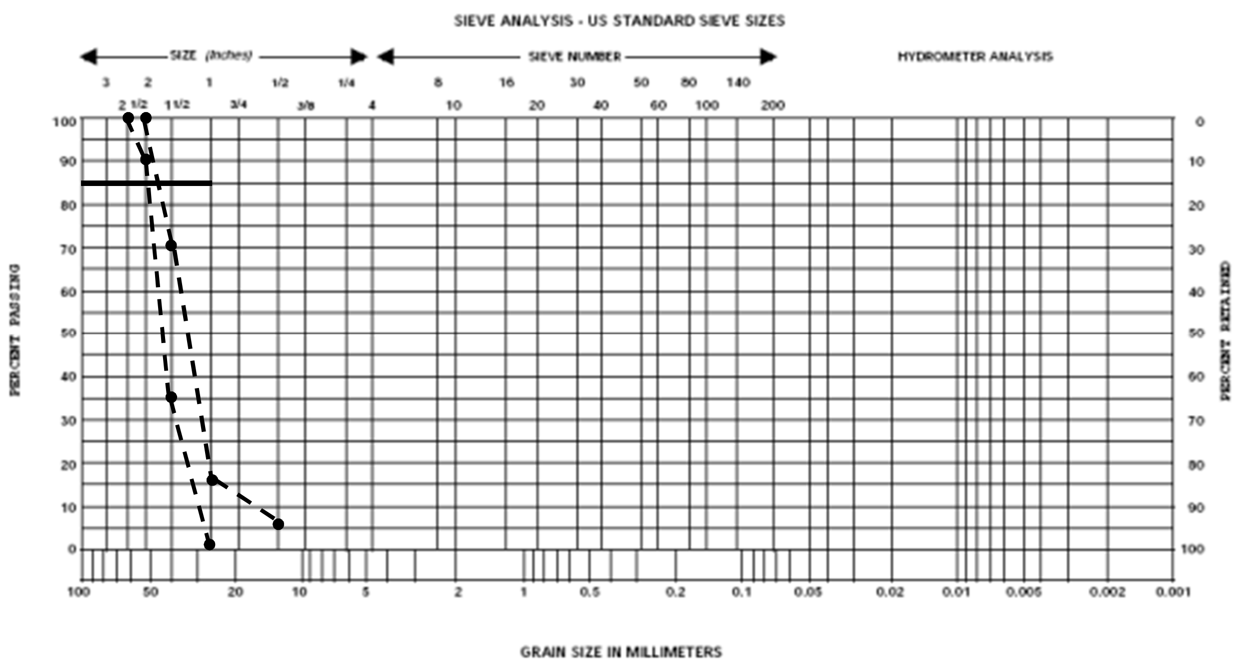
Civil & Environmental Consultants, Inc.

PROJECT **Chemical Waste Management of the Northwest** PROJECT NO. **194-991**

L14 Expansion; Cells 5-8

Leachate Collection Piping Flow Capacity

MADE BY **DVS** DATE **1/24/2020** CHECKED BY **TDM** DATE **2/3/2020**



The specified leachate collection piping perforations are small enough to provide retention of coarse aggregate, but are large enough to allow the unrestricted inflow of leachate. Additionally, pipes may be periodically cleaned and maintained.

CONCLUSION: Based on the preceding calculations, the 3/4-inch diameter pipe perforations and 8-inch diameter SDR 11 pipe are adequate to convey the estimated Maximum Daily Leachate Generation rate of 5.56 gpm. Additionally a AASHTO No. 3 gradation aggregate is suitable for use in the leachate collection pipe trench.

ATTACHMENT NO. 6

LCS PIPE STRENGTH CALCULATIONS

CALCULATION BRIEF

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
L14 EXPANSION; CELLS 5-8
LEACHATE COLLECTION SYSTEM PIPE STRENGTH CALCULATIONS

OBJECTIVE: **Determine whether the 8-inch diameter high-density polyethylene (HDPE) pipe with a standard dimension ratio (SDR) of 11 possesses adequate strength properties to be used in the leachate collection zone of the L14 Landfill Expansion.**

REFERENCE:

1. "Handbook of Polyethylene Pipe;" Second Edition; Plastic Pipe Institute.

2. L14 Landfill Expansion Permit Drawing Set at Chemical Waste Management of the Northwest L14 prepared by Civil & Environmental Consultants, Inc., February 2020.

3. "Landfill Design and Operations Plan for Chemical Waste Management of the Northwest, Inc." Standalone Document No. 14, Issued by Oregon Department of Environmental Quality, December 2015.

ANALYSIS:

Pipe Strength Evaluation:

The proposed leachate collection zone piping will be analyzed for three possible modes of failure, including:

1. Ring Deflection (Fig. 1A);
2. Ring Compression (Fig. 1B); and
3. Ring Buckling (Fig. 1C).

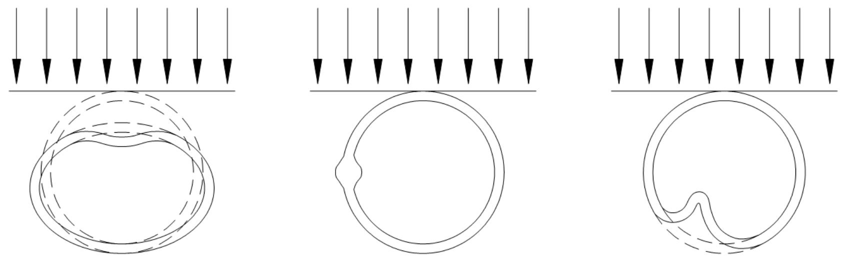


FIG. 1A RING DEFLECTION

FIG. 1B RING COMPRESSION

FIG. 1C RING BUCKLING

The design calculations that follow are based on the design methodology for deep fill installation presented in Reference Number (Ref. No.) 1.

Ring Deflection

To determine the deflection anticipated in the leachate collection pipes, it is necessary to first determine the relative stiffness between pipe and soil, given as the Rigidity Factor, R_F, as determined by the following equation:

$$R_F = \frac{12\ E_s\ (DR-1)^3}{E}$$

Where: DR = Dimension Ratio

E = Apparent modulus of elasticity of pipe material, psi

E_s = Secant modulus of soil, psi

Ref. No. 1 provides tables to determine the various factors required to solve for pipe deflection. For E, Ref. No. 1 provides the following table for Apparent Elastic Modulus.

Apparent Elastic Modulus for 73°F (23°C)

Duration of Sustained Loading	Design Values For 73°F (23°C) [1,2,3]					
	PE 2XXX		PE3XXX		PE4XXX	
	psi	MPa	psi	MPa	psi	MPa
0.5hr	62,000	428	78,000	538	82,000	565
1hr	59,000	407	74,000	510	78,000	538
2hr	57,000	393	71,000	490	74,000	510
10hr	50,000	345	62,000	428	65,000	448
12hr	48,000	331	60,000	414	63,000	434
24hr	46,000	317	57,000	393	60,000	414
100hr	42,000	290	52,000	359	55,000	379
1,000hr	35,000	241	44,000	303	46,000	317
1 year	30,000	207	38,000	262	40,000	276
10 years	26,000	179	32,000	221	34,000	234
50 years	22,000	152	28,000	193	29,000	200
100 years	21,000	145	27,000	186	28,000	193

For pipes subject to earth and vehicle loading, Ref. No. 1 recommends using the 100-year modulus. Assuming a 3XXX category pipe will be used, E is approximately 27,000 psi.

The maximum anticipated operating temperatures at the base of the landfill are estimated to be approximately 110°F, greater than the standard 73°F in the table above. The elevated temperatures at the base of the landfill will influence the long-term strength of the pipe. Ref. No. 1 provides the following temperature adjustment:

TABLE B.1.2

Temperature Compensating Multipliers for Determination of the Apparent Modulus of Elasticity at Temperatures Other than at 73°F (23°C)

Equally Applicable to All Stress-Rated PE's (e.g., All PE2xxx's, All PE3xxx's and All PE4xxx's)

Maximum Sustained Temperature of the Pipe °F (°C)	Compensating Multiplier
-20 (-29)	2.54
-10 (-23)	2.36
0 (-18)	2.18
10 (-12)	2.00
20 (-7)	1.81
30 (-1)	1.65
40 (4)	1.49
50 (10)	1.32
60 (16)	1.18
73.4 (23)	1.00
80 (27)	0.93
90 (32)	0.82
100 (38)	0.73
110 (43)	0.64
120 (49)	0.58
130 (54)	0.50
140 (60)	0.43

As such, the Apparent Elastic Modulus, E, is adjusted as follows:

$$E = 27{,}000 \text{ psi } (0.64) = 17{,}280 \text{ psi.}$$

The secant modulus of soil, E_S, can be determined by the following equation:

$$E_S = Ms \frac{(1+\mu)(1-2\mu)}{(1-\mu)}$$

Where: M_s = One-dimensional soil modulus

μ = Void Ratio (Ref. No. 1 recommends a typical value = 0.3)

To determine the one-dimensional soil modulus, M_s, it was assumed that the vertical soil stress acting on the pipe is approximately 100 psi compacted to 95% of the standard proctor, as shown in the following table:

TABLE 3-12
Typical Values of M_s, One-Dimensional Modulus of Soil

Vertical Soil Stress[1] (psi)	Gravelly Sand/Gravels 95% Std. Proctor (psi)	Gravelly Sand/Gravels 90% Std. Proctor (psi)	Gravelly Sand/Gravels 85% Std. Proctor (psi)
10	3000	1600	550
20	3500	1800	650
40	4200	2100	800
60	5000	2500	1000
80	6000	2900	1300
100	6500	3200	1450

* Adapted and extended from values given by McGrath[20]. For depths not shown in McGrath[20], the MS values were approximated using the hyperbolic soil model with appropriate values for K and n where n=0.4 and K=200, K=100, and K=45 for 95% Proctor, 90% Proctor, and 85% Proctor, respectively.

[1] Vertical Soil Stress (psi) = [soil depth (ft) x soil density (pcf)]/144

As such, E_s can be calculated as:

$$E_s = 6500\text{psi}\,\frac{(1+0.3)(1-2(0.3))}{(1-0.3)} = 4{,}829 \text{ psi}$$

In turn, the Rigidity Factor, R_F, can be calculated as:

$$R_F = \frac{12\ (4{,}829 \text{ psi})\ (11-1)^3}{17{,}280 \text{ psi}} = 3{,}353$$

Anticipated pipe deflection is determined using the following equation:

$$\frac{\Delta X}{D_M} = D_F \varepsilon_s$$

Where: $\Delta X/D_M$ = Horizontal Deflection (%)
D_F = Deformation factor
ε_s = Soil Strain, calculated as:

$$\varepsilon_s = \frac{wH}{144\ Es}$$

Where: wH = Soil Loading = Max. Waste Thickness*γ_{waste}
Max Waste Thickness = 206 ft. (Ref. No. 2)
γ_{waste} = 110 pcf (Ref. No. 3)

$$wH = 206\ \text{ft} \times 110\text{pcf} = 22{,}660\ \text{psf}$$

$$\varepsilon_s = \frac{22{,}660\ \text{psf}}{144\ (\ 4{,}829\ \text{psi})}\ \text{x}\ 100 = 3.3\%$$

The deformation factor, D_F, can be determined from the calculation above, which calculates the Rigidity Factor as approximately 3200, and the following table provided in Ref. No. 1:

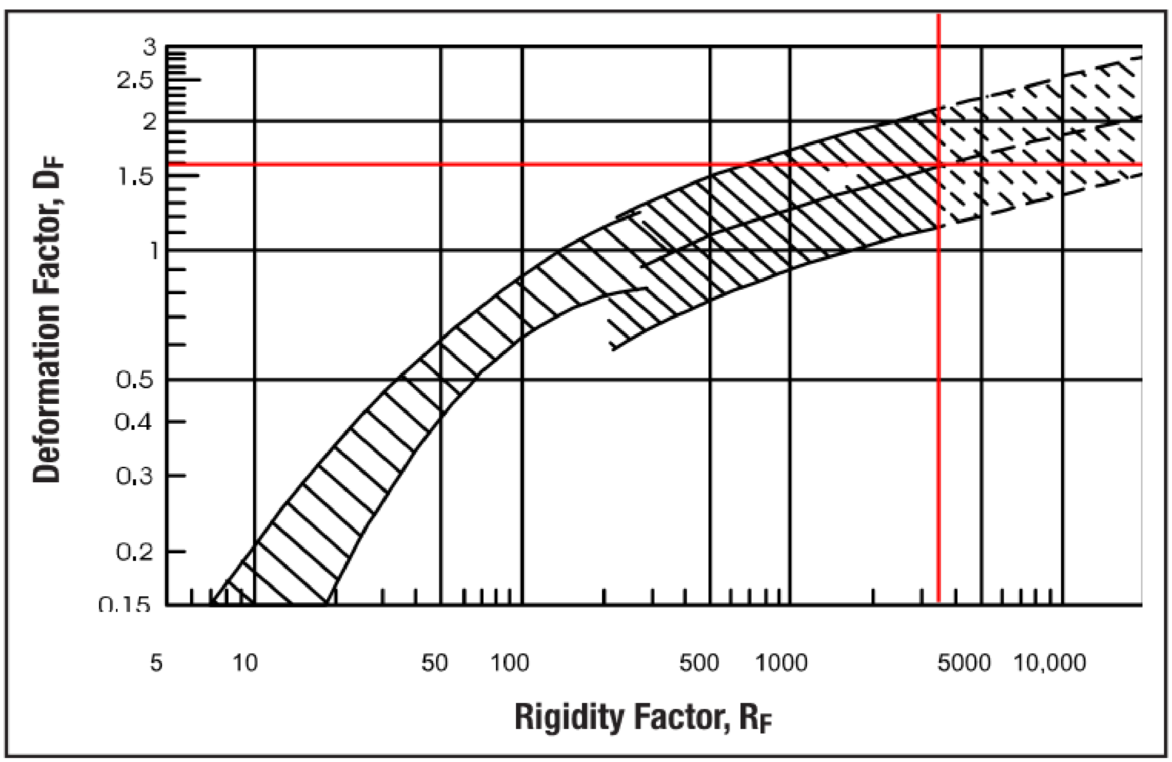


Figure 3-6 Watkins-Gaube Graph

Using a deformation factor of 1.6, the anticipated pipe deflection is shown as:

$$\frac{\Delta X}{D_M} = \varepsilon_s D_F = 3.3\% \, (1.6) = 5.2\%$$

The maximum allowable pipe deflection provided in Ref. No. 1 is set at 7.5%. As such, the factor of safety against excessive pipe deflection is as follows:

$$FS_{deflection} = \frac{\text{Allowable Deflection}}{\text{Actual Deflection}} = \frac{7.5\%}{5.2\%} = 1.44$$

Ring Compression (Crushing)

To determine the compressive stress that occurs on the pipe in deep fill conditions, it is necessary to first determine the vertical arching factor, VAF, given by the following equation:

$$VAF = 0.88 - 0.71 \, \frac{S_A - 1}{S_A + 2.5}$$

Where: VAF = Vertical arching factor
S_A = Hoop thrust stiffness ratio, calculated as:

$$S_A = \frac{1.43 \, M_s \, r_{CENT}}{EA}$$

Where: M_s = One-dimensional soil modulus
r_{CENT} = Radius to centroidal axis of pipe, inches
E = Apparent modulus of elasticity of pipe material, psi
A = Wall thickness of pipe, inches

For 8-inch diameter HDPE pipe with a SDR of 11, the radius to the centroidal axis of the pipe is estimated to be as follows:

$$r_{CENT} = \frac{ID}{2} + \frac{A}{2}$$

Where: ID = Inside diameter of pipe, inches
A = Wall thickness of pipe, inches

Therefore, the radius to the centroidal axis of the pipe for SDR 11 8-inch diameter pipe can be calculated as:

$$r_{CENT} = \frac{6.96 \text{ inches}}{2} + \frac{0.78 \text{ inches}}{2} = 3.87 \text{ inches}$$

As such, the hoop thrust stiffness ratio can be calculated to be:

$$S_A = \frac{1.43\ (6{,}500 \text{ psi})\ (3.87 \text{ inches})}{(17{,}280 \text{ psi})\ (0.78 \text{ inches})} = 2.67$$

Substituting the calculated value for the hoop thrust stiffness ratio into the vertical arching factor equation above, the vertical arching factor becomes:

$$VAF = 0.88 - 0.71\ \frac{(2.67) - 1}{(2.67) + 2.5} = 0.65$$

The radial directed earth pressure, P_{RD} , acting on the leachate collection pipe is given by the following equation:

$$P_{RD} = (VAF)\ wH = 0.65\ (22{,}660 \text{ psf}) = 14{,}729 \text{ psf}$$

Ref. No. 1 provides the following equation to determine the compressive stress, S, acting on the leachate collection pipes:

$$S = \frac{P_{RD} * D_o}{288A}$$

Where: D_o = Pipe outer diameter (8.625 inches for 8” diameter SDR11 HDPE pipe)

Therefore, the compressive stress, S, acting on the leachate collection pipes is shown as:

$$S = \frac{14{,}729 \text{ psf}\ \ (8.625 \text{ inches})}{288\ (0.78 \text{ inches})} = 565 \text{ psi}$$

From Ref. No. 1, allowable ring compression can be determined using the following table:

Allowable Compressive Stress for 73°F (23°C)

	Pe Pipe Material Designation Code (1)					
	PE 2406 / PE 2708		PE3408 / PE 3608 / PE 3708 / PE 3710 / PE 4708		PE 4710	
	psi	MPa	psi	MPa	psi	MPa
Allowable Compressive Stress	800	5.52	1000	6.90	1150	7.93

It is assumed that the pipe will be of the 3XXX series. Therefore, the allowable compressive stress is 1,000 psi.

As such, the factor of safety against ring compression failure is:

$$FS_{compression} = \frac{\text{Allowable Compressive Stress}}{S} = \frac{1000 \text{ psi}}{565 \text{ psi}} = 1.77$$

Ring Buckling

From Ref. No. 1, the critical constrained pipe buckling pressure, P_{CR}, is determined using the following equation:

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

Where: P_{CR} = critical constrained buckling pressure (psi)
φ= Calibration Factor (Ref. No.1 recommends 0.55 for granular soils)
R_H = Geometry Factor (Ref. No. 1 recommends 1.0 for burials in deep fill)
D_M = Mean diameter, 7.8 inches for 8 inch diameter SDR 11 pipe
I = Pipe wall moment of inertia (wallthickness^3/12), = 0.78^3/12 = 0.040 in^4/in for 8 inch SDR 11 pipe
E_s^* = E_s / (1-μ) = 4,829 psi / (1-0.3) = 6,898 psi
E_s = Secant modulus of soil, psi [previously calculated to be 4,829 psi]
μ = Void Ratio (Ref. No. 1 recommends a typical value = 0.3)

Therefore, the critical constrained pipe buckling becomes:

$$P_{CR} = \frac{2.4\,(0.55)\,(1.0)}{7.8\text{ inches}}\,(17{,}280\text{ psi} * 0.04\text{ in}^4/\text{in})^{\frac{1}{3}}\,(6{,}898\text{ psi})^{\frac{2}{3}}$$

$$P_{CR} \approx 542\text{ psi} \approx 78{,}077\text{ psf}$$

As such, the factor of safety against buckling failure is:

$$FS_{buckling} = \frac{P_{CR}}{P_E} = \frac{778{,}077\text{ psf}}{22{,}660\text{ psf}} = 3.45$$

CONCLUSION: **Based on the above analyses, the proposed 8-inch diameter SDR 11 HDPE pipe will possess adequate strength properties for the leachate collection zone pipe for the L14 Landfill Expansion at CWM. All calculations provided in this calculation are attached in spreadsheet form in Attachment A. As shown in the attached spreadsheet, factors of safety were determined. In accordance with Ref. No. 1, Factors of Safety (FS) greater than 1.0 are considered satisfactory.**

ATTACHMENT A

PIPE STRENGTH CALCULATIONS

Project: L14 Landfill Expansion - CWM

Project No.: 194-991

Subject: Leachate Collection Zone - Pipe Strength Calculations

Prepared By: David Spang

Date: 1/27/2020

Checked By: Tim Mitchell

Date: 2/3/2020

PIPE STRENGTH CALCULATIONS

	FACTORS:	Symbol	Unit	Value
COMPRESSION	Vertical Arching Factor	VAF	dimensionless	0.65
	Hoop Thrust Stiffness Ratio	S_A	dimensionless	2.655
	1-D Modulus of Soil	Ms	psi	6,500
	radius to centroidal axis of pipe	R_{cent}	inches	3.870
	Pipe Apparent Modulus of Elasticity	E	psi	17,280
	Wall thickness of pipe	A	inches	0.784
	Radial Directed Earth Pressure	P_{RD}	psf	14,775
	Earth Pressure Loading	wH	psf	22,660
	Compressive Stress	S	psi	564
	Pipe Outer Diameter	D_o	inches	8.625
	Allowable Compressive Stress		psi	1,000

	FACTORS:	Symbol	Unit	Value
DEFLECTION	Rigidity Factor	R_F	dimensionless	3,353
	Pipe Apparent Modulus of Elasticity	E	psi	17,280
	Secant Modulus of Soil	E_S	psi	4,829
	1-D Modulus of Soil	Ms	psi	6,500
	Dimension Ratio	DR	dimensionless	11
	Void ratio of soil	µ	dimensionless	0.30
	Earth Pressure Loading	wH	psf	22,660
	Soil Strain	ε_S	dimensionless	3.3%
	Deformation Factor	DF	dimensionless	1.6
	Deflection	ΔX/Dm	dimensionless	5.2%
	Allowable Deflection		dimensionless	7.5%

	FACTORS:	Symbol	Unit	Value
BUCKLING	Buckling Pressure	P_{CR}	psi	542
	Buckling Pressure	P_{CR}	psf	78,077
	Pipe Apparent Modulus of Elasticity	E	psi	17,280
	Calibration Factor	ϕ	dimensionless	0.55
	Geometry Factor	R_H	dimensionless	1.0
	Mean Pipe Diameter	D_M	inches	7.80
	Pipe Wall Moment of Inertia	I	in^4/in	0.040
	Secant Modulus of Soil	E_S	psi	4,829
	Void ratio of soil	μ	dimensionless	0.30
		Es*	psi	6,898

FACTORS OF SAFETY:

FS Against RING COMPRESSION	1.77
FS against RING DEFLECTION	1.44
FS Against RING BUCKLING	3.45

ATTACHMENT NO. 7

RESPONSE ACTION PLAN

Response Action Plan For Landfill L-14

For

Chemical Waste Management of the Northwest Arlington Facility
17629 Cedar Springs Lane Arlington, Oregon 97812

Last Revised
February 2020

Table of Contents

APPENDICES

EXECUTIVE SUMMARY

This *Response Action Plan for Landfill L-14* (RAP) has been prepared for the Chemical Waste Management of the Northwest, Inc. (CWMNW) Arlington Facility in accordance with Title 40, Code of Federal Regulations (40 CFR) Part 264 Subpart N, Oregon Administrative Rule (OAR) 340-104, and United States Environmental Protection Agency (EPA) guidelines as outlined in the double liner and leak detection rules for hazardous waste and disposal units (FR 57, January 29, 1992). This RAP addresses: (1) the requirements of CFR Part 264.301; (2) identification and quantification of potential sources of liquids within the Leak Detection System (LDS) on a cell-specific basis; (3) the criteria to be used to detect, evaluate, and respond to liquids in the LDS; (4) the proposed response actions which may be triggered by detection of liquids within the LDS; and (5) the reporting procedures to state and federal agencies.

The rates of flow into the LDS from potential sources of liquids have been evaluated following a series of conservative assumptions. Because of the geosynthetic clay liner (GCL) and the drainage geocomposite within the LDS, no internal sources for liquid generation are accommodated in this RAP. All potential liquids sources are external to the lining system.

Based on the definition in the final leak detection rule (also 40 CFR Part 264.302), an Action Leakage Rate (ALR) of an unreasonably high flow rate was calculated. The primary motive behind the selection of the LDS drainage geocomposite was to provide a drainage system that would have satisfactory structural performance under the anticipated overburden pressures of the landfilled waste. If the maximum drainage capacity of the LDS is adopted as the ALR, then during the active life of the landfill cells, a leak condition that requires an action may never be triggered regardless of the severity of the leakage. Also, the use of the flow capacity of the LDS drainage geocomposite would result in a significant overdesign of the LDS collection sump and the leachate pumping system.

Considering the large disparity between the cell-specific liquid leakage rates into the LDS (as estimated in Section 3.3.6 of this RAP) and the flow capacity of the LDS drainage geocomposite, a more reasonable flow rate is proposed for the ALR. The ALR flow rate is based on the minimum required transmissivity of 3×10^{-5} m^2/sec in the drainage geocomposite of the LDS per 40 CFR Part 264.301. Based on this transmissivity, the Action Leakage Rate (ALR) is calculated to be approximately 376 gallons/day.

Section 5.0 of this RAP details a series of actions that will be taken in the event the leak rates into the LDS exceed the ALR. These actions include EPA and Oregon Department of Environmental Quality (DEQ) requirements and an additional set of measures that CWMNW will implement if the leak rates beyond the ALR are observed in the leak detection system.

1.0 INTRODUCTION

1.1 General

The owners or operators of landfill units subject to Resource Conservation and Recovery Act (RCRA) Subtitle C (Title 40, Code of Federal Regulations [40 CFR] Part 264.301(c) or (d)) regulations must have an approved Response Action Plan (RAP) before receipt of waste at the landfill facility. 40 CFR Part 264.301, also adopted by the Oregon Administrative Code (OAR 340-100-002), requires that the leachate collection system between the liners and immediately above the bottom composite liner functions as a leachate collection and removal system as well as a leak detection system (LDS).

A RAP describes the criteria used to address liquids which accumulate in the LDS. Details of the definition of the "Action Leakage Rate" (ALR) which trigger a response on the part of the owner/operator to address such accumulations are given in 40 CFR Part 264.302.

In the final leak detection rule the EPA (1992) has adopted a single level of action identified by the Action Leakage Rate which triggers regulatory response in the event of significant releases of landfill liquids into the LDS. By its definition, the ALR is the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner exceeding one foot. The ALR must include an adequate safety margin to allow for uncertainties including design and construction of the landfill, waste and leachate characteristics, and proposed response actions.

This RAP for Landfill L-14 at the CWMNW Arlington Facility has been prepared in accordance with 40 CFR Part 264 Subpart N, OAR 340-104, and EPA guidelines as outlined in the double liner and leak detection rules for hazardous waste and disposal units (FR 57, January 29, 1992). This RAP addresses: (1) the requirements of Part 264.301; (2) identification and quantification of potential sources of liquids within the LDS on a cell-specific basis; (3) the criteria to be used to detect, evaluate, and respond to liquids in LDS; (4) the proposed response actions which may be triggered by detection of liquids within LDS, and (5) the reporting procedures to state and federal agencies.

1.2 Project Location

The CWMNW Arlington Facility is located in Gilliam County, Oregon. Landfills L-12, L-13, and L-14 (Cell No. 1 through 4) are currently in operation. CWMNW is currently seeking approval to expand Landfill L-14 to include Cells 5-8.

Landfill L-14 has been designed to comprise eight (8) cells, and will have a total capacity of approximately $10x10^6$ cubic yards (cy). The design of L-14 meets or exceeds the requirements detailed in 40 CFR Part 264.301, OAR 340-104, and guidelines for landfill construction as described in *Minimum Technology Guidance on Double Liner Systems for Landfill and Surface Impoundment Design, Construction and Operation* - EPA 530SW85014.

1.3 Waste Characterization

Landfill units at the Arlington Facility are designed for permanent disposal of bulk solid hazardous wastes, containerized wastes free of liquids, and stabilized wastes. A complete description of wastes which are not accepted at the Arlington Facility is presented in Part A (Attachment 3) of the Permit Renewal Application.

2.0 LANDFILL DEVELOPMENT

2.1 General

Landfill L-14 is divided into eight (8) cells for development and operational purposes. Details of the design and construction of each Landfill at the facility can be found in Standalone Document 14 – Design and Ops Plan.

Four (4) inter-cell berms in the north-south direction and three (3) intercell berms in the east-west direction divide the base area into eight (8) cells. The primary and secondary leachate collection and detection systems have been designed to be hydraulically independent. Details of the primary and secondary leachate collection and detection system can be found in Standalone Document 14 – Design and Ops Plan

Liquids collected in the primary and secondary collection sumps will be removed by pumps placed within large diameter riser pipes that extend from the ground surface down the sideslope to the each sump.

The landfill base (top of protective layer) grades vary between 938 feet MSL and 1026 feet MSL which vary from 10 feet above to 90 feet below the existing grade. The maximum top of landfill elevation is approximately 1,150 feet. The maximum depth of waste in the landfill is approximately 206 feet.

2.2 Description of Landfill Lining System

The lining system components of Landfill L-14 have been designed in accordance with 40 CFR Part 264 Subpart N 264.301 and the details are included in Standalone Document 14 – Design and Ops Plan.

2.2.1 Base Liner System

The base liner system incorporates separate primary and secondary composite lining systems in compliance with Standalone Document 14 – Design and Ops Plan.

2.2.2 Sideslope Liner System

Sideslopes are lined with a four-component lining system in compliance with Standalone Document 14 – Design and Ops Plan

2.2.3 Leachate Leak Detection Systems

Each of the eight (8) cells of Landfill L-14 will be equipped with primary (LCS) and secondary (LDS) leachate collection systems in compliance with Standalone Document 14 – Design and Ops Plan. Leachate flow between cells will be prevented by means of separation/ intercell berms built into the base liner and leachate collection system. Separation of the cells will also be ensured in the design of primary and secondary leachate collection systems. Both the primary and the secondary leachate collection systems will have separate sumps where leachate collection, pumping, and leak detection functions will be performed by means of sideslope risers. A typical section through the primary and secondary sumps can be found in the facility's *Landfill Design Drawings* document.

Complete design analyses for the LCS and the LDS are provided in the following document previously submitted to the DEQ:

- *Hydrogeologic Investigation and Engineering Design Report for Landfill L-14, Arlington, Oregon*, prepared for Chemical Waste Management of the Northwest, Inc., by Rust Environment and Infrastructure Inc., dated February, 1998.

2.2.4 Tertiary Sump Monitoring System

In addition to the primary and secondary lining systems, a tertiary detection monitoring system has been designed directly beneath the LDS sump to monitor any releases into the environment. Inside the LCS and LDS sumps, the leachate heads will reach measurable levels during landfill operations, increasing the probability of liner leakage at these locations. The tertiary sump monitoring system will be capable of detecting releases through the LDS sump as well as enable sampling of the liquids collected for purposes of chemical analyses.

2.3 Description of the LDS

Subtitle C Part 264.301 (c)(3)(ii) allows the use of a geosynthetic drainage composite within the LDS with a transmissivity equal to or greater than $3x10^{-5}$ meters squared per second (m^2/sec). The secondary leachate collection layer was designed using a geonet/geotextile drainage composite.

2.4 Leachate Management

Fluids from landfill operations (leachate) are intercepted by the primary leachate collection and removal system (LCRS), and collected in the sumps. The LDS is designed to effectively intercept liquids which may have migrated through the primary lining system. Fluids intercepted by the LDS are also channeled to discrete sumps from which they are removed.

3.0 POTENTIAL SOURCES OF LIQUIDS IN LDS

3.1 General

The potential sources of liquids that may be collected within the secondary leachate detection/collection system can be broadly categorized as: (1) construction-related, (2) internal; and (3) external sources.

This section addresses: (1) the potential sources of liquids inside the secondary leachate detection/collection system; and (2) quantification of the liquids due to each potential source.

3.2 Potential Sources of Liquid

3.2.1 Construction-Related Liquids

Liquids generated during installation of the lining system components and before placement of the waste inside each cell will be classified as construction-related liquids.

These liquids generally occur as a result of: (1) direct precipitation onto the secondary geomembrane and secondary drainage layer prior to installation of the primary lining system; (2) permeation and localized leakage (through flaws in the primary lining system) of water that enters the primary drainage layer during construction; and (3) permeation of water from direct precipitation onto the primary drainage layer that occurs after completion of the drainage layer placement.

Water collected in the secondary collection sump as a result of direct precipitation (item 1 listed above) is not considered a part of the liquid quantity to be used as the basis for the ALR. Leakage as a result of Item 2 above should take place relatively rapidly before the start of waste placement operations, and therefore it will be considered as construction-related. Additional leak quantities due to direct precipitation (Item 3 above) during this period will also be considered construction-related. Any leakage that results from direct precipitation after the start of waste placement operations will be considered as due to external sources.

3.2.2 Internal Sources

Internal sources of liquids in the secondary detection/collection system sump typically consist of (1) compression of the soil component of the primary lining system; and (2) compression of the secondary drainage layer material. Compression water from the primary lining system drains into the secondary detection/collection system.

The air-dry moisture content of the bentonite in GCL's is low enough not to release any moisture under subsequent waste loading. Therefore, no measurable amounts of liquids in the secondary detection/collection system are anticipated as a result of GCL compression.

3.2.3 External Sources

External liquid sources inside the secondary detection/collection system consist of: (1) leakage of leachate and initial water within the primary drainage layer through the primary geomembrane/GCL system; (2) compression water from the secondary soil/bentonite liner leaking into the secondary collection system through pinholes or larger-size construction related flaws through the secondary geomembrane; and (3) seepage of groundwater and/or other liquids through the secondary lining system if an inward gradient condition exists.

The uppermost groundwater-bearing zone beneath Landfill L-14 is the Selah aquifer at a depth of approximately 75 to 95 feet from the base of the secondary soil liner component. Therefore, no migration of liquids into the secondary collection system is anticipated as a result of inward seepage of groundwater unless perched groundwater above the base grades is encountered.

3.3 Quantification of Liquids

The quantities of liquids from external sources were estimated based on the assumptions listed below:

Specific to the protective soil layer material above the primary leachate collection geocomposite:

- The lining system construction will take place during periods with very little precipitation.
- The protective soil layer material will have an areal averaged hydraulic conductivity greater than $1x10^{-3}$ cm/sec.
- The protective soil layer will be placed rapidly so that it can be assumed to cover the entire base area of the cell (or, portion of the cell).

Specific to the cells:

- The maximum length of drainage to the primary and secondary collection sumps is approximately 889 feet.
- Base slope of the cell is a minimum of 1 percent at the time of construction in conformance with 40 CFR264.301(c)(3)(i).

Specific to the lining system:

- Secondary soil/bentonite liner can drain only in the downward direction as it consolidates under increasing waste loading unless there are pinholes in the overlying lining system.

The following paragraphs address the quantification of the leakage into the secondary detection system from external sources.

3.3.1 Leakage through Holes in the Primary Geomembrane

The calculations in Appendix A of this RAP show that the leachate removal capacity of the primary leachate collection system exceeds the annual precipitation. This result indicates that even if the drainage layer received direct precipitation throughout the year, the hydraulic head build-up above the primary base geomembrane would be negligible. Therefore, the potential for leakage through any flaws in the primary geomembrane is very small.

For a conservative estimate of the leakage rate through the primary liner system on the floor of each cell, a hydraulic head of 12 inches was assumed in the drainage layer and protective soil overlying the primary geomembrane. In the calculations, the methodology devised by Giroud and Bonaparte (1989) was employed to estimate the leakage.

The 60-mil HDPE geomembrane was assumed to be in good contact with the underlying GCL and to have four one-square-centimeter holes per acre. The result obtained is approximately 0.057 gallons per day (gpd) per 1 cm^2 hole in the geomembrane, or 0.228 gallons per day per acre of lined area.

On the sideslopes, the hydraulic head of the leachate above the primary geomembrane will be insignificantly small. The geocomposite drainage capacity on the sideslopes will be much larger than the transmissivity required to drain the leachate impinging upon the slopes. However, as a conservative value, the leakage rate estimated above was assumed to also occur through holes within the primary sideslope liner system.

Within the primary leachate collection sump areas, a hydraulic head of three feet was used in the leakage rate estimates. However, because two layers of GCL are installed in the sumps, one GCL layer beneath the sump was assumed to remain intact. The leakage rate in this case was found to be approximately 0.38 gpd/hole. Two holes were assumed per sump, in addition to the four holes per acre assumed in the remainder of the base liner.

3.3.2 Leakage Through an Assumed Tear Within the Primary Geomembrane and GCL

In this scenario a 12-inch long and 0.25-inch wide tear along a geomembrane seam was assumed. It was also assumed that the tear continues through the GCL. By the nature of the bentonite material used in their manufacture, GCL's are generally self-sealing. However, this characteristic of the bentonite was neglected in the analysis for increased conservatism.

The leakage rate in this scenario is controlled by the hydraulic conductivity of the protective layer soil rather than the size of the tear and the hydraulic head over it. Due to the high assumed hydraulic conductivity, the assumed tear will result in a higher leak rate. A leakage rate of about 12.1 gpd per tear was calculated assuming a hydraulic head of 12 inches above the tear. One tear was assumed per cell.

Within the primary leachate collection sump areas, a hydraulic head of three feet was used to calculate the leakage rates. Similar to leak rate estimates through holes discussed above, one of the GCL layers beneath the leachate collection sump was assumed to remain intact. The leakage rate for this case was found to be approximately 7.35 gpd/tear with one tear per sump assumed in addition to the tear assumed in the floor of the each cell.

3.3.3 Leakage of Consolidation Water Through the Secondary Geomembrane Flaws

Consolidation time for the 3-foot thick soil/bentonite liner was estimated from the consolidation tests performed as part of the design of Landfill L-12 (Golder Associates, 1993).

The compacted soil/bentonite liner will be less than fully saturated immediately after construction. Also, there is no identifiable groundwater condition that could cause the liner to become saturated during filling of the landfill or after closure. Therefore, significant excess pore pressures that develop in response to loading of the low-permeability saturated soil materials are not likely to occur within the soil/bentonite liner.

The calculations indicate that the liner consolidates almost completely within a period of one week after each load increment is applied. Since the upper surface of the liner is in contact with the geomembrane, the single-drainage condition into the in-situ soils was considered in this evaluation. Soil liner consolidation will progress as the waste load on it increases gradually. To conservatively estimate the liquid generation rate as a result of soil liner consolidation, the overburden pressure obtained with the first increment was used in consolidation water calculations.

The daily average flow into the LDS was calculated as approximately 0.026 gpd per 1 cm^2 hole in the secondary liner system. The number of holes per acre was assumed to be four, identical to the assumption for the primary geomembrane. The calculations are provided in Appendix A of this RAP.

Tears were also assumed in the secondary liner system. The leakage rate due to these is approximately 0.5 gpd, assuming one tear per cell, the same as the assumption for the primary geomembrane. Appendix A of this RAP contains the relevant calculations.

3.3.4 Permeation through Intact Primary Geomembrane

Intact HDPE geomembrane is capable of transmitting water only in the form of water vapor in response to vapor pressure gradients. An equivalent hydraulic conductivity value of $2x10^{-13}$ cm/sec and a hydraulic head of 1-foot were used in estimating the permeation rate through the intact geomembrane. This value is approximately 0.037 gpd/acre. Such small amounts of water permeating the primary HDPE geomembrane will be largely absorbed by the GCL. If the absorption capacity of the GCL under the waste overburden pressure is exceeded, the permeation liquid may be released into the LDS in very small quantities. To be conservative, the absorptive capacity of the GCL was ignored in the calculations.

3.3.5 Permeation through Intact Secondary Geomembrane

Due to the presence of the soil/bentonite liner below the secondary HDPE geomembrane, some permeation of soil/bentonite liner pore water through the overlying secondary geomembrane may take place under hydraulic or vapor pressure gradients as the soil liner consolidates under waste loading. The rate of liquid transfer for this condition was estimated to be approximately 0.0075 gpd/acre.

3.3.6 Summary of Leakage Rates

Table 3-1 summarizes leakage rates from different sources as estimated in this section.

TABLE 3-1

LEAKAGE RATES FROM DIFFERENT SOURCES

Leakage Mechanism	Leakage Rate
Permeation through intact primary geomembrane	0.037 gpd/acre
Leakage through primary geomembrane flaws (1-foot head): • Four (4), 1 cm^2 holes per acre • One (1), 12-inch long tear (GCL also torn) per cell	 0.057 gpd/hole 12.1 gpd/tear
Leakage through primary geomembrane flaws at sump locations (3-foot head): • two (2), 1 cm^2 holes per cell • One (1), 12-inch long tear (GCL intact) per cell	 0.38 gpd/hole 7.35 gpd/tear
Permeation through intact secondary geomembrane	0.0075 gpd/acre
Consolidation water through secondary geomembrane flaws: • Four (4), 1 cm^2 holes per cell • One (1), 12-inch long tear	 0.026 gpd/hole 0.50 gpd/tear

Table 3-2 is a summary of the total leakage rates for each cell in Landfill L-14 based on the base liner and sideslope liner areas.

TABLE 3-2

CONSERVATIVE ESTIMATE OF CELL-SPECIFIC LEAKAGE RATES INTO LDS

Cell	Total Area (acres)	Total Leak Rate (gpd)
1	6.5	23.2
2	4.1	22.3
3	4.0	22.2
4	8.5	23.9
5	5.3	22.7
6	5.2	22.7
7	9.3	24.2
8	9.0	24.1

As indicated in the calculations, the cell-specific leakage rates shown in the table are based on very conservative assumptions. The actual leakage rates should be significantly lower than those shown.

4.0 LIQUID REMOVAL CAPACITY OF THE LDS

4.1 General

The minimum transmissivity of the geocomposite drainage layers for the LDS has been specified as $3x10^{-5}$ m^2/sec in the final leak detection rule. This is interpreted as the long-term value which is obtained after the application of several safety factors to account for potential long-term performance degradation. Some of these factors are related to the long-term filtration performance of the geotextile component and some to the long-term structural performance of the geonet. As discussed in Section 4.2 below, these factors have been included in the analysis of the long-term performance of the LDS.

4.2 LDS Design Considerations

Table 4-1 summarizes the safety factors used in the evaluation of the long-term performance of the geonet/geotextile drainage composite. The documentation for the selection of each safety factor value is provided in Appendix A of this RAP.

TABLE 4-1

DRAINAGE GEOCOMPOSITE PARTIAL REDUCTION FACTORS

Performance Factor	**Assigned Safety Factor**
Out-of-plane creep (geonet)	2.0
Void intrusion (geonet)	1.2
Soil clogging (geotextile)	1.0
Chemical clogging (geotextile)	1.5
Biological clogging (geotextile)	1.2
Overall Reduction Factor (Product of all above factors)	**4.32**

The geotextile-related factors listed in Table 4-1 do not necessarily affect the long-term transmissivity of the geonet. However, they force a decrease in the flow rate of liquid into the geonet, and therefore, indirectly affect the flow capacity of the drainage geocomposite.

The initial transmissivity value for the drainage geocomposite selected for the LDS was obtained from a transmissivity vs. normal stress chart published by the manufacturer. The maximum design waste thickness was used to calculate the design normal stress. This published transmissivity value, in part, includes the effect of the creep of the HDPE due to sustained loading. An additional creep factor of safety of 2.0 was applied to the transmissivity value obtained from the chart as shown in Table 4-1.

By combining the partial safety factors listed above, the long-term transmissivity of the drainage geocomposite was obtained as 7.8×10^{-4} m^2/sec. This long-term transmissivity exceeds the minimum required transmissivity of 3×10^{-5} m^2/sec (per 40 CFR Part 264.301). Conservatively, the flow capacity of the geocomposite drainage layer was estimated based on the required transmissivity of 3×10^{-5} m^2/sec in order to estimate the minimum allowable flow capacity of the geocomposite drainage layer. The flow capacity of the LDS geocomposite ranges from 376 to 670 gpd. This accounts for the configuration of the secondary collection trench along the southern edge of the Cells 1 through 3 and collection trenches in Cells 4 through 8, which intercept flow from portions of each cell. These values are 18 to 27 times larger than the estimated total flow of liquids into the LDS.

4.3 Leak Detection Time

Based on the capability of the composite secondary leachate detection/collection systems to detect extremely small flows regardless of the time scale involved in the arrival of such flows to the LDS sumps, the final leak detection rule requires that the LDS "be capable of detecting … leaks at the earliest practicable time."

In Landfill L-14, the slowest calculated leachate flow path is along the base of Cell 1. This path consists of approximately 180 feet along the sideslope (3H:1V west-east direction), 480 feet along the base (1.0 & 1.5 percent slope in the north-south direction), and 90 feet along the south toe collection trench (0.7 percent slope), for a total of 750 feet. The leak detection time for this path is estimated to be approximately one day.

4.4 Action Leakage Rate

In its final leak detection rule, the EPA has adopted a single level of leak detection (ALR), which is defined similarly to the Rapid and Large Leak (RLL) in the proposed rule (EPA, 1992). By its definition, the ALR is the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner exceeding 1-foot. This description applies largely to the LDS's that have a 12-inch thick granular drainage layer. For the geocomposite drainage layers, an equivalent condition would be the full flow within the drainage layer that has the same transmissivity as a 12-inch thick granular layer with a hydraulic conductivity not less than 1×10^{-2} cm/sec.

Based on the definition in the final leak detection rule (also 40 CFR Part 264.302), an ALR value should be based on the long-term transmissivity of the drainage geocomposite that considers decreases in the flow capacity of the system over time. However, as discussed in section 4.2, the minimum required transmissivity of the LDS drainage geocomposite is 3×10^{-5} m^2/sec per 40 CFR Part 264.301, which is less than the estimated long-term transmissivity of the LDS drainage geocomposite. The flow capacity of the LDS geocomposite ranges from 376 to 670 gpd and is 18 to 27 times larger than the estimated total flow of liquids into the LDS. Using the long-term transmissivity of 7.8×10^{-4} m^2/sec would result in an unreasonably high flow rate that greatly exceeds the average daily precipitation at the facility. The primary motive behind the selection of the LDS drainage geocomposite was to provide a drainage system that would have satisfactory structural performance under the calculated overburden pressures. The drainage capacity of the selected LDS drainage geocomposite exceeds, by a large margin, the calculated potential leakage rate into the LDS.

Therefore, if the maximum drainage capacity of the LDS is adopted as the ALR, then during the active life of a cell a leak condition that requires an action will likely never be triggered regardless of the severity of the leakage. Also, the use of the flow capacity of the LDS drainage geocomposite would result in a significant overdesign of the LDS collection sump and the leachate pumping system.

Considering the large disparity between the cell-specific liquid leakage rates into the LDS (as estimated in Section 3.3.6 of this RAP) and the flow capacity of the LDS drainage geocomposite, a more reasonable flow rate is proposed for the ALR. The ALR flow rate is based on the minimum required transmissivity of 3×10^{-5} m^2/sec in the drainage geocomposite of the LDS per 40 CFR Part 264.301.

Based on this transmissivity and the cell floor width and slope, the maximum drainage capacities of the LDS and thus ALRs are as follows.

TABLE 4-2

CELL SPECIFIC ACTION LEAKAGE RATES (ALRs)

Cell	Cell Floor Width (ft)[1]	Minimum Cell Floor Slope (%)	Max Drainage Capacity (gpd)
1	210	1.0	438
2	214	1.0	447
3	214	1.5	670
4	120	1.5	376
5	134[2]	1.5	419
6	134[2]	1.5	419
7	134[2]	1.5	419
8	134[2]	1.5	419

Note:

1. Due to the herringbone configurations of Cells 4, 5, 6, 7, and 8 the maximum drainage capacity of these cells was based on the perimeter length of the sump rather than the width of the cell floor.
2. Per the detail in the permit drawing set, sumps in Cells 5, 6, 7, and 8 are 41 ft long by 26 ft wide.

The use of these action leakage rates enables the owner/operator to take action before large releases into the LDS begin to occur.

4.5 Verification of LDS Sump Capacity

The LDS sump in each cell was designed to be approximately 3 feet deep. The depth of the toe trench on both sides of the sump will be approximately 1-foot at the point of connection to the sump. In order to prevent liquid accumulation inside the toe trench, the liquid head within the LDS sump will not be allowed to exceed 2 feet. The liquid capacity of the LDS sump has been calculated assuming that the hydraulic head will be limited to a minimum of 1-foot and a maximum of 2 feet.

The existing LDS sumps for cells 1 to 3 have a capacity of approximately 474 gallons. Based on the proposed LDS sump design for Cell 4 the liquid capacity of the LDS sumps was calculated as approximately 1,017 gallons. The liquid capacity for proposed LDS sump design for Cells 5, 6, 7, and 8 was calculated at 1,599. In this analysis, a porosity of 40 percent was used for the granular material within the sump and the storage volume of the sump riser was ignored. The LDS sump dimensions can be found in the facility's *Landfill Design Drawings* document.

The ALR's of 376 to 670 gallons/day/sump are relatively small flow rates. A wide range of commonly available pumps have the capacity to handle these flow rates. Based on the available LDS sump volume, a pump will need to operate approximately once per day for a period of only about 1.5 to 2.5 hours to stay ahead of the proposed ALR.

5.0 RESPONSE ACTION

5.1 General

This section details response actions for possible excursions from the cell-specific ALR's for Landfill L-14 Cells 1 through 5. A summary of the monitoring to be performed is also included.

5.2 Monitoring of the Primary Leachate Collection Sumps

During the active life of Landfill L-14, all primary leachate collection system sumps will be inspected in accordance with the facility's *Inspection Plan*, and the accumulated leachate in these sumps will be pumped at a frequency determined by the liquid accumulation rate, sump size, and the characteristics of the leachate pumps installed in each sump. Frequent removal of the leachate from the primary leachate collection system will minimize the hydraulic gradients that increase the potential for leakage into the LDS.

5.3 LDS Monitoring

During the active life of Landfill L-14, all L-14 LDS sumps will be inspected for liquid accumulation in accordance with the facility's *Inspection Plan*. Liquids accumulating within the LDS sumps will be removed to the extent possible by the leachate removal system. This will minimize the hydraulic head on the secondary containment system, also minimizing the potential for leakage through the secondary geomembrane and the soil liner. The maximum liquid level within the sumps will be 2 feet. This will prevent the liquids from backing into portions of the leachate collection trench along the southern edge of the cells. The liquid level within the sump will be at least 1 foot below the lowest point of the LDS drainage geocomposite blanket on the cell floor.

During the active life of Landfill L-14, as well as during final closure, liquid will be pumped from each LDS sump at least once per week, recorded, and compared to previous volumes. After final closure, the amount of liquid removed from each LDS sump will be recorded at least monthly. The monitoring frequency may be decreased to quarterly or semi-annually after closure in accordance with the requirements outlined in 40 CFR Part 264.303(c)(2). The volume of liquid removed over the time since last evacuation (end of pumping to end of pumping) will be averaged to determine if the ALR has been exceeded.

If it is determined that the ALR's have been exceeded, the following responses will be initiated until such time as the accumulations are determined to be within the cell's/sump's acceptable operating limits. The agencies have authority, upon determining the existence of a significant threat to human health and the environment, to require additional response actions.

5.4 Response Action Plan

For flow rates below the ALR, routine monitoring will continue.

Flow rates that equal or exceed the proposed ALR will require the implementation of a set of actions as described in Section 5.5 below. Pumping rates out of the LDS sumps greater than the ALR are indicative of flows into the LDS greater than expected due to one or more of the mechanisms described in Section 3.0.

5.5 EPA and DEQ Requirements

In the event of exceedance of the cell-specific ALR value in a cell, CWMNW will, per the minimum specifications detailed in 40 CFR Part 264.304(b)(c), and 340 OAR 104, take the following actions:

1. Notify the Department in writing of exceedance within 7 days of the determination, and indicate that the response action plan will be implemented.

2. Submit a preliminary written assessment to the Department within 14 days of the determination, describing the amount and likely sources of liquids, possible location, size, and cause of any leaks and short-term actions taken and planned.

3. Determine to the extent practicable, the location, size, and cause of any leak.

4. Determine whether waste receipt should cease or be curtailed, whether any waste should be removed from the unit for inspection, repairs, or controls, and whether or not the unit should be closed.

5. Determine other short-term and long-term actions to mitigate or stop any leaks.

6. Within 30 days after the notification that the ALR has been exceeded, submit to the Department the results of the analysis specified in Steps 3, 4, and 5 (above) and the results of actions taken and planned.

   Monthly thereafter, as long as the flow rate in the LDS exceeds the ALR, submit to the Department a report summarizing the results of remedial actions taken and actions planned.

7. To make the leak and/or remediation determinations in Steps 3, 4, and 5 (above), the owner/operator must:

   i. Assess the source(s) of liquids and amounts of liquids by source;

   ii. Conduct a fingerprint, hazardous constituent, or other analysis of liquids in the LDS to identify the source of liquids and possible location of any leaks, and the hazard and the mobility of the liquid; and

iii. Assess the seriousness of any leaks in terms of potential for escaping into the environment; or document why such assessments are not necessary.

5.6 Additional Requirements

In addition to the above requirements, CWMNW will also include the following actions in response to an exceedance of the ALR for the LDS sump:

1. In the event that leakage greater than the ALR is detected in any secondary leachate collection system sump, CWMNW will sample and analyze the liquid to determine whether it is derived from hazardous waste. CWMNW will determine the parameters for analysis, based on their knowledge of the wastes placed in the unit. Result of the analysis will be maintained in the operating record.

2. If the flow remains above the ALR for two consecutive one-week monitoring periods, CWMNW will provide written notification to the Department, and implement the following actions:

   i. Increase pumping frequency as necessary for both LCRS and LDS sumps until flows are reduced below the ALR;

   ii. Remove all standing water from within the landfill including from within temporary retention basin(s);

   iii. Inspect the exposed sideslope liner, if any, repair any damage or defects, and document the location and extent of liner damage;

   iv. Examine the primary liner 5 feet on either side of the damage and from the elevation of the damage to the top elevation of the waste and repair any observed damage;

   v. Cease placement of waste within 15 feet of the sideslope liner until a leak has been located, other appropriate actions have been taken, or flow to the secondary sumps has decreased below the ALR; and

   vi. Verify that the waste surface is sloping away from the landfill sideslopes. If necessary, regrade the waste or place soil to achieve a minimum one percent slope away from the landfill side.

3. If flow continues to exceed the ALR for an additional one week monitoring period, CWMNW will inspect and investigate alternative sources of liquids.

4. If the leak cannot be located or the flow continues to exceed the ALR after both the protective cover and primary liners have been repaired as necessary, CWMNW will prepare a written report describing actions taken to date and proposed future responses, and submit it to the Department within 60 days of the completion date of

the report.

6.0 TERTIARY SUMP MONITORING PROGRAM

A tertiary sump is constructed beneath each primary and secondary sump. The tertiary sump system effectively represents an “engineered vadose zone”, protected from the true in-situ vadose zone materials by a tertiary liner system. The tertiary sump will be constructed in accordance with the requirements of Standalone Document 14 – Design and Ops Plan .

6.1 Objective of Tertiary Sump Monitoring Program

The primary purpose of the tertiary sump is to detect leaks in the LDS sump. Additionally, the tertiary sump monitoring program is intended to provide data to help identify the nature of the Landfill L-14 long-term detection monitoring program that will eventually replace the interim monitoring program. The tertiary sump monitoring program is designed to provide the following information: (1) whether any liquid is present in the tertiary sumps; (2) the rate of liquid accumulation in the tertiary sump; and (3) the chemistry of liquid that might accumulate in the sump.

6.2 Tertiary Sump Monitoring Frequency

Monitoring will be implemented at a given tertiary sump once waste placement begins in the cell that is monitored by the sump. A monthly tertiary sump monitoring schedule will be adequate to detect the presence of liquid. In the event that liquid is detected in the tertiary sump, liquid removal will occur, and subsequent monitoring and liquid removal will be performed weekly as long as liquids continue to be detected in the sump. Pumping will be performed with a dedicated low-flow pump, such as a bladder pump (or equivalent). Pumping will occur only if the liquid head is sufficient to operate the pump. The volume of liquid removed will be recorded. If liquid is detected but the volume is insufficient to activate the pump, this will be noted.

6.3 Tertiary Sump Volume and Chemical Measurements

During each monitoring event, a device for measuring the presence of liquid will be used to evaluate water volumes. Evidence of surface contamination or discoloration, the condition of the riser, and the integrity of the locking cap will be recorded and maintained as part of the permanent monitoring record at the site. If no liquid is present in the tertiary sumps, this will be noted along with the date and time of the observation.

Liquid samples will be collected quarterly, if a sufficient quantity of liquid is present to allow for sampling, from the tertiary sump and analyzed for the chemical indicator parameters listed in the Table 6.1 below. In addition, field indicator parameters (pH, SC, and temperature) will also be measured in the secondary and tertiary sumps. If a sufficient quantity of liquid is present to allow for sampling, one sample will be collected from both the secondary and tertiary sumps in order to evaluate whether there has been a potential release. Based on the analytical results, additional tertiary sump samples may be collected. If volatile organic compounds are detected in the tertiary sump samples, the secondary sump will be immediately sampled and analyzed for the constituents listed in Table 6.1. Weekly measurements of volume and field indicator parameters will continue as long as liquid is observed in the tertiary sumps.

TABLE 6-1

TERTIARY SUMP PARAMETERS

Volatile Organic Compounds [Method 8260B]	
General Inorganics:	Common Anions/Cations
Calcium	
Magnesium	
Sodium	
Potassium	
Nitrate	
Bicarbonate	
Carbonate (when pH greater than 8.0)	
Sulfate	
Chloride	
Indicator Parameters:	
Dissolved Iron	
Dissolved Manganese	

6.4 Sump Sampling, Laboratory Analysis Procedures, and Reporting

Samples will be collected from the secondary and tertiary sump using the dedicated low-flow pumps installed in the sumps for liquid removal. The use of a low-flow pump for sampling is generally considered better for collecting samples that require analysis for volatile organic compounds (VOCs) because a low-flow pump tends to induce less sample volatilization than other types of samplers (e.g., high pressure-vacuum lysimeters).

Samples for chemical analysis will be collected according to the procedures specified in the *Manual for Groundwater Sampling* (see Appendix 1 of the *Groundwater Monitoring Plan*), with the exception that no purging of the sumps will be performed prior to sample collection due to the anticipated slow recharge rates. Samples will be handled and sent to the laboratory using strict chain-of-custody procedures, as described in the *Manual for Groundwater Sampling*.

Quality assurance / quality control (QA/QC) procedures used in the field and in the laboratory will also follow the procedures outlined in the *Manual for Groundwater Sampling*. Equipment blanks will not be required since a dedicated low-flow pump will be used to collect the samples.

An annual data report and summary will be submitted to the Department each year for the tertiary sump monitoring program. This information will be contained in the second semiannual groundwater monitoring report for the facility, which is usually submitted during December of each year.

7.0 REFERENCES

40 CFR 1993 (Updated as of September 30, 1993).

FR Vol. 57, (1992) *Environmental Protection Agency - Liners and Leak Detection Systems for Hazardous Waste Land Disposal Units.*

Giroud, J.P., and Bonaparte, R (1989) *Leakage Through Liners Constructed with Geomembranes - Part I. Geomembrane Liners*, Geotextiles and Geomembranes, V.8, pp.27-67.

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Golder Associates, Inc. (1993) *Consolidation Test - ASTM D2435 and Consolidation Test Summary", prepared for CWMNW - Arlington, Fill Unit L-12.*

Office of Solid Waste, EPA (1985) *Minimum Technology Guidance on Double Liner Systems for Landfill and Surface Impoundment Design, Construction and Operation* -EPA 530SW85014.

Office of Solid Waste, EPA (1992) *Action Leakage Rates for Leak Detection Systems" (Supplemental Background Document for the Final Double Liners and Leak Detection Systems Rule for Hazardous Waste Landfills, Waste Piles, and Surface Impoundments)* EPA 530-R-92-004.

Oregon Administrative Rules, Chapter 340 - Department of Environmental Quality.

RUST E&I (1995) *Response Action Plan - Landfill Unit L-12 - Arlington Facility*

APPENDIX A
CALCULATIONS

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
MAXIMUM DRAINAGE CAPACITY ANALYSIS
TOAL LEAKAGE RATE INPUT TABLE

OBJECTIVE

Estimate the total leakage rate into the Seondary Leachate Collection System

METHOD

Use calculation methods described in Giroud, J.P., and Bonaparte, R (1989) Leakage Through Liners Constructed with Geomembranes. Full reference provided in text of RAP. Sum the individual leakage rates to compute a total leakage rate.

CALCULATION

Cells	Lined Area	Permeation through Primary Geomembrane		Primary Geomembrane Leakage			Primary Sump Geomembrane Leakage		Permeation through Secondary Geomembrane		Secondary Geomembrane Consolidation Water Leakage			Total Leakage Into Secondary LCRS (gpd)
		Leakage Rate (gpd/acre)	Leakage (gpd)	Holes	Leakage from Holes[1] (gpd)	Leakge from Tears[2] (gpd)	Leakage from Holes[3] (gpd)	Leakage from Tears[4] (gpd)	Leakage Rate (gpd/acre)	Leakage (gpd)	Holes per Cell	Leakage from Holes (gpd)	Leakge from Tears (gpd)	
1	6.5	0.037	0.241	26.0	1.482	12.1	0.76	7.35	0.0075	0.049	26	0.676	0.5	23.2
2	4.1	0.037	0.152	16.4	0.935	12.1	0.76	7.35	0.0075	0.031	16.4	0.4264	0.5	22.3
3	4	0.037	0.148	16.0	0.912	12.1	0.76	7.35	0.0075	0.030	16	0.416	0.5	22.2
4	8.5	0.037	0.315	34.0	1.938	12.1	0.76	7.35	0.0075	0.064	34	0.884	0.5	23.9
5	5.3	0.037	0.196	21.2	1.208	12.1	0.76	7.35	0.0075	0.040	21.2	0.5512	0.5	22.7
6	5.2	0.037	0.192	20.8	1.186	12.1	0.76	7.35	0.0075	0.039	20.8	0.5408	0.5	22.7
7	9.3	0.037	0.344	37.2	2.120	12.1	0.76	7.35	0.0075	0.070	37.2	0.9672	0.5	24.2
8	9	0.037	0.333	36.0	2.052	12.1	0.76	7.35	0.0075	0.068	36	0.936	0.5	24.1

Notes

1. Assumed 4 holes/acre with leakage rate of 0.0057 gpd/hole
2. Assumed 1 tear/cell with leakage rate of 12.1 gpd/tear
3. Assumed 2 holes per sump with leakage rate of 0.38 gpd/hole
4. Assumed 1 tear per sump with leakage rate of 7.35 gpd/tear
5. Assumed 4 holes per acre with leakage rate of 0.026 gpd/hole
6. Assumed 1 tear per cell with leakage rate of 0.5 gpd/tear

Calculated By: David Spang Date: 1/22/2020

Checked By: Tim Mitchell Date: 2/3/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
LDS MAXIMUM DRAINAGE CAPACITY ANALYSIS
INPUT TABLE

OBJECTIVE
Estimate the maximum drainage capacity of the leachate detection system geocomposite.

METHOD
Use Darcy's equation to estimate the maximum drainage capacity based

ASSUMPTIONS
Geocomposite transmissivity = 3x10^-5 m^2/sec, as required by 40 CFR 264.301
The geocomposite remains free draining so that the slope of the cell floor is equal to the flow gradient.
The geometry of the cell floor is given in the design drawings.

CALCULATIONS

	Cell	1	2	3	4	5	6	7	8
Minimum Required Transmissivity	m^2/sec	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05
	m^2/day	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
	ft^2/day	27.90	27.90	27.90	27.90	27.90	27.90	27.90	27.90
Cell Floor Width (Approximate*)	ft	210	214	214	120	140	140	140	140
Cell Floor Gradient		0.010	0.010	0.015	0.015	0.015	0.015	0.015	0.015
LDS Capacity	ft3/day	58.59	59.71	89.56	50.22	58.59	58.59	58.59	58.59
	gpd	438	447	670	376	438	438	438	438

***Due to the herringbone configurations of cells 5 through 8, the perimeter length of the sump was used instead of the cell width.**

Calculated By: Zach Metzler Date: 1/20/2020
Checked By: David Spang Date: 1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 1 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 1

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	175	232	246	90	-	-	-	743
Gradient		0.333	0.010	0.015	0.007	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	1.40E-03	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	0.240	-	-	-	
	m	0.0061	0.0061	0.0061	0.0061	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	0.230	-	-	-	
Flow Velocity	m/sec	0.0765	0.0023	0.0034	0.0016	-	-	-	
	ft/sec	0.2508	0.0075	0.0113	0.0053	-	-	-	
Sectional Travel Time	sec	698	30,806	21,777	17,073	-	-	-	
	hours	0.19	8.56	6.05	4.74	-	-	-	
Total Travel Time	hours					-	-	-	19.5
	days					**-**	**-**	**-**	**0.81**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 1 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump. Flow paths in Cells 2, 3, 5, and 6 are faster than the design conditions for Cell 1, so those cell detection times are not calculated here.

Calculated By:	Zach Metzler	Date:	1/21/2020
Checked By:	David Spang	Date:	1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 4 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 4

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	222	213	252	114	-	-	-	801
Gradient		0.333	0.025	0.025	0.025	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	1.40E-03	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	0.240	-	-	-	
	m	0.0061	0.0061	0.0061	0.0061	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	0.230	-	-	-	
Flow Velocity	m/sec	0.0765	0.0057	0.0057	0.0057	-	-	-	
	ft/sec	0.2508	0.0188	0.0188	0.0188	-	-	-	
Sectional Travel Time	sec	885	11,313	13,385	6,055	-	-	-	
	hours	0.25	3.14	3.72	1.68	-	-	-	
Total Travel Time	hours					-	-	-	8.8
	days					**-**	**-**	**-**	**0.37**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 4 sum will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By: Zach Metzler Date: 1/21/2020

Checked By: David Spang Date: 1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 7 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 7

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	200	571	118	-	-	-	-	889
Gradient		0.333	0.020	0.017	-	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	-	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	-	-	-	-	
	m	0.0061	0.0061	0.0061	-	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	-	-	-	-	
Flow Velocity	m/sec	0.0765	0.0046	0.0039	-	-	-	-	
	ft/sec	0.2508	0.0151	0.0128	-	-	-	-	
Sectional Travel Time	sec	798	37,911	9,217	-	-	-	-	
	hours	0.22	10.53	2.56	-	-	-	-	
Total Travel Time	hours				-	-	-	-	13.3
	days				**-**	**-**	**-**	**-**	**0.55**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 7 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By: Zach Metzler Date: 1/21/2020

Checked By: David Spang Date: 1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 8 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 8

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	175	570	93	-	-	-	-	838
Gradient		0.333	0.020	0.022	-	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	-	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	-	-	-	-	
	m	0.0061	0.0061	0.0061	-	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	-	-	-	-	
Flow Velocity	m/sec	0.0765	0.0046	0.0051	-	-	-	-	
	ft/sec	0.2508	0.0151	0.0166	-	-	-	-	
Sectional Travel Time	sec	698	37,844	5,613	-	-	-	-	
	hours	0.19	10.51	1.56	-	-	-	-	
Total Travel Time	hours				-	-	-	-	12.3
	days				**-**	**-**	**-**	**-**	**0.51**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 8 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By: Zach Metzler Date: 1/21/2020

Checked By: David Spang Date: 1/22/2020

ATTACHMENT NO. 8

SITE CAPACITY AND SOIL BALANCE

CALCULATION BRIEF

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
L14 EXPANSION
SITE CAPACITY AND SOIL BALANCE CALCULATIONS

OBJECTIVE: **Determine the waste volume capacity for the proposed L14 expansion footprint (Cells 1 – 8). Also, prepare a remaining soil balance evaluation to determine the required soil cut and fill to construct the remaining cells (Cells 4C - 8) and to close the entire Landfil L14 area.**

REFERENCE: 1. L14 Landfill Expansion Permit Drawing Set, Chemical Waste Management of the Northwest, prepared by Civil & Environmental Consultants, Inc., February 2020.

ANALYSIS:

WASTE VOLUME CAPACITY

The waste volume capacity for the L14 Expansion was estimated based on Reference Number (Ref. No.) 1. CEC performed a volume comparison between the Top of Protective Cover and Top of Waste for Cells 1 through 8 using the AutoCAD Civil3D software. With L14 Expansion, the site will have a total waste volume capacity of 10,105,000 cubic yards (cy). However, please note that this volume does not account for the volume of existing in-place waste volume (Cells 1 – 4B) or future daily cover soil placement.

REMAINING SOIL BALANCE

The remaining soil balance for the L14 Expansion was estimated based on Ref. No. 1. CEC performed a volume comparison between various surfaces for Cells 4C through 8 with AutoCAD Cvil3D software to estimate the required cut and fill volumes and protective cover soil. To estimate the cut and fill volume, CEC compared the Subgrade for Cells 4C – 8 to the Existing Ground Surface. To estimate the protective cover soil volume, CEC compared the Subgrade to the Top of Protective Cover for Cells 4C-8. To estimate the volumes of final cover soils, CEC measured the three-dimensional (3D) area of the Top of Waste surface for Cells 1 through 8 and multiplied this area by the thickness of the final cover soil layer. The results of these comparisons are included in Attachment A. Note that these volumes do not account for shrink/swell of the soil materials.

CONCLUSION: **Based on the above analyses and results in Attachment A, the L14 Expansion has an overall waste volume capacity of 10,105,000 cy. Please note that this volume does not account for the volume of existing in-place waste volume (Cells 1 – 4B) or future daily cover soil placement.**

Additionally, the site will have an excess of approximately 1,047,000 cy of soils, available after construction of the remaining Cells 4C through 8 and closure of the entire L14 area.

ATTACHMENT A

SITE CAPACITY AND SOIL BALANCE CALCULATIONS

Chemical Waste Management of the Northwest
L14 Expansion
Site Capacity and Soil Balance

SITE CAPACITY			
			Volume (cy)
Total Waste Volume Capacity of the Landfill L-14; Cells 1 - 8 (See Note 1)			**10,105,000**
SOIL BALANCE (See Note 4)			
Soil Requirements	Thickness (ft)	3D Area (sf)	Volume (cy)
Fill Necessary to Reach Base Grade (Cells 4C-8)			21,000
Protective Cover Soil (1.5 ft along base and 1 ft along sideslopes)			64,000
Final Cover Soil (See Note 2)	3	2,342,727	261,000
		Total Soil Required	346,000
Soil Volume Available From Excavation			
Cut to Reach Base Grades			1,393,000
		Total Soil Available	1,393,000
		Total Soil Balance (See Note 3)	**1,047,000**

Notes:
1. Waste Volume Capacity is the volume between the Top of Protective Cover and Top of Waste for Cells 1 - 8 and does not account for the existing volume of waste or volume of cover soil.
2. Assumes 3-ft thick Evapotranspiration cover layer (to be designed by others)
3. Excess soil will be stockpiled within property boundaries or used for other on-site earthen structures.
4. These volumes do not account for shrink/swell of the soil materials.

ATTACHMENT NO. 9

TECHNICAL SPECIFICATIONS FOR LANDFILLS AND SURFACE IMPOUNDMENTS

SECTION 310516
AGGREGATE PRODUCTION AND STOCKPILING

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope:

1. Contractor shall provide all labor, materials, equipment, and incidentals required to produce and stockpile the specified aggregate to be used as part of the Work, as shown in the Drawings and/or as described in the Specifications. This work shall include, but is not limited to overburden removal, excavating, drilling, blasting, crushing, screening, and stockpiling aggregate materials.

B. Related Sections

1. Section 312316 Excavation and Stockpiling.
2. Section 312430 Geocomposite.

1.2 REFERENCES

A. 2021 Oregon Standard Specifications for Construction

B. Oregon Department of Transportation Construction Manual – January 2017

1.3 SUBMITTALS

A. Contractor shall submit a Work Plan as part of Bid, for review and approval by Owner. This Work Plan shall include:

1. Proposed methods, equipment, and stockpiling plans for aggregate production;
2. Equipment/production layout; and
3. Dust control procedures.

B. Prior to mobilization, Contractor shall obtain all permits required by Part 1.5 of this Section.

1.4 QUALITY CONTROL AND QUALITY ASSURANCE TESTING AND PROCEDURES

A. Quality control and quality assurance testing and procedures shall be as outlined in Section 312316 Excavation and Stockpiling of these Specifications.

1.5 PERMITS

A. Contractor shall obtain all necessary permits required for the pit/quarry development, blasting, and crushing and screening plants, including MSHA permit for all screens.

PART 2: PRODUCTS

2.1 PRODUCED AGGREGATE

A. The aggregate produced for this Work shall be sourced from the locations presented in Section 312316 Excavation and Stockpiling of these Specifications. The aggregate shall meet the product specifications as outlined in Section 312316 Excavation and Stockpiling of these Specifications.

PART 3: EXECUTION

3.1 OVERBURDEN REMOVAL

A. Contractor shall coordinate with Owner for overburden stockpile location.

B. Topsoil shall be stripped, as necessary, from quarry area, and hauled and stockpiled in location designated by Owner.

3.2 QUARRY DEVELOPMENT

A. Develop quarry in compliance with MSHA requirements.

B. Develop quarry in a manner that leaves it suitable for future development.

C. Obtain representative aggregate samples at earliest convenience for rock quality testing.

D. Perform durability testing in accordance with 2021 Oregon Standard Specifications for Construction Section 02630.10(c).

3.3 CRUSHING

A. Produce required quantities of specified gradations of materials, as presented in Section 312316 Excavation and Stockpiling of these Specifications.

3.4 DUST CONTROL

A. Contractor shall control dust during quarrying, crushing, and stockpiling per the submitted Work Plan.

3.5 STOCKPILING

A. Contractor shall clear, grade, level, and smooth-roll stockpile locations for placement of materials.
B. Each produced material type/gradation shall be stockpiled separately.
C. Fines and other reject material shall be stockpiled as directed by Owner.
D. Stockpile heights shall be limited to heights agreed to by Owner.
E. Material shall be stockpiled at angle of repose. Contractor shall not rework slopes of stockpiles unless needed to control runoff or erosion of materials.
F. Contractor shall limit traffic over stockpiled materials in order to preserve produced gradations.

3.6 REJECT MATERIAL

A. All reject material produced shall be disposed of in a location designated by the Owner. The Contractor shall have no claim to the material.

3.7 SURVEYING

A. A Surveyor, contracted by the Owner, shall record data for the stockpile areas upon completion of preparation of the stockpile area and at completion of stockpiling operations.
B. This survey data will be used to determine quantities of produced material for payment.

[END SECTION]

SECTION 310530

GEOSYNTHETICS DELIVERY, STORAGE AND HANDLING

PART 1: GENERAL

1.1 SECTION INCLUDES

A. Unloading, storage, and protection of Owner furnished geosynthetics until Geosynthetics Contractor mobilizes to site and accepts materials.

B. Unloading, storage, and protection of Owner furnished geotextiles installed by Contractor.

1.2 REFERENCES

A. ASTM D5888 – Standard Guide for Storage and Handling of Geosynthetic Clay Liners.

B. ASTM D4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.

PART 2: PRODUCTS

Not Used.

PART 3: EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. Storage Area Preparation

1. Owner will provide on-site storage area for geosynthetic rolls from time of delivery until installation.
2. Grade area to have uniform grades and to effectively drain surface water.
3. Compact area if necessary to ensure that rolls do not settle into area during storage.

B. Unloading

1. Follow Manufacturer's recommendations and relevant ASTM standards for unloading

C. Acceptance at Site

1. Perform inventory and surface inspection of all geosynthetic rolls upon delivery for defects and damage.
2. Inform Manufacturer and Owner immediately if any geosynthetic rolls appear damaged.

D. Storage and Protection

1. Store and protect geosynthetics from dirt, water, and other sources of damage.
2. Store and handle GCL in accordance with ASTM D5888.
3. Preserve integrity and readability of geosynthetic roll labels.
4. Use off-specification geomembrane rolls for scrap sheet installations.
5. Clearly mark off-spec geomembrane rolls and store separately to prevent their use in liner construction.
6. Immediately repair damage to protective coverings of rolls.
7. Replace geosynthetics damaged by improper unloading or improper storage and handling not in accordance with these specifications at no cost to Owner.

E. Transfer of Responsibility

1. Geosynthetic Contractor will take responsibility for storage and protection of geosynthetics they will install upon mobilization at site and inspection of materials.
2. Contractor retains responsibility for storage and protection of geosynthetics until acceptance by Geosynthetics Contractor.

[END SECTION]

SECTION 312316

EXCAVATION AND STOCKPILING

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope:

1. Contractor shall provide all labor, materials, equipment, and incidentals required to perform all site preparation, excavation, filling, and grading, and furnish all required soil materials, as shown in the Drawings and/or as described in the Specifications.

2. No classification of excavated materials will be made. Excavation shall include all materials regardless of type, character, composition, moisture, or condition thereof.

B. Coordination:

1. Contractor shall review installation procedures under other Sections and coordinate the installation of items that must be installed with the earthworks.

C. Related Sections

1. Section 310516 Aggregate Production and Stockpiling.

2. Section 312440 Geotextile.

3. Section 312420 HDPE Geomembrane.

4. Section 312450 Geosynthetic Clay Liner.

5. Section 312430 Geocomposite.

1.2 REFERENCES

A Standards referenced in this Section are:

1. ASTM D6913 - Standard Test Method for Particle-Size Analysis of Soils.

2. ASTM D698 - Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

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

4. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

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

1.3 TERMINOLOGY

A. The following words or terms are not defined but, when used in this Section, have the following meaning:

1. "Subgrade" is the uppermost surface of native soil material unmoved from cuts or of placed fill.

1.4 SOURCE OF SUPPLY

A. The source for all Earthfill shall be from the cell excavation or other on-site borrow area identified by the Owner or Construction Quality Assurance Consultant. For bidding purposes, the Contractor may assume that sufficient quantities of such material, meeting the specified requirements, will be available for use.

1.5 SUBMITTALS

A. The Contractor shall discuss with the Construction Quality Assurance Consultant the proposed methods of construction, including stripping, dewatering, excavation, filling, moisture-conditioning, compaction, and backfilling for the various portions of the Work. The review shall be for method only. The Contractor shall remain responsible for the adequacy and safety of the methods.

B. The Contractor shall submit a Work Plan for aggregate production detailing the proposed methods, equipment, and stockpiling plans for aggregate material and protective soil production and include a plan detailing locations and dimensions of equipment, including dust control equipment. Proposed equipment shall meet all applicable safety and environmental requirements and the developed Work Plan shall include lockout-tagout procedures for all proposed equipment. Contractor responsible for obtaining all necessary permits required for the crushing and screening plants, including MSHA permits.

C. The Contractor shall notify the Construction Quality Assurance Consultant in writing at least fourteen (14) days in advance of his/her intention to perform the Work of this Section.

D. If the Work is interrupted for reasons other than inclement weather, the Contractor shall notify the Construction Quality Assurance Consultant immediately and provide a plan and schedule for resumption of the Work.

1.6 CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL

A. All Work shall be constructed, monitored, and tested in accordance with these Specifications and the Quality Control requirements set forth in Table 312316-1 below and the CQA Manual, or as set forth by the Construction Quality Assurance Consultant.

TABLE 312316-1

EARTHWORKS MATERIALS QUALITY CONTROL AND

CONFORMANCE TESTING REQUIREMENTS

TEST	ASTM METHOD	PRECONSTRUCTION QUALITY CONTROL TESTING FREQUENCY[1,2]	CONFORMANCE TESTING FREQUENCY[2]
Road Base Course			
Sieve Analysis	C117/C136/D6913	1 per 1,000 CY	NA
Road Surface Course			
Sieve Analysis	C117/C136/6913	1 per 1,000 CY	NA
Structural Fill Material			
Sieve Analysis	C117/C136/D6913	1 per material type	1 per 10,000 CY
Modified Proctor	D1557		
Moisture Content, Field	D6938	NA	1 per 2,500 CY
Moisture Content, Oven	D2216 or D4643		1 per 10,000 CY
In-Situ Nuclear Density and Moisture	D6938		1per 2,500 CY
Protective Cover, Floor and Sideslope			
Sieve Analysis	C117/C136/D6913	1 per 20,000 CY	1 per 5,000 CY
Permeability	D2434	1 per material type or 1 per 10,000 CY – no conformance testing required	

Table Notes: [1]Pre-Construction Quality Control Testing for Road Base Course, Road Surface Course, and Protective Soil (floor and sideslope) shall consists of testing performed in conjunction with the production of these materials from on-site sources.

[2]Testing frequencies shall be increased should, based on visual observations of changes in the material, additional testing is deemed necessary to verify the conformance of the material.

B. All soil testing (both field and laboratory testing) shall be the responsibility of the Contractor (Quality Control) and/or the Construction Quality Assurance Consultant (Quality Assurance), as specified above. The Contractor shall be responsible for cooperating with the Construction Quality Assurance Consultant during all testing activities. The Contractor shall provide equipment and labor to assist the Construction Quality Assurance Consultant in sampling, if requested, and they shall also provide access to all areas requiring testing activities.

C. The Construction Quality Assurance Consultant may reject any material that does not meet the Specifications, based on either the Contractor's quality control testing, or the Construction Quality Assurance Consultant's quality assurance testing. Any or all portions of stockpiled material that does not meet Specifications shall be removed at no additional cost to the Owner. No additional material shall be added to the stockpile(s) until all rejected material is removed.

D. All excavation, fill, and grading operations shall be monitored by the Construction Quality Assurance Consultant, including placement of Earthfill, aggregate materials, and protective soil.

E. Any Work found unsatisfactory or any Work disturbed by subsequent operations before acceptance is granted shall be corrected by the Contractor as directed by the Construction Quality Assurance Consultant at no additional cost to the Owner.

F. The Contractor shall be aware of the activities outlined in the Drawings and account for these activities in the construction schedule.

1.7 TOLERANCES

A. Excavation and fill limits are defined by the lines and grades shown in the Drawings.

B. Contractor shall maintain uniform gradients between adjacent elevations shown in the Drawings without sags or humps.

C. The tolerances for cell construction subgrade, unless otherwise approved by Construction Quality Assurance Consultant, shall be as follows:

1. Slopes:

   a. Line: ± 1.0 feet

   b. Grade: ± 0.3 feet

2. Floors:

   a. Line: ± 0.5 feet

   b. Grade: - 0.2 feet to + 0.0 feet

3. Cell Base Slope shall be within ± 20% from specified slopes, as indicated on the Drawings.

D. The tolerances for perimeter road grading area, unless otherwise approved by Construction Quality Assurance Consultant, shall be:

1. Line: ± 1.0 feet

2. Grade: ± 0.3 feet

3. For the Perimeter Road, minimum thickness of 12 inches for base road course and 6 inches for surface road course, as measure from underlying surface.

E. The tolerances for cell liner as-built, unless otherwise approved by Construction Quality Assurance Consultant, shall be:

1. Line: ± 1.0 feet

   2. Grade: As measured

F. The tolerances for Protective Soil placement, unless otherwise approved by Construction Quality Assurance Consultant, shall be:

1. Minimum thickness of 18 inches on floor and 12 inches on sideslopes (perpendicular to slope) as measured from the as-built liner surface

2. Line: ± 1.0 feet

3. Grade: ± 0.2 feet (from as-built liner surface)

1.8 PROTECTION OF WORK

A. Contractor shall use all means necessary to protect all prior work and materials.

B. Contractor shall contact utility companies and locate, mark out, and protect all existing utilities before commencement of the Work.

C. Contractor shall protect benchmarks, survey markers, fences, roads, sidewalks, paving, curbs, and other existing structures from damage due to the Contractor's activities.

D. Contractor shall repair damage caused by the Work at no additional cost to Owner.

E. Erosion control must be maintained.

F. After fill materials have been placed, the Contractor shall maintain the surface free of ruts, depressions, and/or damage resulting from the hauling and handling of any material, equipment, tools, etc. In the event of damage, the Construction Quality Assurance Consultant will identify any areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the satisfaction of the Construction Quality Assurance Consultant and at no additional cost to the Owner.

PART 2: PRODUCTS

2.1 MATERIALS

A. Earthfill materials used in conjunction with the Work shall be on-site soils derived from the excavation and/or other on-site borrow area that consist of relatively homogenous, well-graded natural soils that are free of debris, foreign objects, large rock fragments, roots and organic material, frozen material, ice, snow, or excessive moisture. The maximum particle size for the Earthfill shall be as follows:

1. General Cell Earthfill: 3 inches

2. Earthfill in direct contact with GCL: ¾ inch

3. Perimeter Road Grading Area and road Earthfill: 6 inches

B. The aggregate materials used for Protective Soil, in both the floor and the sideslope, used in conjunction with the Work shall be from on-site sources, as specified in Part 1.4 of this Section, that consist of relatively homogenous, well-graded natural material that is free of debris, foreign objects, roots and organic material, frozen material, ice, snow, or excessive moisture.

C. Any material which is found to be unsuitable for construction by the Construction Quality Assurance Consultant shall be removed from the work area by the Contractor at no additional cost to the Owner.

PART 3: EXECUTION

3.1 SITE PREPARATION

A. The Contractor shall develop access to the construction area(s) as necessary and in consideration of Part 1.8 of this Section.

B. The Contractor shall maintain erosion control for the duration of the Work. Accumulated sediment shall be disposed of on-site by the Contractor in a manner approved by the Owner.

3.2 CLEARING AND GRUBBING

A. If required, clearing shall be done within the footprint of the limits of the construction area(s), as delineated in the Drawings. Clearing shall extend a maximum of 15 feet and a minimum of 10 feet outside of the construction limits, or as directed by Construction Quality Assurance Consultant.

B. No clearing shall be performed until written permission is given by the Owner, and until construction staking has been provided for the proposed Work.

C. Contractor shall strip all vegetative matter, rubbish, roots in excess of 1-inch diameter, and other deleterious materials from the designated area(s). In no case shall unsuitable deleterious materials, as determined by Construction Quality Assurance Consultant, be incorporated into Earthfill materials.

D. In areas designated to be stripped of unsuitable or objectionable materials, said materials shall be stripped to the full depth of organic or other unsuitable material as determined by the Construction Quality Assurance Consultant.

E. Stripped and grubbed vegetation shall be removed and disposed in stockpiles or wasted by way of other approved methods in an area designated by Owner in accordance with permits obtained from the appropriate local, state, and federal regulatory agencies.

3.3 TOPSOIL REMOVAL

A. Topsoil shall be stripped to a minimum depth of 6 inches, or as approved by Construction Quality Assurance Consultant, where required.

B. Topsoil shall be excavated and removed in a manner that will minimize contamination with other soil horizons. Such measures as are necessary shall be taken to ensure that the removal of topsoil does not result in erosion or excessive sedimentation.

C. Removed topsoil shall be stockpiled at locations designated by Owner. Stored topsoil shall not be disturbed by construction or on-site activities, and shall be protected from wind and water erosion, unnecessary compaction, and contamination that would lessen the capability of the material to support vegetation when redistributed.

D. Topsoil stockpiles shall be graded to minimize erosion and prevent ponding of precipitation in the stockpile areas. Stockpiled topsoil shall be protected by an effective temporary re-vegetation. Contractor to submit a re-vegetation plan to the Construction Quality Assurance Consultant for review and approval.

E. Stockpiled topsoil shall not be moved until required for redistribution on a regraded area.

3.4 EXCAVATION

A. Excavation shall be performed to the lines and grades indicated in the Drawings. No excavation shall begin until the Owner has provided construction staking for the proposed Work.

B. Contractor shall minimize the disturbance to surrounding areas during excavation

C. Work shall be suspended by Contractor when, in the opinion of the Construction Quality Assurance Consultant, the Site is overly wet, muddy, or otherwise unsuitable for proper maintenance, until directed otherwise by Construction Quality Assurance Consultant.

D. Where the required lines, levels and grades are not otherwise defined (such as where the excavation is anchor trenches or to assist with in tie-in with existing liner), Contractor shall excavate, as necessary, for the items that are to be placed in the excavations and as necessary to provide working space to install and inspect those items.

E. All necessary precautions shall be taken to preserve the material below and beyond the lines of excavation in the soundest possible condition. Where required to complete the Work, all excess excavation or over-excavation shall be refilled with approved Earthfill materials placed and compacted to the satisfaction of the Construction Quality Assurance Consultant.

F. Safe temporary construction slopes shall be the responsibility of Contractor. Contractor shall inspect all temporary and permanent open-cut excavations on a regular basis for signs of instability. Should signs of instability be noted, Contractor shall immediately undertake remedial measures and shall notify Construction Quality Assurance Consultant immediately. Permanent cut slopes shall be left in smooth, safe, and stable condition at the end of the workday.

G. All materials excavated shall either be placed in stockpiles to be used as Earthfill material or hauled to the designated waste spoil stockpile area. During excavation, grades shall be maintained to provide drainage of any surface waters that may impact the Work.

3.5 UNAUTHORIZED EXCAVATION

A. All excavations outside lines and grades shown or indicated and that are not approved by the Owner, together with removing and disposing of the associated material, shall be at Contractor's expense. Unauthorized excavations shall be filled and properly compacted with Earthfill material at Contractor's expense.

3.6 STOCKPILE CONSTRUCTION

A. Stockpiles shall have side slopes no steeper than 3H:1V. The stockpiles shall be graded to drain, sealed by tracking parallel to the slope with a dozer or other means, and dressed daily during periods with fill is taken from the stockpile. The Contractor shall cover stockpiles with plastic sheeting or other temporary re-vegetation.

B. Surplus excavated soils shall be hauled and deposited in the designated fill areas for the north berm and perimeter roadway construction. The material shall be placed in accordance with the Earthfill requirements of this Section.

C. Watering shall be performed during stockpiling to control dust.

3.7 SURFACE WATER CONTROL

A. Contractor shall construct surface water control features as shown in the Drawings and/or as required to prevent significant erosion and sediment transport of stockpiles, excavation, and fill areas from stormwater runoff.

B. The Contractor shall provide all equipment and facilities and perform all Work to make and keep the Work areas dry of surface water; construct the temporary sediment control systems; and improve the systems immediately if improvements are subsequently found to be necessary or prudent.

C. The Contractor shall prevent injury and damage due to dewatering, disposal of water, and sediment control.

D. The Contractor shall remove the temporary facilities when they are no longer necessary and restore the areas disturbed by dewatering and temporary sediment control.

E. The Contractor shall be liable for injury and damage resulting from failure to satisfactorily control sediment.

F. The Contractor is responsible for control of all surface water, as determined by Owner or Construction Quality Assurance Consultant, for the orderly progress of the Work.

3.8 EARTHFILL PLACEMENT AND COMPACTION

A. Earthfill shall be placed, as required, in areas where fill is required to achieve the lines and grades shown in the Drawings.

B. Earthfill materials shall meet the requirements of Part 2 of this Section.

C. Earthfill shall be placed in loose lifts that result in a compacted lift thickness of no greater than 12-inches.

D. If the moisture content of the prepared foundation or of any lift of Earthfill is too dry or too smooth to bond properly with the subsequent lift or to prevent proper compaction, it shall be moisture-conditioned and/or re-worked with harrow, scarifier, disk, or other suitable equipment to provide a satisfactory moisture content and surface before additional Earthfill material is placed thereon.

If the moisture content of the prepared foundation or of any lift of Earthfill is excessively wet to allow for proper compaction or for subsequent lifts of Earthfill to be placed thereon, it should be removed and allowed to dry, or re-worked with a harrow, scarifier, disk, or other suitable equipment to reduce the moisture content to an acceptable level, as determined by the Construction Quality Assurance Consultant. It shall then be re-compacted before the next lift of Earthfill material is placed.

Determination of such wet or dry conditions shall be made by the Construction Quality Assurance Consultant. Subgrade surfaces, including previously approved subgrade, which become softened or otherwise unsuitable, shall be repaired to the Construction Quality Assurance Consultant's satisfaction at no additional cost to the Owner.

E. The Contractor shall be responsible for the installation of suitable materials that meet Project Specifications. The Contractor shall not proceed to the next lift until the current lift has been tested and approved by the Construction Quality Assurance Consultant. The Contractor shall be held responsible for proceeding to the next lift without prior approval from the Construction Quality Assurance Consultant.

F. Each lift shall be compacted to at least 95% of the maximum dry density and within ± 4 percent of optimum moisture, as measured according to ASTM D1557 (Modified Proctor). The dry unit weight and moisture content shall be measured in-place according to ASTM D6938 at the frequencies presented in Table 312316-2.

G. Compaction shall be accomplished with equipment and by methods approved by Construction Quality Assurance Consultant. If such equipment or methods are found unsatisfactory for the intended use, Contractor shall replace the unsatisfactory equipment with other types or to adjust methods until proper compaction is achieved. After each layer of fill material has been placed, spread, and moisture-conditioned, the layer shall be compacted by passing compaction equipment over the entire surface of the layer a sufficient number of times to obtain the required density, as specified herein.

H. No frozen or partially thawed Earthfill material shall be placed, spread, or compacted. No Earthfill shall be placed or spread while the surface on which the material is being placed is frozen or thawing, during unfavorable weather conditions, or during periods of precipitation.

I. If the Earthfill freezes during construction, the Contractor shall remove the frozen Earthfill, scarify the remaining unfrozen fill, and then place and compact new Earthfill in accordance with this Section. The frozen Earthfill shall not be reused until has been thawed, disked, and re-worked to acceptable uniform moisture content.

J. The entire construction area shall be left in a manner to promote runoff at the end of each day.

K. Contractor shall remove all hubs and survey stakes prior to geosynthetic clay liner or other geosynthetic material deployment after approval from the Construction Quality Assurance Consultant.

3.9 FINISH GRADING

A. Contractor shall uniformly grade the areas within limits of grading as indicated in the Drawings.

B. Contractor shall smooth subgrade surfaces within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.

3.10 SUBGRADE PREPARATION

A. The prepared subgrade shall be smoothed and fine-graded with a motor-grader or similar equipment and proof-rolled with a smooth-drum roller, with a minimum drum weight of 4,000 pounds per foot of drum width, or by other Construction Quality Assurance Consultant-approved method, to create a smooth, unyielding surface (i.e., no excessive rutting or pumping of the material is observed). The prepared subgrade shall be free of loose materials, clods, rock and other debris including grade stakes and hubs.

B. In areas where the smooth-drum roller does not yield a surface that is suitable for the placement of overlying geosynthetics (i.e., the prepared surface could potentially damage the overlying geosynthetics), the Contractor may need to over-excavate the subgrade and place and compact finer material over the over-excavated surface in order to provide a smooth surface that will not damage overlying geosynthetics.

C. If excessive rutting or pumping (movements of more than 1 inch) is noted, as determined by Construction Quality Assurance Consultant, the subgrade at that location will be compacted or removed and replaced until deemed acceptable by the Construction Quality Assurance Consultant.

3.11 ANCHOR TRENCH EXCAVATION AND BACKFILL

A. The anchor trenches shall be excavated to the lines, grades, and widths shown in the Drawings, prior to any geosynthetic material placement. Construction Quality Assurance Consultant shall verify that the trenches have been constructed according to the Drawings.

B. The anchor trenches shall be backfilled with Earthfill in Direct Contact with GCL (maximum partible size of 3/4 inches) and compacted as approved by the Construction Quality Assurance Consultant.

C. Anchor trench backfill material shall be placed in 9- to 12-inch-thick loose lifts and compacted by wheel rolling with light compaction equipment, as approved by Construction Quality Assurance Consultant. Anchor trench backfill shall be moisture-conditioned, as required, to achieve a moisture content of ± 3 percent of optimum moisture content as required by method specification as approved by Construction Quality Assurance Consultant.

D. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic materials. At no time shall construction equipment come into direct contact with the geosynthetic materials. If damage occurs, it shall be repaired by the Contractor prior to the completion of backfilling, at no additional cost to the Owner.

E. Contractor shall coordinate with Geosynthetics Installer on the timing for anchor trench excavation and assist the Geosynthetics Installer with placing geosynthetic materials into the anchor trench as shown in the Drawings, as required. The geosynthetic materials shall be seamed, bonded, or attached along the entire distance of the anchor trench by the Geosynthetics Installer prior to backfilling the anchor trenches.

3.12 PROTECTIVE SOIL PLACEMENT

A. Placement of Protective Soil over geosynthetics shall not occur at temperatures below 32°F (0°C) or above 104°F (40°C) unless otherwise specified.

B. Contractor shall place the Protective Soil layer in a single lift, as shown in the Drawings. No mechanical compaction is necessary.

C. The Contractor shall not place any Protective Soil material until the Construction Quality Assurance Consultant has approved the installation of all underlying geosynthetics and authorizes the placement of the Protective Soil layer.

D. A dozer with a ground pressure of less than 7 psi, or Construction Quality Assurance Consultant-approved equivalent shall be used to spread the Protective Soil over the underlying geosynthetics and shall operate only over previously placed Protective Soil material. At all times, a minimum of 12 inches of Protective Soil material shall be maintained between equipment and the geomembrane.

E. If rubber-tired vehicle traffic is required, a minimum of 36 inches of Protective Soil material shall be maintained between the underlying geosynthetics and the base of the rubber-tired vehicles. Costs associated with building extra-thickness haul roads, staging areas, turnarounds, etc. will be considered incidental to placement costs.

F. The Contractor shall take steps to minimize wrinkle size and generation in the geomembrane being covered. Placement hours and methods of Protective

Soil placements operations may be restricted to prevent the development of wrinkles and stress bridging of the underlying geosynthetics. Contractor must be prepared to adjust material placement schedules, so operations take place during cool temperature periods (e.g. early morning or night hours). Contractor shall provide adequate illumination if early morning or night hours are necessary to place material. Contractor shall notify Owner three days in advance of proposed schedule change for early morning or night hours placement operations.

H. Wrinkles that must unavoidably be buried should be divided into smaller wrinkles by ground personnel walking them out and approved by the Construction Quality Assurance Consultant. The wrinkles must be trapped in a near-vertical position by a ground-man as they are buried by sand, and in no case shall be greater than three (3) inches.

I. Contractor shall expose by hand all locations where spinning tracks or tires may have damaged underlying geosynthetics, as directed by the Construction Quality Assurance Consultant. If underlying geosynthetics have been damaged, all effected geosynthetics shall be replaced by the Geosynthetics Installer, at the cost of the Contractor.

3.13 ROAD BASE COURSE AND ROAD SURFACE COURSE PLACEMENT

A. The Construction Quality Assurance Consultant shall verify the subgrade meets Specifications, and the lines and grades as shown on the Drawings. Contractor shall not place any Road Base Course until authorized by the Construction Quality Assurance Consultant.

B. Contractor shall load and haul materials from stockpiles to the Landfill Haul Road and place materials at the thicknesses indicated on the Drawings (12 inches for Road Base Course and 6 inches for Road Surface Course), and to the lines and grades shown on the Drawings. Materials shall be placed in one lift.

C. Contractor shall add water, as necessary, to assist in compaction of the material.

D. If excess moisture is apparent, material shall be removed and allowed to dry to reduce moisture content.

E. Compact using a minimum of three (3) passes with a smooth-drum roller with a minimum drum weight of 4,000 pounds per foot of drum width, or by other Construction Quality Assurance Consultant-approved method.

3.14 SURVEY CONTROL

A. Surveying of the final location and elevation of the tops of the liner subgrade, as- built liner surface, Protective Soil layer, north berm, stormwater basin, and perimeter road will be performed by the Owner after placement of fill materials to verify quantities for payment purpose.

[END SECTION]

SECTION 312323.23
COMPACTION

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the construction of earthwork structures as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.

B. The work of this Section shall include, but not necessarily be limited to: separating, hauling, stockpiling, backfilling, compacting, and grading of soils. The work of this Section may pertain in whole or in part to construction of any earth embankments or any other structure that requires compacted earth fill.

C. Notwithstanding the prequalification of any material sources for the fill, the CONTRACTOR shall be entirely responsible for meeting the requirements of this Section.

1.02 REFERENCES

A. Construction Quality Assurance (CQA) Plan.

B. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils.
2. ASTM D 698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
3. ASTM D 1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
4. ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
5. ASTM D 2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
6. ASTM D 2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
7. ASTM D 2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
8. ASTM D 2937, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method.

9. ASTM D 3017, Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
10. ASTM D 4220, Standard Practices for Preserving and Transporting Soil Samples.
11. ASTM D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.03 SUBMITTALS

A. The CONTRACTOR shall discuss with the OWNER and the CQA ENGINEER the proposed methods of construction, including stripping, dewatering, excavation, filling, compaction, and backfilling for the various portions of the work. The review shall be for method only. The CONTRACTOR shall remain responsible for the adequacy and safety of the methods.

B. For each soil type specified in Part 2 of this Section, the CONTRACTOR shall submit to the OWNER and the CQA ENGINEER the following information and samples a minimum of 14 days prior to starting construction:
1. the proposed material source;
2. the results of grain-size analyses conducted on the proposed material in accordance with ASTM D 422;
3. for fine-grained materials, the results of liquid and plastic limit tests conducted on the proposed material in accordance with ASTM D 4318;
4. the results of a moisture-density relation test (ASTM D 698); and
5. a 50-lb sample of each of the proposed soils or authorization to access the proposed source(s) for sampling.

C. The CONTRACTOR shall notify the OWNER and the CQA ENGINEER in writing at least 7 days in advance of intention to perform the work of this Section.

D. If work is interrupted for reasons other than inclement weather, the CONTRACTOR shall notify the OWNER and the CQA ENGINEER immediately and provide a plan and schedule for resumption of the work.

E. The CONTRACTOR shall abide by all qualification requirements of the CQA Plan.

1.04 CONSTRUCTION QUALITY ASSURANCE

A. The construction of the fill shall be performed in accordance with the requirements of this section and the CQA Plan.

B. The construction of the fill shall be monitored by the CQA ENGINEER as outlined in the CQA Plan.

C. The CONTRACTOR shall be aware of the activities outlined in the CQA Plan and account for these CQA activities in the construction schedule.

1.05 PROTECTION

A. The CONTRACTOR shall contact utility companies and locate, mark and protect all existing utilities before commencement of construction.

B. The CONTRACTOR shall protect trees, shrubs, lawns, rock outcroppings and other features remaining as part of final landscaping.

C. The CONTRACTOR shall protect benchmarks, survey markers, fences, roads, sidewalks, paving, curbs and other existing structures from damage due to the CONTRACTOR's activities.

D. The CONTRACTOR shall repair damage caused by the construction operations.

E. Erosion control must be maintained. Erosion control measures shall be as noted on the grading plan or as directed by the Company.

PART 2 PRODUCTS

2.01 MATERIALS

A. All laboratory testing to evaluate the suitability or conformance of soil materials for the fill shall be carried out in accordance with the test methods indicated in Part 1.04 of this Section.

B. Fill shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments, roots, and organics. The maximum particle size for the fill materials shall be as follows:

1. General earthfill in cells or impoundments: 3-inches
2. Earthfill in contact with GCL: ¾-inches

3. General earthfill for access roads: 6-inches
4. The fill shall be classified according to the Unified Soil Classification System (USCS) as SP, SW, SM, SC, ML, CL, CH, or MH material.

B. Fill shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments, roots, and organics. No materials larger than 3 inch shall be allowed. If fill is to be placed above geosynthetics, no materials larger than 1 inch shall be allowed within 1 foot of the geosynthetics. The fill shall be classified according to the Unified Soil Classification System (USCS) as SP, SW, SM, SC, ML, CL, CH, or MH material.

PART 3 EXECUTION

3.01 FAMILIARIZATION

A. Prior to implementing any work described in this Section, the CONTRACTOR shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section and the CQA Plan.

B. Inspection:

1. Prior to implementing any of the work in this Section, the CONTRACTOR shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.
2. If the CONTRACTOR has any concerns regarding the installed work of other Sections, the OWNER should be immediately notified in writing within 48 hours of the site inspection. Failure to notify the OWNER or continuance with fill placement shall be construed as CONTRACTOR's acceptance of the related work of all other Sections.

3.02 SITE PREPARATION

A. The CONTRACTOR shall develop access to the construction area in accordance with the requirements of the Drawings and any supplemental Specifications.

B. The CONTRACTOR shall install silt fences immediately down-slope of each area to be disturbed prior to the beginning of work in that area. The CONTRACTOR shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the CONTRACTOR in a manner approved by the OWNER.

C. All brush, vegetation, rubbish, and other objectionable material shall be removed from the construction area and disposed of in an area designated by the OWNER.

D. All topsoil shall be removed from the construction area and stockpiled.

E. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Drawings. The CONTRACTOR shall be responsible for constructing diversion ditches as required to divert potential run-on around the construction area. The construction of temporary ditches not shown on the Drawings shall not be undertaken until the CONTRACTOR's plan for constructing the ditches is approved by the OWNER.

3.03 EXCAVATION AND STOCKPILING

A. Excavated materials to be used as fill shall be stockpiled in designated areas segregated from soils not suitable for use as fill, clearing debris, or other objectionable materials. Stockpile areas shall be designated by the OWNER.

B. Stockpiles of fill shall have side slopes no steeper than 3H:1V (3 horizontal:1 vertical) unless approved otherwise by the OWNER. The stockpiles of fill shall be graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the OWNER, and dressed daily during periods when fill is taken from the stockpile. The CONTRACTOR may cover fill stockpiles with plastic sheeting or other material approved by the OWNER in order to preserve the moisture content of the fill.

C. Stockpiles that shall remain out of active use for a period greater than seven months shall either be covered as described in Part 3.03.B of this Section or stabilized by seeding and fertilizing in accordance with the requirements given in Section 329219.

D. Surplus excavated soils shall not be removed from the site or disposed of by the CONTRACTOR unless such removal or disposal is approved by the OWNER.

3.04 FILL

A. The fill used during this construction shall be constructed to the lines and grades shown on the Drawings using the appropriate material.

B. The fill shall meet the requirements of Part 2.01 of this Section.

C. The fill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 6 inches.

D. Each lift shall be compacted to at least 95 percent of the maximum dry unit weight as measured according to ASTM D698. The moisture content shall range from -3% to +3% of the Optimum Moisture Content as measured by ASTM D698. The dry unit weight and moisture content shall be measured in place in accordance with ASTM D6938.

E. If the moisture content of the fill is not suitable for proper compaction, the fill shall be moisture conditioned and reworked, as appropriate. Wetting shall be accomplished using a water truck and spray nozzle, unless the CQA ENGINEER approves an alternative method. During wetting or drying, the fill shall be regularly disced or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

F. The CONTRACTOR shall not place frozen fill, nor shall fill be placed on frozen ground.

G. If the fill freezes during construction, the CONTRACTOR shall remove the frozen fill, scarify the remaining unfrozen fill, and then place and compact new fill in accordance with these Specifications and any supplemental Specifications. The frozen fill shall not be reused until it has thawed, been disced, and then reworked to an acceptable uniform moisture content.

3.05 SURVEY CONTROL

A. The CONTRACTOR shall survey the location and elevation of the fill, access road, drainage ditches, and drainage swales.

B. The OWNER may supply surveying for quality assurance purposes and Record Drawings.

3.06 PROTECTION OF WORK

A. The CONTRACTOR shall use all means necessary to protect all materials and all partially-completed and completed work specified in this Section and prior work of other Sections.

B. At the end of each day, the CONTRACTOR shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled to protect finished work.

C. In the event of damage to prior work or work completed as specified in this Section, the CONTRACTOR shall submit a repair plan to the OWNER and CQA ENGINEER. The repair plan shall describe the areas requiring repair, and the CONTRACTOR shall make all repairs and replacements necessary to the approval of the OWNER and CQA ENGINEER and at no additional cost to the OWNER.

3.07 PUMPING AND DRAINAGE

A. At all times during construction, the CONTRACTOR shall provide and maintain proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory condition for progress of work.

B. Drainage shall be disposed of only in an area approved by the OWNER. Drainage shall be disposed of in a manner which prevents flow or seepage back into the excavated area.

[END OF SECTION]

SECTION 312333
TRENCHING AND BACKFILLING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, tools, supervision, transportation, and installation equipment to perform all trenching work as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.

B. The CONTRACTOR shall be prepared to construct all trenches in conjunction with the other aspects of the work.

C. The work of this section shall include, but not necessarily be limited to: trenching for leachate transmission piping and culverts, providing pipe bedding and backfill materials, placing pipes, backfilling around and over the pipes, and excavating and backfilling the geosynthetics anchor trench.

1.2 REFERENCES

A. Construction Quality Assurance (CQA) Plan.

B. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.
2. ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
3. ASTM D2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
4. ASTM D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
5. ASTM D2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
6. ASTM D3017, Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
7. ASTM D4254, Standard Test Method for Minimum Index Density and Unit Weight Soils and Calculation of Relative Density.

1.3 SUBMITTALS AND QUALIFICATIONS

A. The CONTRACTOR shall submit to the OWNER and CQA ENGINEER for review a letter describing the proposed methods of construction, including stripping, dewatering, excavation, filling, compaction, and backfilling for the various portions of the work. The review shall be for method only. The CONTRACTOR shall remain responsible for the adequacy and safety of the methods.

B. The CONTRACTOR shall submit to the CQA ENGINEER the following information and samples for all proposed fill materials a minimum of 14 days prior to starting construction, unless otherwise approved by the CQA ENGINEER:

1. The results of grain-size analyses conducted on the proposed material in accordance with ASTM D 422.
2. The results of liquid and plastic limit tests conducted on the proposed material in accordance with ASTM D 4318.
3. The results of a moisture-density relation test (ASTM D 698).

C. The CONTRACTOR shall notify the OWNER's Representative in writing at least 7 days in advance of intention to perform the work of this Section.

D. If work is interrupted for reasons other than inclement weather, the CONTRACTOR shall notify the OWNER and CQA ENGINEER a minimum of 24 hours prior to the resumption of work.

1.5 CONSTRUCTION QUALITY ASSURANCE

A. The CONTRACTOR shall be aware of the activities outlined in the CQA Plan and account for these CQA activities in the construction schedule.

1.6 PROTECTION

A. The CONTRACTOR shall contact utility companies and locate, mark and protect all existing utilities before commencement of construction.

B. The CONTRACTOR shall protect trees, shrubs, lawns, rock outcroppings and other features remaining as part of final landscaping.

C. The CONTRACTOR shall protect benchmarks, survey markers, fences, roads, sidewalks, paving, curbs and other existing structures from damage due to the CONTRACTOR's activities.

D. The CONTRACTOR shall repair damage caused by the construction operations.

E. Erosion control must be maintained. Erosion control measures shall be as noted on the grading plan or as directed by the OWNER.

PART 2 PRODUCTS

2.1 EXCAVATED MATERIALS

A. Material to be excavated shall include in-situ natural subgrade soils and embankment soils.

2.2 PIPE TRENCH CONSTRUCTION MATERIALS

A. Bedding Material: The Bedding Material shall meet the requirements of Table 312333-1

1. The gradations shown in Table 312333-1 are the maxima and minima for all sources and the gradation from any one source shall be reasonably uniform and not subject to the extreme limits in Table 312333-1.

B. Trench Backfill: fill material shall meet the requirements as defined in Section 313526.13. The material for trench backfill can be select backfill or other material approved by the OWNER and the CQA ENGINEER.

2.3 ANCHOR TRENCH CONSTRUCTION MATERIALS

A. Anchor trench shall be backfilled using structural fill meeting the requirements described in Section 313526.13 for structural fill placed within 1 feet of geosynthetics.

PART 3 EXECUTION

3.1 FAMILIARIZATION

A. Prior to implementing any work described in this Section, the CONTRACTOR shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section and the CQA Plan.

B. Inspection:

1. Prior to implementing any of the work in this Section, the CONTRACTOR shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may

properly commence without adverse impact.

2. If the CONTRACTOR has any concerns regarding the installed work of other Sections, he/she should immediately notify the OWNER in writing within 48 hours of the site visit. Failure to notify the OWNER or continuance with earthworks will be construed as CONTRACTOR's acceptance of the related work of all other Sections.

3.2 PREPARATION

A. The CONTRACTOR shall establish and identify required lines and levels.

B. The CONTRACTOR shall maintain benchmarks, monuments, and other reference points and re-establish if disturbed or destroyed, at no cost to OWNER.

C. Before start of grading, the CONTRACTOR shall establish the location and extent of utilities in the work areas. The CONTRACTOR shall notify utilities to remove and relocate lines which are in the way of construction and are not to be relocated as a part of the Work covered by these specifications.

D. The CONTRACTOR shall maintain, protect, reroute, or extend as required existing utilities to remain which pass through the work area.

E. The CONTRACTOR shall develop access to the construction area in accordance with the requirements of the Drawings.

F. The CONTRACTOR shall install silt fences as shown on the Drawings, immediately down-slope of each area to be disturbed prior to the beginning of work in that area. The CONTRACTOR shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the CONTRACTOR in a manner approved by the OWNER.

G. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Drawings. The CONTRACTOR shall be responsible for constructing diversion ditches as required to divert run-on around the construction area. The construction of temporary ditches not shown on the Drawings shall not be undertaken until the CONTRACTOR's plan for constructing the ditches is approved by the OWNER.

H. The CONTRACTOR shall install barriers and other devices to protect areas adjacent to construction.

3.3 STOCKPILING

A. Prior to the start of excavation, the CONTRACTOR shall prepare a written excavation plan. The plan shall indicate the areas and sequence of excavation, and the anticipated classification of the excavated material (e.g., topsoil, fill to be used as recompacted soil). This excavation plan must be reviewed and approved by the OWNER. The CONTRACTOR shall take into account that the stockpiling portion of the excavation plan may be modified during construction based on the results of conformance testing of the excavated material.

B. Excavated materials classified as fill shall be stockpiled in designated areas free of incompatible soil, clearing debris, or other objectionable materials. Stockpile areas will be shown on the Drawings or designated by the OWNER.

C. Excavated material classified as spoil shall be segregated from fill and stockpiled or disposed of in the manner shown on the Drawings or as specified by the OWNER.

D. Excavated material classified as topsoil shall be segregated from fill and stockpiled in the manner shown on the Drawings or as specified by the OWNER or CQA ENGINEER.

E. Stockpiles of fill, spoil, or topsoil shall be no steeper than 3:1 (horizontal:vertical) without approval of the OWNER, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the OWNER, and dressed daily during periods when fill is taken from the stockpile. The CONTRACTOR may cover fill stockpiles with plastic sheeting or other material approved by the OWNER in order to preserve the moisture content of the fill.

F. Stockpiles that will remain out of active use for a period greater than seven months shall either be covered as described previously or stabilized by revegetation in accordance with the requirements for revegetation.

3.4 EXCAVATION - GENERAL

A. Excavation shall be performed, at a minimum, to the lines and grades indicated on the Drawings. Additional excavation shall be performed to achieve a stable working base or to "bridge" over weak subgrade materials. The limits of additional excavation shall be determined by the OWNER.

B. Excavated materials shall be transported to stockpile or placement locations, as indicated on the Drawings or as directed by the OWNER.

3.5 EXCAVATION - PIPE TRENCHES

A. Excavation shall be performed in such a manner as to form a suitable trench in which to place the pipe and so as to cause the least inconvenience to the public.

B. Maximum width at the crown of the pipe shall be two (2) feet plus the nominal diameter of the pipe, unless approved specifically by the OWNER or OWNER's Authorized Representative due to unusual bracing and shoring requirements. The minimum width at the crown at the pipe shall be one (1) foot plus the nominal pipe diameter.

C. Trench depth shall be as noted on the Drawings.

D. The CONTRACTOR shall align trench as shown on the Drawings unless a change is necessary to miss an unforeseen obstruction or avoid tree root systems.

E. When unstable soil is encountered at the trench bottom, the CONTRACTOR shall remove it to a depth required to assure support of the pipeline and backfill to the proper grade with the pipe bedding material.

F. The CONTRACTOR shall remove rock encountered in trench excavation to a depth of 6 inches below the bottom of the pipe barrel, backfill with an approved material, and compact to uniformly support the pipe. In no case shall solid rock exist within six (6) inches of the finished pipeline.

3.6 SHEETING, SHORING, AND BRACING

A. When necessary, the CONTRACTOR shall furnish, put in place, and maintain such sheeting, bracing, etc., as may be required to support the sides of the excavation and to prevent movement.

B. Care shall be taken to prevent voids outside the sheeting.

C. If voids are formed, they shall be immediately filled and compacted.

D. Unless adjacent facilities will be damaged, the CONTRACTOR shall remove all sheeting, shoring, and bracing after backfill has been placed to a depth of 18 inches over the pipeline.

E. Shoring shall be cut off at the top of the pipe with the lower section left in the trench.

F. CONTRACTOR shall be responsible for performance and safety on all sheeting, shoring, and bracing.

3.7 OBSTRUCTIONS

A. Obstructions shown on the Drawings are for information only and do not guarantee their exact locations nor exclude the presence of other obstructions.

B. The CONTRACTOR shall exercise due care in excavating adjacent to existing obstructions and shall not disturb same.

C. In the event obstructions are disturbed, the CONTRACTOR shall repair or replace them as quickly as possible to the condition existing prior to their disturbance. This repair or replacement will not be a pay item.

D. If desired by the utility OWNER, the CONTRACTOR shall pay for the repair or replacement work performed by the forces of the utility OWNER or other appropriate party.

E. If replacement or repair of disturbed obstructions is not performed after a reasonable period of time, the OWNER may have the necessary work done and deduct the cost of same from payments to the CONTRACTOR.

3.8 CLEAN-UP AND DISPOSAL OF DEBRIS

A. The CONTRACTOR shall remove surplus materials and debris from site.

B. The CONTRACTOR shall satisfactorily dispose of all excess excavated material that cannot be used.

3.9 PUMPING AND DRAINAGE

A. At all times during construction, the CONTRACTOR shall provide, maintain and operate proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory subgrade to allow the construction of the recompacted soil.

B. Drainage shall be disposed of only in an area approved by the OWNER.

3.10 SURVEY CONTROL

A. The CONTRACTOR shall survey the location and elevation of the excavation. He shall also survey the location and elevation of the top of subgrade shown on the Drawings. Surveying shall be performed in general accordance with the CQA Plan.

B. The CONTRACTOR shall provide Record Drawings of the location and elevation of the excavation and the top of subgrade, in accordance with the requirements of the CQA Plan. The CONTRACTOR shall submit this drawing to the OWNER or OWNER's Authorized Representative at least 48 hours prior to the start of fill placement. The CONTRACTOR may submit a partial Record Drawing to obtain approval for a portion of work. The OWNER will define the minimum requirements for a partial submittal.

C. The OWNER may supply surveying for QA purposes and record drawings. The CONTRACTOR provides surveying for QC purposes.

3.11 PIPE BACKFILL

A. The CONTRACTOR shall deposit a 6 inch bedding layer of material meeting the requirements of this Section in the bottom of the trench.

B. Backfilling shall not begin before the OWNER or OWNER's Representative has inspected the grade and alignment of the pipe, the bedding of the pipe, and the joints between the pipes. If backfill material is placed over the pipe before an inspection is made, the CONTRACTOR shall reopen the trench in order for an inspection to be made.

C. The CONTRACTOR shall deposit pipe bedding gravel, together with hand tamping in loose lifts not exceeding 8 inches to an elevation of one-half the height of the pipe.

3.12 COMPACTION

A. Fill materials shall be compacted to a minimum density of 95 percent of the maximum dry density as determined by ASTM D 698.

3.13 FINISH GRADING

A. All earthwork shall be shaped to the lines and grades indicated on the Drawings, with proper allowance for topsoil, where specified. Slopes shall be free of roots and loose stones exceeding 3 inch diameter. Rounded surfaces shall be neatly and smoothly trimmed. All new grading shall be blended into the surrounding, existing terrain.

3.14 FIELD QUALITY CONTROL

A. The minimum frequency and details of quality assurance testing are provided in the CQA Plan. The CONTRACTOR shall be aware of all field quality assurance activities, as these may affect his schedule.

B. All perforations resulting from testing the recompacted soil shall be filled with soil compacted to the satisfaction of the OWNER.

C. If a defective area is discovered in the earthwork, the OWNER shall immediately determine the extent and nature of the defect. The OWNER shall determine the extent of the defective area by additional tests, observations, a review of records, or other means that the OWNER deems appropriate.

D. After determining the extent and nature of a defect, the CONTRACTOR shall correct the deficiency at his expense to the satisfaction of the OWNER.

E. Additional testing shall be performed to verify that the defect has been corrected before any additional work is performed by the CONTRACTOR in the area of the deficiency.

3.15 PRODUCT PROTECTION

A. The CONTRACTOR shall use all means necessary to protect all prior work, including all materials and completed work of other Sections.

B. In the event of damage, the CONTRACTOR shall immediately make all repairs and replacements necessary, to the approval of the OWNER at no additional cost to OWNER.

C. Small perforations in the recompacted soil resulting from the CQA ENGINEER's nuclear density testing shall be backfilled by the CQA ENGINEER. All other perforations of holes shall be backfilled and recompacted by the CONTRACTOR.

D. At the end of each day, the CONTRACTOR shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled to protect finished work.

TABLE 312333-1
REQUIREMENTS OF AGGREGATE FOR TRENCH BACKFILL

SIEVE SIZE	PERCENT PASSING
3 Inch	100
1 ½ Inch	100
1 Inch	100
½ Inch	100
No. 4	100
No. 10	100
No. 40	20-100
No. 60	15-85
No. 200	6-40

The material passing the No. 40 sieve shall meet the following Group C with the LL max of 30 and a PI max of 10.

[END OF SECTION]

SECTION 31 23 60
HIGH DENSITY POLYETHYLENE (HDPE) PIPE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Supplying, storage, fabricating, and installing solid-wall and perforated HDPE pipe as components of the LCRS, leachate monitoring system, and landfill gas collection system.

1.2 REFERENCES

A. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.

B. ASTM D696 – Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between –30 degrees C and 30 Degrees C With a Vitreous Silica Dilatometer.

C. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

D. ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable

E. ASTM D1505 - Standard Test Method for Density of Plastics by the Density- Gradient Technique.

F. ASTM D1525 - Standard Test Method for Vicat Softening Temperature of Plastics.

G. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics.

H. ASTM D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

I. ASTM D2240 - Standard Test Method for Rubber Property—Durometer Hardness.

J. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.

K. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.

L. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.

M. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

N. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

O. CQA Plan.

1.3 DEFINITIONS

A. Standard Dimension Ratio (SDR) is defined as the outside pipe diameter divided by the minimum wall thickness.

PART 2 PRODUCTS

2.1 HDPE PIPE

A. SDR 17 of the diameters as shown on drawings.

B. With holes drilled in accordance with dimensions shown on Drawings. Two- inch pipe may be slotted instead of perforated if open area of slots is equivalent to open area of holes. Maximum slot width = 1/8inch.

C. Use only shop fabricated fittings connections, and associated hardware shown on Drawings or described in these specifications, unless otherwise approved by Owner and Engineer.

D. Provide pipe conforming to the requirements of ASTM D3261 and ASTM F714 and the following properties listed in Table 31 23 60-1.

Table 312360-1
HDPE Pipe Specifications

Property	Test Procedures	Unit	Required Values
1. Material Designation	Plastic Pipe Inst/ASTM	—	PE 3408 PE 4710
2. Material Classification	ASTM D1248		III C 5 P34
3. Cell Classification	ASTM D3350	—	345464C 445574C
4. Density	ASTM D1505	gm/cm^3	>0.955
5. Melt Index	ASTM D1238	gm/10 min.	≤0.11
6. Flexural Modulus	ASTM D638	psi	min. 130,000
7. Tensile Strength	ASTM D638	psi	min. 3,200
8. Environmental Stress Crack	ASTM D1693		Fo >5,000 hrs
9. Hydrostatic Design Basis 73°F (23°C)	ASTM D2837	psi	min. 1,600
10. UV Stabilizer (Carbon Black Content)	ASTM D1603	%	2 – 3
11. Elastic Modulus	ASTM D638	psi	>105,000
12. Brittleness Temperature	ASTM D746	Fahrenheit	<-180
13. Vicat Softening Temperature	ASTM D1525	Fahrenheit	>254
14. Thermal Expansion	ASTM D696	in/in/degree F.	1.2×10^{-4}
15. Shore Hardness	ASTM D2240		≥64

E. Containing no recycled compound except that generated in the manufacturer's own plant and from resin of the same specification as the raw material supplier.

F. Resin for pipe and fittings listed by both N.S.F. and P.P.I. and manufactured in accordance with ASTM D-3035/F. 714-81.

G. Homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other injurious defects.

H. Being uniform in color, capacity, density, and other physical properties.

I. Provide the following information continuously marked on the pipe or spaced at intervals not exceeding 5 feet.

1. Name and/or trademark of the pipe manufacturer.

2. Nominal pipe size.

3. Standard Dimension Ratio (SDR).

4. PE 3408.

5. Manufacturers Standard Reference.

6. A production code from which the date and place of manufacturer can be determined.

PART 3 EXECUTION

3.1 STORAGE AND HANDLING

A Follow manufacturer's recommendations for pipe storage and handling.

B. Exercise care during unloading to prevent damage by abrasion and puncturing.

C Store pipe with support to prevent sagging, deformation, or development of permanent set in pipe.

3.2 PLACING AND LAYING PIPE

A Follow the manufacturer's recommendations when hauling, unloading, and stringing the pipe.

B. Do not push or pull pipe and fittings over sharp projections, or drop, or have objects dropped on the pipe.

C Inspect for defects before installation.

D. Remove any pipe showing kinks, buckles, cuts, gouges, or any other damage that in the opinion of the CQAC will affect performance of the pipe.

E. Replace material found to be defective before or after laying with sound material.

F. Carefully lower pipe and accessories into place by means of derrick, ropes, belt slings, or other equipment that will not cause any damage to the pipe.

G. Weld joints prior to placing the polyethylene pipe, except as noted.

H. Do not drop or dump material into the trench.

I. Rest the full length of each section of pipe solidly upon underlying material.

3.3 FUSION WELDING PIPE

A. Polyethylene Fusion Qualification: All pipe fusion must be performed by a supplier, or a factory supplied and/or certified fusion operator and certificate shall be submitted to CQAC and Engineer for inclusion into CQA Certification Report.

B. Only fully trained personnel will be allowed to perform the installation, supervision, or inspection of polyethylene-fusion joints.

C. Training: Provide training by manufacturer/supplier of the pipe materials in proper fusion procedures and techniques.

D. Join the polyethylene pipe by the method of thermal butt or side wall fusion, outlined in ASTM D3261.

E. Perform fusion joining of pipe and fittings in accordance with the procedures established by the pipe manufacturer. Of particular importance is the use of proper interface pressures and heater plate temperatures.

F. Use fusion pressures, temperatures, and cycle times according to pipe manufacturer's recommendations.

G. Do not perform pipe fusion in water or when conditions are unsuitable for the work.

H. Secure open ends of pipe and close valves when work is not in progress, so that no trench water, earth, or other substance will enter the pipe or fittings.

I. Plug or cap or valve pipe ends left for future connections.

J. Clear welding and grade sites, if necessary, to provide enough space for pipe storage and fusion.

K. Keep the site free of rocks, stumps, and debris that could cut, scar, or gouge the pipe.

L. In order to allow the joining operation to continue in adverse weather conditions, a shelter may be required for the joining machine.

M. Particular caution should be exercised to prevent water from entering the pipe and from coming in contact with the heater plate.

N. Clean pipe of all shavings and other debris.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Do not damage underlying geomembrane while completing the work of this Section.

* * * END OF SECTION * * *

SECTION 312420
HDPE GEOMEMBRANE

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope
1. This Section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of High Density Polyethylene (HDPE) geomembranes associated with the Work.
2. The geomembrane will be procured directly by the Owner from the Geosynthetics Manufacturer. The Contractor shall be responsible for unloading and storing the geomembrane as specified under this Section until the scheduled installation by the Geosynthetics Installer.
3. The Geosynthetics Installer shall provide all labor, materials, equipment, and services required to place and seam the geomembrane as shown on the Drawings or as described in the Specifications.

B. Related Sections
1. Section 312430 Geotextile.
2. Section 312450 Geosynthetic Clay Liners.
3. Section 312430 Geocomposite.
4. Section 312316 Excavation and Stockpiling.

1.2 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:
1. ASTM D792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement
2. ASTM D1004 - Test Method for Initial Tear Resistance of Plastic Film and Sheeting
3. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
4. ASTM D1505 - Standard Test Method for Density of Plastics by Density- Gradient Technique
5. ASTM D1603 - Test Method for Carbon Black in Olefin Plastics
6. ASTM D3895 – Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
7. ASTM D 4218 – Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

8. ASTM D4437 - Standard Test Method for Determining the Integrity of Field Seals Used in Joining Flexible Polymeric Sheet Geomembranes
9. ASTM D4833 - Test Method for Puncture Resistance of Geotextiles, Geomembranes, and Related Products
10. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
11. ASTM D5321 - Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
12. ASTM D5199 – Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
13. ASTM 5397 – Procedure to Perform a Single Point Notched Constant Tensile Load (SP_NCTL) Test: Appendix
14. ASTM D5596 – Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
15. ASTM D5641 – Standard Practice for Geomembrane Seam Examination by Vacuum Chamber
16. ASTM D5721 – Standard Practice for Air-Oven Again of Polyolefin Geomembranes
17. ASTM D5820 - Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
18. ASTM D5885 – Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Geomembranes
19. ASTM D5994 – Test Method for Measuring the Core Thickness of Textured Geomembranes
20. ASTM D6370 – Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
21. ASTM D6392 – Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
22. ASTM D6693 – Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Non-Reinforced Polypropylene Geomembranes
23. ASTM D7238 – Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
24. ASTM D7466 – Test Method for Measuring the Asperity Height of Textured Geomembranes

B. Geosynthetics Research Institute (GRI):
   1. GRI-GM10 – Specification for the Stress Crack Resistance of Geomembrane Sheet
   2. GRI-GM13 – Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

3. GRI-GM14 – Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples using the Method of Attributes

C. Latest Version of Site Construction Quality Assurance (CQA) Manual

1.3 PRE-QUALIFICATION

A. The Geosynthetics Installer shall pre-qualify for geosynthetic installation by providing the following qualification documentation:

1. The Geosynthetics Installer shall have a minimum of 10,000,000 square feet (sf) of HDPE cumulative geosynthetic installation experience.
2. The Geosynthetics Installer shall provide at least three references from prior installation projects in excess of 500,000 sf, including the following information:
   a. Client's name, address, phone number, and contact or representative's name
   b. Project Site and description
   c. Geosynthetic type(s) and quantity installed

1.4 SUBMITTALS

A. Production Data: The Geosynthetics Manufacturer shall furnish the following in writing to the Construction Quality Assurance Consultant a minimum of fourteen calendar days prior to geomembrane shipment to the Site:

1. Resin:
   a. Statement of production dates and origin of resin used to manufacture the geomembrane for the project.
   b. Certification stating all resin is from the same Manufacturer.
   c. Copies of the quality control certificates issued by the Manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets the minimum requirements of GRI Specification.

B. Quality Control: The Geosynthetics Manufacturer shall provide a copy of the Geosynthetics Manufacturer's Quality Control Program to the Construction Quality Assurance Consultant a minimum of seven calendar days prior to geomembrane shipment to the Site. Quality control testing shall be performed by the Geosynthetics Manufacturer in accordance with the test procedures, and frequency listed in the Quality Control Program and as approved by the Construction Quality Assurance Consultant. Prior to delivery, the following shall be submitted to the Construction Quality Assurance Consultant for review and approval:

1. General
    a. Certificates for each shift's production of geomembrane, and statements of production dates.
    b. Certification(s) stating all geomembrane rolls are furnished by one Manufacturer, and all rolls are manufactured from one resin type obtained from one resin supplier.
    c. List of materials that comprise the geomembrane, expressed in the following categories as percent by weight: base polymer, carbon black, and other additives.
    d. Copies of quality control certificates issued by the Manufacturer. The quality control certificates shall include:
        i. Roll numbers and identification;
        ii. Sampling procedures; and
        iii. Results of quality control tests, including descriptions of the test methods used.
    e. Results of the quality control tests verifying each of the following properties
        - Density (ASTM D1505/D792)
        - Carbon black content (ASTM D4218)
        - Carbon black dispersion (ASTM D5596)
        - Thickness (ASTM D5199-smooth/ASTM D5994-textured)
        - Tensile properties (ASTM D638/D6693)
    f. Geomembrane delivery, storage, handling and installation instructions.
2. Extrudate Beads and/or Welding Rod:
    a. Statement of production dates.
    b. Certification stating all extrudate is from one Manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.
    c. Copies of quality control certificates issued by the Manufacturer.

C. Prior to mobilization of the Geosynthetics Installer to the Site, the Geosynthetics Installer shall submit the following:
1. Shop drawings indicating panel layout and field seams 14 calendar days prior to installation of geomembrane. Each panel shall be assigned an identification number.
2. Installation schedule.
3. Copy of Geosynthetics Installer letter of approval or license by the Geosynthetics Manufacturer.
4. Installation capabilities, including:
    a. Information on equipment proposed for this project;
    b. Average daily production anticipated for this project; and

c. Quality control procedures.

5. Résumé of the Superintendent and Quality Control Inspector for GEOSYNTHETIC INSTALLER to be assigned to this Project, including dates and duration of employment. Substitution of these key personnel, without prior notification and approval by Construction Quality Assurance Consultant will be sufficient grounds for removal of Geosynthetics Installer from the Project.
6. Résumés of all Geosynthetics Installer personnel who will perform seaming operations on this project, including dates and duration of employment.

D. The installation crew shall have the following experience.

1. The Superintendent shall have supervised the installation of a minimum of 10,000,000 sf of polyethylene geomembrane.
2. The master seamer shall have experience seaming a minimum of 1,000,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at the Site.
3. All other seaming personnel shall have seamed at least 100,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at the Site. Personnel who have seamed less than 100,000 sf of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

E. During the installation, the Geosynthetics Installer shall be responsible for the timely submission to the Construction Quality Assurance Consultant of subgrade acceptance certificates, signed by the Geosynthetics Installer and Contractor, for each area to be covered by geosynthetic clay liner and geomembrane.

F. The Geosynthetics Manufacturer or Geosynthetics Installer shall furnish the Owner upon completion of the project:

1. A 20-year written warranty provided by the Geosynthetics Manufacturer against defects in material. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.
2. A 1-year warranty provided by the Geosynthetics Installer against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.
3. Geosynthetics Installer shall submit As-built Panel Drawings for the secondary and primary geomembrane layers.

G. Immediately upon Notice of Award, Geosynthetics Manufacturer shall make available to the Construction Quality Assurance Consultant samples of the 60-mil double-sided textured and smooth HDPE geomembrane, for conformance testing.

1.5 QUALITY ASSURANCE

A. Geosynthetics Installer shall ensure that all personnel performing geomembrane seaming operations are qualified by experience specified in previous subpart of this Section.

B. Geomembrane sampling shall be conducted by Geosynthetics Installer in accordance with this Section for the following:

   1. Conformance Testing
   2. Destructive Seam Testing

C. Geosynthetics Installer shall attend a pre-installation conference. Attendance of parties directly affecting the Work of this Section will be mandatory.

1.6 DELIVERY, STORAGE AND HANDLING

A. Contractor and Geosynthetics Installer shall conform to the Manufacturer's requirements and the pertinent sections of ASTM D4873 for storage and handling to prevent damage to geomembrane.

B. Transportation of the HDPE geomembrane by the Geosynthetics Manufacturer shall be through an independent trucking firm and shall be shipped via a closed or flatbed trailer.

C. Delivery:

   1. Geosynthetics Manufacturer shall deliver materials to the Site only after conformance testing of the material has been conducted and the Construction Quality Assurance Consultant approves the required submittals.
   2. All rolls of geomembrane delivered to the Site shall be identified by the Geosynthetics Manufacturer at the factory with the following:
      a. Manufacturer’s name
      b. Product identification
      c. Lot number
      d. Roll number
      e. Roll dimensions
   3. Construction Quality Assurance Consultant and Contractor shall be present when HDPE geomembrane is delivered to the Site. Geosynthetics Manufacturer shall notify Construction Quality Assurance Consultant a minimum of 2 business days prior to delivery.
   4. Contractor is responsible for separating damaged rolls from undamaged rolls and storing at suitable locations until proper disposition of material is determined by the Owner and the Construction Quality Assurance Consultant.
   5. The Owner will be the final authority regarding damage. Any rolls that are determined to be damaged shall be replaced by the Geosynthetics Manufacturer at no cost to the Owner.

6. Contractor shall separate rolls without proper documentation and store until Construction Quality Assurance Consultant approval is received. Rolls or pallets without proper identification by Geosynthetics Manufacturer shall be subject to rejection and shall be replaced by the Geosynthetics Manufacturer at no cost to the Owner.

D. On-site Offloading and Storage of the material:

1. Offloading, storage, and protection of the material is the responsibility of the Contractor until installation by the Geosynthetics Installer.
2. Contractor shall store material in space allocated by the Owner.
3. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.
4. Store on level, prepared surface (not on wooden pallets).
5. Stack per Geosynthetics Manufacturer's recommendation but no more than three rolls high.

E. On-site Handling:

1. Geosynthetics Installer shall use appropriate handling equipment to load, move, or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Dragging panels on ground surface will not be permitted.
2. Geosynthetics Installer shall not fold geomembrane material; folded material shall be rejected.
3. The Contractor is responsible for storage of material until installation by the Geosynthetic Installer.

F. Damaged Geomembrane:

1. Geomembrane damage will be documented by the Construction Quality Assurance Consultant.
2. Geomembrane found damaged upon arrival at the Site shall be replaced by the Geosynthetics Manufacturer at no additional cost to the Owner.

PART 2: PRODUCTS

2.1 MATERIALS

A. The geomembrane shall be comprised of high-density polyethylene (HDPE) material, with a formulated sheet density of 0.940 g/mL or higher, as indicated on the Drawings. The geomembrane shall be manufactured of new, first-quality products, with no more than 10 percent by weight of recycled materials, designed and manufactured specifically for the purpose of landfill leachate containment. If recycled or reworked material is used, it shall be a similar HDPE (formulation and density) as the new product. No post-consumer resin (PCR) of any type shall be added to the formulation. Additives, filler, or extenders shall be limited to one percent, by weight, not including carbon black.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in this Section. The Construction Quality Assurance Consultant reserves the right to reject any material that would potentially compromise the long-term performance of the geomembrane.

C. The geomembrane shall be manufactured with a minimum seamless width of 15 feet. There shall be no factory seams.

D. The primary geomembrane liner shall be HDPE 60-mil textured, double-sided, or smooth per the Drawings.

E. The geomembrane shall be supplied in rolls; folds will not be permitted.

F. Specifications for HDPE geomembrane properties are presented in Table 310540-1 (textured) below. Supplied material shall conform to these properties based upon the Geosynthetics Manufacturer's QC testing and CQA conformance testing.

TABLE 312420-1
HDPE TEXTURED GEOMEMBRANE PROPERTIES

PROPERTY	QUALIFIER	UNITS	SPECIFICATION	MINIMUM MANUFACTURER QC TEST FREQUENCY	ASTM TEST METHOD
Thickness (min. avg.) 1. Lowest individual for 8 of 10 values 2. Lowest individual for any 2 of 10 values	Nom. Min. Min.	mils	60 (-5%) -10% -15%	Based on Manufacturer's Quality Control Procedure	D5994
Sheet Density	Min.	g/cc	0.940		D792 or D1505
Tensile Properties 1. Yield Strength 2. Break Strength 3. Yield Elongation 4. Break Elongation	Min. Avg.	lb/in lb/in % %	126 90 12 100		D6693, Or D638
Tear Resistance	Min. Avg.	lb	42		D1004
Puncture Resistance	Min. Avg.	lb	90		D4833
Low Temperature	Max.	Deg. C	-60		D746
Stress Crack Resistance	Note 3	hours	200		D5397 (Appendix)
Carbon Black Content	Range	%	2-3		D1603
Carbon Black Dispersion	Rating	Cat.	A-1, A-2, or B-1		D5596

Table Notes:
[1]Property values listed in this table correspond with the current version of GRI (Geosynthetic Research Institute) GM-13

G. Resin:

1. Shall be comprised of high-density polyethylene (HDPE) material, with a formulated sheet density of 0.940 g/mL or higher, as indicated on the Drawings. The geomembrane shall be manufactured of new, first-quality products, with no more than 10 percent by weight of recycled materials. If recycled or reworked material is used, it shall be a similar HDPE (formulation and density) as the new product. No post-consumer resin (PCR) of any type shall be added to the formulation.
2. Do not intermix resin types.

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Shall be free of contamination by moisture or foreign matter.

2.2 EQUIPMENT

A. Welding equipment and accessories of Geosynthetics Installer shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welder) or at wedge (fusion welder).
2. Maintain adequate number of welding apparatus to avoid delaying work.
3. Use power source capable of providing constant voltage under combined- line load.
4. Provide secondary containment to catch spilled fuel under electric generator, if located on geomembrane.

B. Geosynthetics Installer shall provide two (2) calibrated tensiometers (one for backup) capable of quantitatively measuring geomembrane strength:

1. Equipped with gauge accurate to +2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.
2. Provide one inch die for cutting sample specimens.
3. Provide certificate of tensiometer calibration within the past 12-months.
4. Construction Quality Assurance Consultant shall be allowed to utilize tensiometers to conduct testing.

PART 3: EXECUTION

3.1 EXAMINATION

A. Geosynthetics Installer shall verify in writing that the surface on which the geomembrane will be installed is acceptable. In so doing, the Geosynthetics Installer shall assume full liability for the accepted surface.

B. The Geosynthetics Installer shall be responsible for maintenance of the underlying geosynthetics once installation of geomembrane begins.

3.2 PREPARATION

A. Geosynthetics Installer shall maintain the subgrade surface suitability and integrity until the lining installation is completed and accepted.

B. Geosynthetics Installer shall repair rough areas and any damage to the subgrade (below the geosynthetic clay liner, geocomposite, or any other combination of geosynthetics) caused by installation of the lining and fill any ruts in subgrade caused by equipment prior to geosynthetic clay liner and geomembrane deployment.

3.3 DEPLOYMENT

A. Geomembrane shall not be deployed by Geosynthetics Installer under the following conditions. The QUALITY ASSURANCE CONSULTANT shall determine whether any of these conditions are present that would prevent the deployment of the geomembrane:

1. During precipitation;
2. In the presence of excessive moisture;
3. In areas of ponded water;
4. In the presence of excessive winds; and
5. In excessive heat or cold.

B. Each panel shall be marked with an "identification code" (number or letter) by the Geosynthetics Installer consistent with the layout plan. The identification code shall be simple and logical.

C. The number of panels deployed in one day shall be limited by the number of panels that can be seamed on the same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

D. The following is the acceptable method of deployment by Geosynthetics Installer:

1. Use equipment that will not damage geomembrane or underlying geosynthetics by handling, trafficking, leakage of hydrocarbons or other means.
2. Do not allow personnel working on geomembrane to wear damaging shoes, or engage in activities that could damage geomembrane.
3. Smoking on the liner is prohibited.
4. Round sharp corners of clamps and other metal tools used in the Work area.
5. Do not allow clamps and other metal tools to be tossed or thrown.

6. Unroll panels with a method that protects geomembrane from scratches and crimps and protects soil surface and underlying geosynthetics from damage.
7. Do not drag textured geomembrane across underlying geosynthetics or subgrade. Use a smooth rubsheet or other method as necessary.
8. Use a method to minimize wrinkles, especially differential wrinkles between adjacent panels.
9. Place adequate hold-downs to prevent uplift by wind.
10. Use hold-downs that will not damage geomembrane, such as sandbags.
11. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.
12. Panels shall be deployed perpendicular to slope elevation contours and the generation of seams shall be minimized.
13. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane or other suitable materials.
14. Do not allow vehicular traffic including ATVs on geomembrane, geosynthetic clay liner, or other geosynthetic surfaces.

E. Geosynthetics Installer shall visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for replacement, repair, or test. Faulty (requires more than one patch per 200 square feet) geomembrane stock shall be replaced at no additional cost to the Owner.

F. Geosynthetics Installer shall deploy geomembrane in ambient temperatures less than 104° F (40° C) and greater than 32° F (0° C), measured 6 inches above geomembrane surface. In prevailing warm or cold weather conditions deployment may be acceptable if the provisions for sampling in such conditions is satisfied (see Part 3.4 of this Section). The geomembrane shall not be deployed during precipitation, in the presence of excessive moisture, in areas of ponded water, or in the presence of excessive winds.

G. Geosynthetics Installer shall deploy HDPE in a relaxed manner and free of tension and stress. In areas where grade transitions occur, the geomembrane shall not be allowed to bridge or trampoline.

H. Geosynthetics Installer shall be responsible for anchoring and maintaining installed geomembrane and other geosynthetics until the protective soil layer is installed by the Contractor.

3.4 FIELD SEAMING BY GEOSYNTHETICS INSTALLER

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope.

B. Use seam numbering system compatible with panel number system.

C. Minimize the number of field seams in corners, odd-shaped geometric locations and outside corners.

D. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to seam weld material for extrusion welding.

E. Do not use solvent or adhesive unless product is approved in writing by the Construction Quality Assurance Consultant.

F. No horizontal seams shall be allowed within 10 feet of the crest or toe of slopes.

G. Clean surface to be welded of grease, moisture, dust, dirt, debris or other foreign material.

H. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

   1. Clean surface of oxidation by disc grinder or equivalent not more than one hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of overlying geomembrane before bonding and provide continuous tacking in repair areas.
   2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extents of weld. Exposed grinding marks adjacent to an extrusion weld shall be minimized. In no instance shall exposed grinding marks extend more than ¼ in (6 mm) from the finished seamed area.
   3. Clean grinding dust around weld area after grinding.
   4. The following procedure shall be followed for wrinkles and fish-mouths.
      a. Cut along the ridge of the wrinkle or fish-mouth.
      b. Overlap a minimum of 3 inches and seam.
      c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.
   5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.
   6. Keep water from intercepting the weld during and immediately after welding the seam.
   7. For existing welds, or welds that are over 10 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.
   8. No solvent or adhesive shall be used.

I. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining. Use an electric generator capable of providing constant voltage under combined line load. The electric generator shall be located outside of liner unless otherwise approved by Construction Quality Assurance Consultant. If approved by Construction Quality Assurance Consultant to operate on the liner, Geosynthetics Installer shall provide protective lining and secondary containment large enough to catch spilled fuel under electric generators approved to operate on the liner.

J. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding, if extruder is stopped for longer than five minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or mis-aligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding. Remove extrudate rod from welder when not using welder for long periods (over two hours). No welding may commence on the liner until the field trial seam sample, made by that same piece of equipment and seamer, passes destructive testing.

K. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment and seamer has passed destructive testing.

L. In performing hot wedge welding, the welding apparatus shall be automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to a smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field test seams at least every two hours, otherwise once prior to start of work and once at mid-day. No equipment is allowed to commence welding on geomembrane until the field trial seam sample made by that piece of equipment has passed destructive testing.

M. Field trial seams shall be conducted, per seaming apparatus and per seamer, on pieces of geomembrane liner to verify adequate seaming conditions at the following frequency:

1. At beginning of each seaming period.
2. At least once every five hours.
3. At the discretion of the Construction Quality Assurance Consultant

N. Make the trial seams at area of seaming and in contact with geosynthetic clay liner or other underlying geosynthetic material (same condition as the liner to be seamed). The seam sample shall be at least 5 ft long and 12 inches wide with the seam centered lengthwise. A one-foot length of each trial seam sample shall be submitted to the Construction Quality Assurance Consultant for archives. Cut three 1-inch wide specimens and test two for peel adhesion, and one for bonded seam strength (shear). Each double-wedge fusion seam specimens shall be tested for peel on both sides of the weld. Construction Quality Assurance Consultant shall have access to use Geosynthetics Installer tensiometer. A specimen passes when:

1. The break is film tearing bond (FTB) conforming to the values shown in Table 310540-4.
2. The break is ductile.
3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 310540-2.

TABLE 312440-2
HDPE GEOMEMBRANE SEAM PROPERTIES

Property	Unit	Method	Value
Thickness	mils		60
Hot Wedge Seam			
Shear Strength	lb/in	ASTM D4437/D6392	120
Shear Elongation at Break	%	ASTM D4437/D6392	50
Peel Strength	lb/in	ASTM D4437/D6392	91
Peel Separation	%	ASTM D4437/D6392	25
Extrusion Fillet Seams			
Shear Strength	lb/in	ASTM D4437/D6392	120
Shear Elongation at Break	%	ASTM D4437/D6392	50
Peel Strength	lb/in	ASTM D4437/D6392	78
Peel Separation	%	ASTM D4437/D6392	25

O. A trial seam sample passes when all specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

P. The following procedures shall be followed during cold weather conditions (ambient temperature is below 32°F (0°C):

1. Geomembrane surface temperatures shall be determined by the Construction Quality Assurance Consultant at intervals of at least once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32^{o} F (0^{o} C).
2. For fusion welding, preheating may be waived by the Construction Quality Assurance Consultant if the Geosynthetics Installer demonstrates to the

Construction Quality Assurance Consultant's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the Construction Quality Assurance Consultant will observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.
4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.
5. All preheating devices shall receive approval by the Construction Quality Assurance Consultant prior to use.
6. Additional destructive tests will be taken at an interval between 250 and 500 feet of seam length, at the discretion of the Construction Quality Assurance Consultant.
7. Sheet grinding may be performed before preheating, if applicable.
8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10^{o} F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

Q. The following procedures shall be followed during warm weather conditions:

1. At ambient temperatures above 104^{o} F (40^{o} C), no seaming of the geomembrane shall be permitted unless the Geosynthetics Installer can demonstrate to the satisfaction of the Construction Quality Assurance Consultant that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient temperature conditions as the production seams. At the option of the Construction Quality Assurance Consultant, additional destructive testing or trial seaming may be required for any suspected areas.

3.5 FIELD QUALITY CONTROL BY GEOSYNTHETICS INSTALLER

A. The Geosynthetics Installer shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the Construction Quality Assurance Consultant. All documentation will be completed on a daily basis by the Geosynthetics Installer in a neat orderly manner, checked for computations and errors prior to turnover, along with a daily QC summary report.

B. The Construction Quality Assurance Consultant shall:

1. Observe non-destructive testing procedures
2. Record location, data, test unit number, name of tester, and outcome of all testing.
3. Inform the Installer and Project Manager of any required repairs.

C. Non-Destructive Seam Testing by Geosynthetics Installer

1. The Geosynthetics Installer shall non-destructively test field welds for continuity over their full length using vacuum test units or air pressure testing. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall be repaired in accordance with Part 3.6 of this Section. The following non-destructive testing procedures shall be used to test the field seams for continuity.
   a. Vacuum box testing for extrusion welds.
   b. Air pressure testing for double-fusion seams.
2. Vacuum Box Testing
   a. The vacuum box testing equipment shall comprise the following.
      i. Rigid housing; transparent viewing window; a soft rubber gasket attached to bottom of housing; porthole or valve assembly; and a vacuum gauge.
      ii. A vacuum pump capable of applying 3 psi gauge pressure of vacuum to the box.
      iii. A bucket of soapy solution and applicator.
   b. The procedure for vacuum testing is as follows:
      i. Clean window, gasket surfaces, and check for leaks.
      ii. Energize vacuum pump and reduce tank pressure to approximately 3 psi.
      iii. Wet a strip of geomembrane approximately 12 inches by 48 inches (length of box) with soapy solution.
      iv. Place box over wetted area and compress.
      v. Close bleed valve and open vacuum valve.
      vi. Ensure that a leak tight seal is created.
      vii. Examine length of weld through viewing window for presence of soap bubbles for a period of not less than 10 seconds,
      viii. If no bubbles appear after 10 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three inches overlap and repeat process.
      ix. Areas where soap bubbles appear will be marked by the Construction Quality Assurance Consultant with a defect code. The Installer shall then repair the area in accordance with Part 3.6 of this Section and retest the repaired area.
3. Air Pressure Testing (Double-Fusion Seams Only)

a. The air pressure testing equipment shall comprise the following.

i. An air pump, equipped with pressure gauge with an accuracy of 1 psi, capable of generating and sustaining a pressure between 27 to 37 psi and mounted on a cushion to protect geomembrane.

ii. Rubber hose with fittings and connections.

iii. Sharp hollow needle or other pressure feed device approved by the Construction Quality Assurance Consultant.

b. To perform the test:

i. Seal both ends of the seam to be tested.

ii. Insert a needle or other approved pressure feed device into tunnel created by double hot wedge seaming and insert a protective cushion between air pump and geomembrane.

iii. Energize air pump to 27 to 37 psi, close valve, allow 2 minutes for pressure to stabilize, and sustain pressure for a minimum of five (5) minutes.

iv. If loss of pressure exceeds 3 psi or does not stabilize, locate faulty area and repair in accordance with Part 3.6 of this Section.

v. Release pressure at opposite end of seam from gauge to verify that the seam is not blocked.

vi. Remove approved pressure feed device and seal penetration holes by extrusion welding.

D. Destructive Seam Testing

1. For destructive seam testing, the Construction Quality Assurance Consultant shall be provided with a minimum of one sample per 500 feet of seam length for each welding machine. The location will be selected by the Construction Quality Assurance Consultant and the Geosynthetics Installer will not be informed of the sample location in advance. The Geosynthetics Installer shall visually observe, mark and repair suspect welds before release of a section to the Construction Quality Assurance Consultant for destructive sample marking. Cut destructive samples as seaming and nondestructive testing progresses, prior to completion of liner installation. The Construction Quality Assurance Consultant will mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Construction Quality Assurance Consultant I.D., and apparatus settings and date. Record, in written form: weld and test date, time, location, seam number, ambient temperatures, machine settings, apparatus I.D., technician, and pass or fail description. The Geosynthetics Installer shall immediately repair holes in geomembrane resulting from obtaining destructive samples and vacuum test patches. The size of destructive samples shall be 12 inches wide by 48 inches long with seam centered lengthwise.

2. Two 1-inch-wide specimens shall be taken from each side of the sample and tested by the Geosynthetics Installer for peel and shear in the field prior to CQA destructive testing. If any of these specimens fail, the Geosynthetics Installer shall track the failure immediately. The remaining sample shall be cut into three 14-inch long pieces and distributed as follows:
   a. To the Construction Quality Assurance Consultant for destructive testing.
   b. To the Construction Quality Assurance Consultant for archive.
   c. To the Geosynthetics Installer for his/her use.
3. The Geosynthetics Installer shall cut ten 1-inch-wide specimens from one piece. Five specimens shall be tested for peel and five for shear strengths in accordance with the CQA Plan, with test results meeting the requirements of Table 310540-4. Construction Quality Assurance Consultant shall have access to use either of the Geosynthetics Installer tensiometers. In the event of failure, the procedures for failed seam tracking are:
   a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Geosynthetics Installer is confident of seam quality.
   b. Obtain destructive samples from each side of the welding path and distribute, as described above, to the Construction Quality Assurance Consultant for destructive testing.
   c. Repeat process if additional tests fail.
   d. Reconstruct seam between passing test locations to satisfaction of the Construction Quality Assurance Consultant.
   e. Reconstruction may be one of the following:
      i. Cut out old seam, reposition panel and re-seam.
      ii. Add cap strip.
   f. Cut additional destructive samples from reconstruction at discretion of Construction Quality Assurance Consultant.
   g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the Construction Quality Assurance Consultant.

E. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection. The Construction Quality Assurance Consultant will decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. The Construction Quality Assurance Consultant will distinctively mark repair areas and indicate required type of repair.

3.6 REPAIR PROCEDURES FOR GEOSYNTHETICS INSTALLER

A. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Geosynthetics Installer if surface contamination inhibits inspection. The Geosynthetics Installer shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal, and replacement shall be at the Geosynthetics Installer's expense if the damage results from the Geosynthetics Installer's activities.

D. "Fishmouths" shall be slit, laid flat, and seamed with a minimum overlap of 3 inches. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

E. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Geosynthetics Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the Construction Quality Assurance Consultant and the Geosynthetics Installer. Procedures available include:

   1. Patching: Used to repair holes (over 1/4-inch diameter), tears (over 1/4 inch long), undispersed raw materials, and contamination by foreign matter.
   2. Grinding and welding: Used to repair pinholes, blemishes and over-grinding.
   3. Capping: Used to repair large lengths of failed seams.
   4. Removing the seam and replacing with a strip of new material.

F. In addition, the following procedures shall be followed:

   1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.
   2. All geomembrane surfaces shall be clean and dry at the time of repair.
   3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the Construction Quality Assurance Consultant.
   4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., patch or cap shall be a minimum of 12 inches in diameter, and round all corners of material to be patched.
   5. Bevel the edge of the patch; do not cut patch with repair sheet in contact with geomembrane. Temporarily bond the patch to the geomembrane with an approved method, extrusion weld the patch, and then vacuum test the repair.

6. All panel intersections (T-seams) shall be repaired with a patch.

G. Repair Verification:

1. Number and log each patch repair (performed by the Construction Quality Assurance Consultant).
2. Non-destructively test each repair using methods specified in this Section.
3. Provide daily documentation of non-destructive and destructive testing to the Construction Quality Assurance Consultant. The documentation shall identify seams that initially failed the test and include the evidence that these seams were repaired and retested successfully.

3.7 ACCEPTANCE

A. The Geosynthetics Installer shall retain ownership and responsibility for the geomembrane until acceptance by the Owner and covering of the geomembrane or final geosynthetic layer by the Contractor.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs and testing by the Construction Quality Assurance Consultant.
2. All submittals approved.
3. As-built drawings submitted and approved.
4. Construction area cleaned.
5. Final field inspection performed with satisfactory results.
6. Warranty signed over to the Owner.

C. Field Inspections: Inspect the completed Work with the Construction Quality Assurance Consultant; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct and arrange further field inspections until no corrective action is necessary.

3.8 CONFORMANCE TESTING

A. Material will be made available to the Construction Quality Assurance Consultant by the Geosynthetics Manufacturer upon notice to proceed for conformance sampling and testing at a minimum frequency of one per 100,000 square feet of material continuously produced and supplied to the project, with a minimum of one sample per production lot. Materials may be sampled at the plant at the option of the Owner.

B. As a minimum, the following tests will be performed by a geosynthetics CQA laboratory and shall meet the requirements outlined in Tables 310540-1.

1. Thickness (ASTM D5994)
2. Specific Gravity (ASTM D792 or ASTM D1505)
3. Carbon Black Content (ASTM D4218)

4. Carbon Black Dispersion (ASTM D5596)
5. Tensile Properties (ASTM 638/D6693
6. Puncture Resistance (ASTM D4833)
7. Asperity Height (ASTM D7466)

C. If a test result is in non-conformance with the Specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the non-conformance material with additional passing tests conducted by the geosynthetics CQA laboratory. Additional tests shall be conducted by the Geosynthetics Manufacturer at no additional cost to the Owner.

D. Rejected material shall be replaced at no additional cost to Owner.

3.9 ANCHOR TRENCH

A. The Contractor shall excavate the anchor trenches to the lines, grades, and width shown in the Drawings, prior to any geosynthetic material placement. Construction Quality Assurance Consultant will verify that the anchor trench has been constructed according to the Drawings.

B. The anchor trench shall be backfilled and compacted by Contractor as approved by the Construction Quality Assurance Consultant. Trench backfill material shall be placed in 9- to 12-inch-thick loose lifts and compacted by wheel rolling with light, rubber-tired or other light compaction equipment, as approved by Construction Quality Assurance Consultant.

C. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic materials. At no time shall construction equipment come into direct contact with the geosynthetic materials. If damage occurs, it shall be repaired by the Geosynthetics Installer prior to the completion of backfilling, at no cost to Owner.

D. Geosynthetics Installer shall extend geosynthetic materials into the anchor trench as shown in the Drawings. The geosynthetic materials shall be seamed, bonded, or attached along the entire distance of the anchor trench, using approved methods described in this Section.

3.10 PLACEMENT OF SOIL OR GRANULAR MATERIALS

A. All soil materials located on top of a geomembrane shall be placed by the Contractor in such a manner as to ensure:
1. The geomembrane and any underlying geosynthetic material is not damaged.
2. Minimal slippage of the geomembrane on underlying layers occurs.
3. Minimal movement and wrinkling or folding of the underlying geosynthetic layer(s) occurs.

4. No excess tensile stresses shall occur in the geomembrane, such as by earth moving equipment making sudden starts, stops, or turns. The allowable ground pressure for equipment shall be prescribed by Construction Quality Assurance Consultant for the material type and layer thickness.

END OF SECTION

SECTION 312430
GEOCOMPOSITE

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope

1. This section describes the requirements for the manufacture, supply, installation, and quality control of the geocomposite associated with the Work.
2. The geocomposite will be procured directly by the Owner from the Geosynthetics Manufacturer. The Contractor shall be responsible for unloading and storing the geocomposite as specified under this Section until the scheduled installation by the Geosynthetics Installer.
3. The Geosynthetics Installer shall provide all labor, materials, equipment, and services required to place the geocomposite as shown on the Drawings or as described in the Specifications.

B RELATED SECTIONS

1. Section 312440 Geotextile.
2. Section 312420 HDPE Geomembrane.
3. Section 312450 Geosynthetic Clay Liner (GCL).
4. Section 312316 Excavation and Stockpiling.

1.2 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Gravity) of Plastics by Displacement
2. ASTM D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique
3. ASTM D1603 – Standard Test Method for Carbon Black in Olefin Plastics
4. ASTM D4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
5. ASTM D4354 – Practice for Sampling of Geosynthetics for Testing
6. ASTM D4491 – Standard Test Method for Water Permeability of Geotextiles by Permittivity
7. ASTM D4716 – Standard Test Method for Constant Head Hydraulic Transmissivity of Geotextiles and Geotextile Related Products
8. ASTM D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile

9. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
10. ASTM D5035 – Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
11. ASTM D5199 – Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
12. ASTM D5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles
13. ASTM D5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic Friction by the Direct Shear Method
14. ASTM D7005 – Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites
15. ASTM D7179 – Standard Test Method for Determining Geonet Breaking Force

B. Latest Version of Site Construction Quality Assurance (CQA) Manual

1.3 SUBMITTALS

A. Geosynthetics Manufacturer shall submit to the Construction Quality Assurance Consultant the following information relating to the geocomposite a minimum of fourteen (14) days prior to shipping the material for review and approval by the Construction Quality Assurance Consultant. No material will be shipped to the Project Site without approval by the Construction Quality Assurance Consultant.

1. Quality control certificates issued by the raw material supplier(s), including the production dates of the raw material used to manufacture the geocomposite.
2. A copy of the Manufacturer’s Quality Control Program.
3. Quality control certificates for test results at the sampling frequencies indicated by the Manufacturer’s QC Plan.
   a. Manufacturing quality control certificates shall be signed by responsible parties employed by the Manufacturer (such as the production manager).
   b. The quality control certificates shall include:
      i. Roll numbers and identification;
      ii. Sampling procedures; and
      iii. Results of the quality control tests verifying each of the following properties
         - . Mass per unit area (ASTM D5261)
         - Thickness (ASTM D5199)
         - Geotextile-geonet adhesion (ASTMD7005)
         - Transmissivity (ASTM D4716)
4. Quality Control Submittals:

a. Quality control (QC) certificates containing the Manufacturer's QC testing results. QC certificates shall be submitted at a the frequency indicated in the Manufacturer's QC Plan for geocomposite continuously produced and supplied to the project and at least one per lot.

b. Manufacturer's certification that products meet or exceed specified requirements.

5. Product warranty

B. Immediately upon Notice of Award:

1. The Geosynthetics Manufacturer shall make available samples of the geocomposite to the Construction Quality Assurance Consultant for interface shear testing. The samples will be tested to simulate the interface between the Project-specified geomembrane and geocomposite

2. The Geosynthetics Installer shall provide shop drawings indicating panel layout and field seams 14 calendar days prior to installation of the geocomposite. Each panel shall be assigned an identification number.

C. Upon completion of the Work, the Geosynthetics Installer shall:

1. Provide an as-built panel layout drawing, with assigned identification numbers.

2. Provide warranty of Work and certification that the Work was performed in accordance with the Specifications. The warranty shall be the Manufacturer's standard written warranty against defects in material, but in no case shall be for less than 5 years. A 1-year warranty shall be provided by the Geosynthetics Installer against defects in installation and workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.4 QUALITY ASSURANCE

A. All Work shall be constructed, monitored, and tested in accordance with the CQA Manual. The Contractor, Geosynthetics Installer and Geosynthetics Manufacturer shall participate and comply with all items in the CQA Manual.

B. Construction Quality Assurance Consultant shall verify that the Geosynthetics Manufacturer has an internal product quality control (QC) program that meets the requirements of this Section.

C. Geosynthetics Installer and Contractor shall be aware of all activities described in the CQA Manual. Geosynthetics Installer and Contractor shall account for these activities in the construction schedule.

D. Geosynthetics Manufacturer shall ensure that the geocomposite is delivered to the site at least 14 calendar days prior to scheduled installation.

E. Samples of the geocomposite shall be collected at the Manufacturer's plant as directed by the Construction Quality Assurance Consultant for laboratory testing by the

Construction Quality Assurance Consultant's testing laboratory to ensure compliance with this Section. Unless otherwise requested, samples shall be 3 feet long by the width of the roll. Conformance testing will be performed in accordance with the CQA Manual. Passing results shall be confirmed by the Construction Quality Assurance Consultant prior to shipment to the Site.

F. Geocomposite rolls that do not meet the requirements of the CQA Manual as determined by the Construction Quality Assurance Consultant shall be rejected. Geosynthetics Manufacturer shall be required to replace the rejected material with new material that complies with the CQA Manual, at no additional cost to Owner.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Offloading and storage of the geocomposite shall be the responsibility of the Contractor. Handling and care of the geocomposite after acceptance by the Construction Quality Assurance Consultant, prior to installation will be the responsibility of the Contractor.

B. Rolls shall be stored on a flat, dry surface. If necessary, the material shall be stored off of the ground, on pallets or other equivalent device, to keep the material from contacting the ground. Tarping the stored materials is suggested to avoid any unnecessary degradation of the packaging. Geocomposite shall be protected from ultraviolet light exposure, moisture, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Manufacturer shall be the Contractor's responsibility

C. All rolls of geocomposite shall be identified at the factory with the following information:
   1. Manufacturer's name
   2. Product identification
   3. Lot number
   4. Roll number
   5. Roll dimensions

D. Geocomposite rolls shall be shipped and stored by the Geosynthetics Manufacturer in relatively opaque and watertight wrappings.

E. Rolls shall be handled utilizing a solid steel bar inserted through the core bar and slings or chains attached to the ends of the bar. The core bar shall be suspended from a spreader bar so that the edges of the geocomposite are not damaged by the suspending straps or chains.

F. Rolls shall be stored following all Manufacturer's recommendations and the requirements of ASTM D4873.

G. Acceptance at the Site
   1. Construction Quality Assurance Consultant will perform inventory and surface inspection for defects and damage of all geocomposite rolls upon delivery.

2. Geosynthetics Installer shall unroll and inspect any geocomposite roll that may be damaged below surface layers.
3. Geosynthetics Manufacturer shall repair damage resulting from handling and transport of geocomposite to the Site at no cost to Owner. If irreparable, in the opinion of Construction Quality Assurance Consultant, damaged materials shall be replaced at no cost to Owner.

H. Contractor shall preserve integrity and readability of the geocomposite roll labels and store the rolls such that Construction Quality Assurance Consultant shall have access to the package slips or roll labels for each roll to verify roll acceptance.

1.7 QUALIFICATIONS

A. The Geosynthetics Installer shall be experienced in the installation of at least 1 million square feet of geocomposites. The Geosynthetics Installer shall provide documentation supporting this experience, including a list of the client, client contact, project name, and quantity of geocomposite installed.

PART 2: PRODUCTS

2.1 GEOCOMPOSITE

A. The geocomposite shall consist of Double-Sided 8-275-8 GC material, or other Engineer-approved equivalent. The geocomposite shall be a product comprised of non-woven, needle-punched, continuous or staple filament polypropylene geotextile, heat-bonded to both sides of an integrally formed, solid rib, extruded high-density polyethylene geonet core. Bonding shall be heat-bonding without the use of adhesives or other foreign products.

B. The geonet component shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure. The geonet shall be manufactured of new, first-quality resin and shall be manufactured specifically for this type of application. The geonet shall be comprised of a minimum of 95 percent pure polyethylene, with the remaining portion made up of materials necessary for the performance of the geonet, such as carbon black, antioxidants, etc.

C. Requirements for the properties of the geocomposite are presented in Table 312430 below.

TABLE 312430

QUALITY CONTROL TESTING REQUIREMENTS AND

MINIMUM AVERAGE ROLL VALUES OF GEOCOMPOSITE

Property	Procedure	Value	Qualifier
Geonet[3]			
Thickness	ASTM D5199	275 mil	MAV[5]
Carbon Black	ASTM D4218	2.0%-3.0%	Range
Tensile Strength	ASTM D7179	65 lbs/in	MAV
Melt Flow	ASTM D1238[2]	1.0 g/10 min	Maximum
Density	ASTM D1505	0.94 g/cm^3	MAV
Transmissivity[1]	ASTM D4716	6.0 x 10^{-3} m^2/sec	MAV
Composite			
Ply Adhesion	ASTM D7005	1.0 lb/in	MAV
Transmissivity[1]	ASTM D4716	7.0 x 10^{-4} m^2/sec	MAV
Geotextile[3]			
Fabric Weight	ASTM D5261	7.2 oz/yd^2	MARV[4]
Permittivity	ASTM D4491	0.90 sec^{-1}	MARV
AOS	ASTM D4751	60 US Sieve	MaxARV
UV Resistance	ASTM D4355	70/500 %/hrs	MARV

Table Notes:

1. Transmissivity measured using water at 21±2ºC (70±4ºF) with a gradient of 0.1 and a confining pressure of 10,000 psf between steel plates after 15 minutes.
2. Condition 190/2.16
3. Geotextile and Geonet properties are prior to lamination
4. MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.
5. Minimum average value

D. No separation of geotextile components from the geonet core shall occur.

E. All rolls shall be labeled and wrapped in packaging that is resistant to photodegradation by ultraviolet (UV) light.

PART 3: EXECUTION

3.1 INSTALLATION BY GEOSYNTHETICS INSTALLER

A. The geocomposite shall be installed in accordance with Geosynthetics Manufacturer's recommended procedures.

B. The Construction Quality Assurance Consultant will verify that all geocomposite rolls and underlying layers are free from deleterious material or debris prior to the geocomposite deployment. No excessive dust, stones, or moisture shall be entrapped within the geocomposite that could cause damage or clogging or hamper subsequent seaming. Damaged geocomposite material shall be repaired or replaced per Construction Quality Assurance Consultant's direction at no cost to the Owner.

C. The Construction Quality Assurance Consultant shall approve of all underlying geosynthetic installation(s) prior to placement of the geocomposite.

D. The geocomposite panels shall be positioned to minimize wrinkles.

E. No personnel working on the geocomposite shall smoke, wear damaging shoes, or engage in other activities that could damage the geocomposite. No equipment or tools shall damage the geocomposite by handling, trafficking, or other means.

F. Panel end seams at the base of the slope shall be a minimum of 5 feet from the toe.

G. Pull geocomposite panels from roll suspended at the crest of the slope. Do not drag geocomposite across rough or textured surfaces, to avoid damage to the geocomposite. Use a smooth geosynthetic slip sheet or rub sheet as necessary to reduce friction damage during deployment.

H. For panel (longitudinal) seams, ensure that no soil materials are present between material overlaps at seams. Butt the geonet portion of the panels together along panel edges and tie at 5 ft intervals with plastic zip ties or other Construction Quality Assurance Consultant-approved method. Overlap the upper geotextiles and sew.

I. For end seams, butt geonet components together and tie at 6 in. intervals with plastic zip ties or other Construction Quality Assurance Consultant- approved method. Overlap the upper geotextiles and sew.

J. Sewing shall be done using polymeric thread with chemical and ultraviolet light resistance properties equal to or exceeding those of the geotextile. Sewing shall be done using machinery and stitch types as recommended by the geocomposite Manufacturer and approved by the Construction Quality Assurance Consultant.

K. No equipment shall be operated directly on the geocomposite.

L. Additional soil or geosynthetic layers placed over the geocomposite shall be placed in such a manner as to ensure that the geocomposite and other geosynthetic materials are not damaged, and there is no slippage, movement, or wrinkling of the underlying material, and no excess tensile stresses occur within the geocomposite.

3.2 REPAIR

A. Remove any soil or other material that may have penetrated the torn geocomposite.

B. Repair any holes or tears in the geocomposite by

1. Removing the upper geotextile from the geonet in the damaged area
2. Restoring the geonet to the correct position or removing and replacing the damaged geonet with an undamaged piece that fits the removed area to provide continuity of flow
3. Tying the repair geonet in place to adjacent geonet using plastic zip ties at 6- inch intervals
4. Placing a geotextile patch extending 2 feet beyond the edges of the hole or tear.
5. Heat-sealing (Leicester) the geotextile component of the patch to the geotextile of the geocomposite needing repair.

C. If the hole or tear width across the roll is more than 50 percent of the width of the roll, cut out the damaged area and join the two portions of the geonet in accordance with this Section.

3.3 CONFORMANCE TESTING

A. Material shall be provided to the Construction Quality Assurance Consultant after notice to proceed for sampling and conformance testing by the Construction Quality Assurance Consultant at a minimum frequency of one per 100,000 sf of geocomposite continuously produced and supplied to the project with a minimum of one sample per lot. Samples will be tested for geotextile mass per unit area (ASTM D5261), geonet thickness (ASTM D5199), and geocomposite ply adhesion (ASTM D7005). Test results shall meet the requirements presented in TABLE 312430.

B. If a test result is in non-conformance with the Specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the non-conforming material with additional passing tests conducted by the geosynthetic CQA laboratory. Additional tests and replaced material shall be provided at no additional cost to the Owner. No material shall be shipped until confirmation is received from the Construction Quality Assurance Consultant that samples have passed conformance testing.

3.4 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed in accordance with the CQA Manual and as indicated in the Specifications. The Geosynthetics Installer shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the Construction Quality Assurance Consultant.

B. The Construction Quality Assurance Consultant will examine deployed geocomposite to identify defects, holes, areas damaged during installation, and whether specified overlaps are as specified.

C. No geosynthetics or soil materials shall be placed over the geocomposite until the Construction Quality Assurance Consultant has examined and approved the geocomposite in the subject area. The Construction Quality Assurance Consultant will not accept geocomposite installation until all noted defects have been repaired.

3.5 ANCHOR TRENCH

A. The anchor trenches shall be excavated by the Contractor to the lines, grades, and width shown on the Drawings, prior to any geosynthetic material placement. Construction Quality Assurance Consultant shall verify that the anchor trench has been constructed according to the Drawings.

B. The anchor trench shall be backfilled and compacted by the Contractor as approved by the Construction Quality Assurance Consultant. Trench backfill material shall be placed in 9- to 12-inch-thick loose lifts and compacted by wheel rolling with light, rubber-tired or other light compaction equipment, as approved by Construction Quality Assurance Consultant.

C. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic materials. At no time shall construction equipment come into direct contact with the geosynthetic materials. If damage occurs, it shall be repaired by the Contractor prior to the completion of backfilling, at no cost to Owner.

D. Geosynthetics Installer shall extend geosynthetic materials into the anchor trench as shown on the Drawings. The geosynthetic materials shall be seamed, bonded, or attached along the entire distance of the anchor trench, using approved methods described in this Section.

3.6 PLACEMENT OF SOIL OR GRANULAR MATERIALS

A. Do not place material above the geocomposite until the installation has been inspected and approved in writing by the Construction Quality Assurance Consultant.

B. All soil materials above the geocomposite shall be placed by the Contractor in such a manner as to ensure:

1. The geocomposite and any underlying geosynthetic material are not damaged.
2. No slippage of the geocomposite on underlying layers occurs.
3. No movement and wrinkling or folding of the underlying geosynthetic layer(s) occurs.

4. No excess tensile stresses shall occur in the geocomposite, such as those caused by earth moving equipment making sudden starts, stops, or turns.
5. Only low ground pressure equipment shall be used for spreading soil materials over underlying geosynthetics. The soil material shall be placed in a single lift, carefully pushed from the existing face of the layer. Placement methods and equipment shall be changed as necessary to prevent damage to the underlying materials or if directed by the Construction Quality Assurance Consultant.
6. No equipment shall be operated directly on the geocomposite.

[END SECTION]

SECTION 312440
GEOTEXTILES

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope:
   1. This Section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of cushion geotextile fabric associated with the Work.
   2. The geotextile fabric will be procured directly by the Owner from the Geosynthetics Manufacturer. The Contractor shall be responsible for unloading, storing, and installing the geotextile fabric as specified.
   3. The Contractor shall provide all labor, materials, equipment, and services required to place geotextile fabric as shown on the Drawings or as described in the Specifications.

B. RELATED SECTIONS
   1. Section 312420 HDPE Geomembrane.
   2. Section 312450 Geosynthetic Clay Liner.
   3. Section 312430 Geocomposite.
   4. Section 312316 Excavation and Stockpiling.

1.2 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:
   1. ASTM D4354 – Practice for Sampling of Geosynthetics for Testing
   2. ASTM D4533 - Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
   3. ASTM D4632 - Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
   4. ASTM D4759 – Practice for Determining the Specification Conformance of Geosynthetics
   5. ASTM D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
   6. ASTM D4873 – Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

B. American Association of State Highway and Transportation Officials, latest version:
   1. AASHTO M288-05 – Geotextile Specification for Highway Applications

C. Latest Version of Site Construction Quality Assurance (CQA) Manual

1.3 DEFINITIONS

A. Minimum Average Roll Value (MARV) – Calculated as the typical value minus two (2) standard deviations from documented quality control test results for a defined population from one specific test method associated with one specific property.

1.4 SUBMITTALS

A. The Geosynthetics Manufacturer shall provide the following:
   1. Information from the Geosynthetics Manufacturer including company name, production plant, product name, style number, and other pertinent information to fully describe the geotextile.
   2. List of materials that comprise the geotextile, expressed in the following categories as percent by weight: base polymer, carbon black, and other additives.
   3. Quality Control (QC) Manual for review by Construction Quality Assurance Consultant, including frequency of quality control tests.
   4. Written certification that minimum average roll values given in Geosynthetics Manufacturer's specification are guaranteed by Geosynthetics Manufacturer to meet the properties contained in Part 2 of this section.
   5. Written certification that Geosynthetics Manufacturer has continuously inspected geotextile for the presence of needles and found geotextile to be needle-free.
   6. Quality control certificates for test results at the sampling frequencies indicated by the Manufacturer's QC Plan.
      a. Manufacturing quality control certificates shall be signed by responsible parties employed by the Manufacturer (such as the production manager).
      b. The quality control certificates shall include:
         i. Roll numbers and identification;
         ii. Sampling procedures; and
         iii. At a minimum, results shall be given for
            - Mass per unit area (ASTM D5261)
            - Grab strength (ASTM D4632)
            - Trapezoidal tear strength (ASTM D4533)
            - Puncture strength (ASTM D4833)
   7. Upon review of the submittals, the Construction Quality Assurance Consultant may request additional testing during the manufacturing process at no additional cost to Owner.
   8. Recommendations for the offloading, handling, and storage of geotextile.

1.5 QUALITY ASSURANCE/CONFORMANCE TESTING

A. The Geosynthetics Manufacturer shall ensure that their internal product quality control program meets the Contract requirements.

B. Upon Notice to Proceed, samples of the geotextile shall be provided to the Construction Quality Assurance Consultant for laboratory testing to verify compliance with this Section. Samples shall be taken at a minimum frequency of 1 per 100,000 square feet of material continuously produced and supplied to the project, with a minimum of a one sample per production lot. As a minimum, mass per unit area (ASTM D5261) and Density testing (ASTM D792 or D1505) will be performed for conformance testing. Results shall meet the minimum requirements presented in GRI Specification.

C. Geotextile rolls that do not meet the specified requirements shall be rejected. All material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the non-conforming material with additional passing tests conducted by the geosynthetic CQA laboratory. Geosynthetics Manufacturer shall replace the rejected material with new material that complies with the specified requirements and provide material for additional conformance tests, at no additional cost to Owner. Geotextile shall not be shipped to the Site until confirmation of passing conformance tests is obtained from the Construction Quality Assurance Consultant.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping

1. Geotextile fabric shall be supplied in rolls wrapped in impermeable and opaque protective covers, with straps for unloading.
2. Geotextile rolls shall be marked or tagged with the following information.
    a. Manufacturer's name
    b. Product information
    c. Roll number
    d. Batch or lot number
    e. Roll dimensions
3. The Geosynthetics Manufacturer shall ensure that geotextile rolls are properly loaded and secured to prevent damage during transit.
4. The Geosynthetics Manufacturer shall protect geotextile from excessive heat, puncture, cutting, or other damaging or deleterious conditions during shipping and delivery.
5. The Geosynthetics Manufacturer shall ensure that personnel responsible for loading and transport are familiar with handling and transport constraints imposed by the Geosynthetics Manufacturer and as required by this Section.

6. The Contractor shall ensure that personnel responsible for unloading and storing materials on-site are familiar with handling and transport constraints imposed by Geosynthetics Manufacturer and as required by this Section.

B. Acceptance at the Site

1. The Construction Quality Assurance Consultant will perform inventory and surface inspection for defects and damage of all geotextile rolls upon delivery.
2. The Contractor shall unroll and allow for the Construction Quality Assurance Consultant inspection of any geotextile roll that may be damaged below surface layers.
3. The Geosynthetics Manufacturer shall repair damage resulting from handling and transport of geotextile to Site at no cost to Owner. If irreparable, in the opinion of Construction Quality Assurance Consultant, damaged materials shall be replaced at no cost to Owner.

C. Storage and Protection

1. Owner shall provide on-site storage area for geotextile rolls from time of delivery until installation.
2. The offloading and storage of the materials is the responsibility of the Contractor from the time the materials are off-loaded and inspected by the Construction Quality Assurance Consultant until the time the completed installation is accepted. Contractor is also responsible for preparing the storage location off the ground and for the protection of the material from the elements (e.g. ultraviolet light, moisture, temperature, etc.).
3. After Contractor has removed material from storage area, Contractor shall protect geotextile from puncture, dirt, groundwater, moisture, mud, mechanical abrasion, excessive heat, ultraviolet light exposure, and other sources of damage.
4. Geotextile rolls shall be stored in relatively opaque and water tight wrappings.
5. Contractor shall preserve integrity and readability of the geotextile roll labels, and store such that Construction Quality Assurance Consultant shall have access to the package slips or roll labels for each roll to verify roll acceptance.

PART 2: PRODUCTS

2.1 GEOTEXTILE FABRIC

A. The finished geotextile shall have good appearance qualities. Rolls shall be free of holes, contamination, foreign matter, and any other defect that would affect the specific properties of the geotextile, or its proper function.

B. The geotextile shall meet or exceed the minimum (unless noted otherwise) roll values shown in GRI Specification: GT 12 or GT-13 based on the purpose

PART 3: EXECUTION

3.1 INSPECTION

A. Before deploying geotextiles, Contractor shall verify that subgrade conditions for placement of geotextile are in accordance with the specifications or that installation of the underlying geosynthetic layers has been completed and approved by the Construction Quality Assurance Consultant, as applicable. Do not proceed with placing geotextile until the Construction Quality Assurance Consultant has provided approval in writing.

B. Contractor shall coordinate the installation of items that must be installed prior to and/or in conjunction with the geotextile fabric.

3.2 INSTALLATION

A. The Contractor and\or Geosynthetics Installer shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and all other aspects of geotextile installation.

B. The Contractor shall accept and retain full responsibility for all materials upon delivery to the Site through installation and shall be held responsible for any defects or damage.

C. Contractor shall place geotextile fabric according to Geosynthetics Manufacturer's recommendations.

D. Do not drag geotextile across textured geomembrane or other high-friction surfaces. Utilize a rub sheet or other method to allow deployment without damage.

E. Geotextile seams shall be overlapped in accordance with Geosynthetics Manufacturer's recommendations or a minimum of 6 inches.

F. Geotextiles shall be seamed using either sewing for thermally bonded seaming techniques. Seams shall be continuous. Seaming equipment and methods shall be in accordance with the Geosynthetics Manufacturer's recommendations and shall be approved by the Construction Quality Assurance Consultant in writing prior to use.

G. Prior to placement of overlying material, geotextile shall be protected against wind uplift using sandbags, tires, or other methods that will not damage the geotextile or underlying materials.

H. The Contractor shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed, and damaged geotextile shall be repaired or replaced by the Contractor at no cost to Owner.

I. Contractor shall use care not to damage underlying materials during geotextile installation.

J. Contractor shall prevent the geotextile from accumulating excessive dust.

K. No equipment shall operate directly on geotextile fabric.

3.3 REPAIRS

A. Clean the damaged area as necessary to remove any dirt or other unacceptable materials.

B. Any holes or tears in the geotextile shall be repaired using a geotextile patch consisting of the same geotextile, with a minimum 12-inch overlap. The patch shall be continuously seamed around the perimeter using the approved methods and equipment specified in this section.

C. Damaged areas too large for patching shall be removed and replaced as directed by the Construction Quality Assurance Consultant.

3.4 PLACEMENT OF OVERLYING MATERIALS

A. Do not place material above the geotextile until the installation has been inspected and approved in writing by the Construction Quality Assurance Consultant.

B. Material placed on top of a geotextile shall be placed in such a manner as to ensure:

   1. The geotextile and/or underlying geosynthetic(s) are not damaged.
   2. No slippage of the geotextile on underlying layers occurs.
   3. No movement and wrinkling or folding of the underlying geosynthetic layer(s) occurs.
   4. No excess tensile stresses shall occur in the geotextile, such as by earth moving equipment making sudden starts, stops, or turns.
   5. Only low ground pressure equipment shall be used for spreading soil materials over underlying geosynthetics. The soil material shall be placed in a single lift, carefully pushed from the existing face of the layer. Placement methods and equipment shall be changed as necessary to prevent damage to the underlying materials or if directed by the Construction Quality Assurance Consultant.

[END SECTION]

SECTION 312450
GEOSYNTHETIC CLAY LINER (GCL)

PART 1: GENERAL

1.1 DESCRIPTION

A. Scope

1. This section describes the requirements for the manufacture, supply, installation, and quality control of the geosynthetic clay liner (GCL) associated with the Work.
2. The GCL will be procured directly by the Owner from the Geosynthetics Manufacturer. The Contractor shall be responsible for unloading and storing the GCL as specified under this Section until the scheduled installation by the Geosynthetics Installer.
3. The Geosynthetics Installer shall provide all labor, materials, equipment, and services required to place the GCL as shown on the Drawings or as described in the Specifications.

B RELATED SECTIONS

1. Section 312440 Geotextiles.
2. Section 312420 HDPE Geomembrane.
3. Section 312430 Geocomposite.
4. Section 312316 Excavation and Stockpiling.

1.2 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D2216 – Standard Test Method for Laboratory Water (Moisture) Content of Soil and Rock by Mass
2. ASTM D4354 – Practice for Sampling of Geosynthetics for Testing
3. ASTM D4643 – Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
4. ASTM D4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
5. ASTM D5888 - Standard Guide for Storage and Handling of Geosynthetic Clay Liners
6. ASTM D5889 - Standard Practice for Quality Control of Geosynthetic Clay Liners
7. ASTM D5890 – Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners

8. ASTM D5891 – Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
9. ASTM D5993 - Measuring Mass per Unit Area of Geosynthetic Clay Liners
10. ASTM D6102 – Guide for Installation of Geosynthetic Clay Liners
11. ASTM D6243 – Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method
12. ASTM D6495 – Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners
13. ASTM D6496 – Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
14. ASTM D6766 – Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids
15. ASTM D6768 – Test Method for Tensile Strength for Geosynthetic Clay Liners

B. Geosynthetics Research Institute (GRI):
1. GRI-GCL3 – Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)

C. Latest Version of Site Construction Quality Assurance (CQA) Manual

1.3 SUBMITTALS

A. Geosynthetics Manufacturer shall submit to the Construction Quality Assurance Consultant the following information relating to the GCL a minimum of fourteen (14) days prior to shipping the material for review and approval by the Construction Quality Assurance Consultant. No material will be shipped to the Project Site without approval by the Construction Quality Assurance Consultant.
1. Quality control certificates issued by the raw material supplier(s), including the production dates of the raw materials (bentonite, geotextile, needle- punch tread, etc.) used to manufacture the geosynthetic clay liner.
2. A copy of the Manufacturer’s Quality Control Program.
3. Quality control certificates for test results at the sampling frequencies indicated by the Manufacturer’s QC Plan.
    a. Manufacturing quality control certificates shall be signed by responsible parties employed by the Manufacturer (such as the production manager).
    b. The quality control certificates shall include:
        i. Roll numbers and identification;
        ii. Sampling procedures; and
        iii. At a minimum, results for the GCL as a unit shall be given for:
            o Moisture content (ASTM D4643/D5993)
            o Index Flux (ASTM D5887)
            o Mass per unit area (ASTM D5993)

- o Peel strength (ASTMD6496)
- o Grab strength (ASTMD6768)

4. Quality Control Submittals:
   a. Quality control (QC) certificates containing the Manufacturer's QC testing results. QC certificates shall be submitted at the frequency indicated in the Manufacturer's QC Plan for geosynthetic clay liner continuously produced and supplied to the project and at least one per lot.
   b. Manufacturer's certification that products meet or exceed specified requirements.
5. Product warranty

B. Immediately upon Notice of Award:
1. The Geosynthetics Manufacturer shall make available samples of the GCL to the Construction Quality Assurance Consultant for interface shear testing. The samples will be tested to simulate the interface between the Project-specified geomembrane and the GCL.
2. The Geosynthetics Installer shall provide shop drawings indicating panel layout and field seams 14 calendar days prior to installation of GCL. Each panel shall be assigned an identification number.

C. Upon completion of the Work, the Geosynthetics Installer shall:
1. Provide an as-built panel layout drawing, with assigned identification numbers.
2. Provide warranty of Work and certification that the Work was performed in accordance with the Specifications. The warranty shall be the Manufacturer's standard written warranty against defects in material, but in no case shall be for less than 5 years. A 1-year warranty shall be provided by the Geosynthetics Installer against defects in installation and workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.4 QUALITY ASSURANCE

A. All Work shall be constructed, monitored, and tested in accordance with the CQA Manual. The Contractor, Geosynthetics Installer and Geosynthetics Manufacturer shall participate and comply with all items in the CQA Manual.

B. Construction Quality Assurance Consultant will verify that GCL Manufacture has an internal product quality control (QC) program that meets the Contract requirements.

C. Geosynthetics Installer and Contractor shall be aware of all activities described in the CQA Manual. Geosynthetics Installer and Contractor shall account for these activities in the construction schedule.

D. Geosynthetics Manufacturer shall ensure that the GCL is delivered to the site at least 14 calendar days prior to scheduled installation.

E. Samples of the GCL shall be collected at the Manufacturer's plant as directed by the Construction Quality Assurance Consultant for laboratory testing by the Construction Quality Assurance Consultant's testing laboratory to ensure compliance with this Section. Conformance testing will be performed in accordance with the CQA Manual. Passing results shall be confirmed by the Construction Quality Assurance Consultant prior to shipment to the Site.

F. GCL rolls that do not meet the requirements of the CQA Manual as determined by the Construction Quality Assurance Consultant shall be rejected. Geosynthetics Manufacturer shall be required to replace the rejected material with new material that complies with the CQA Manual, at no additional cost to Owner.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Offloading and storage of the GCL shall be the responsibility of the Contractor. Handling and care of the GCL after acceptance by the Construction Quality Assurance Consultant, prior to installation will be the responsibility of the Contractor.

B. Rolls shall be stored on a flat, dry surface. If necessary, the material shall be stored off of the ground, on pallets or other equivalent device, to keep the material from contacting the ground. Tarping the stored materials is suggested to avoid any unnecessary degradation the packaging. GCL shall be protected from ultraviolet light exposure, moisture, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Manufacturer shall be the Contractor's responsibility.

C. All rolls of GCL shall be identified at the factory with the following information:

1. Manufacturer's name
2. Product identification
3. Lot number
4. Roll number
5. Roll dimensions

D. GCL rolls shall be shipped and stored by the Geosynthetics Manufacturer in relatively opaque and water tight wrappings.

E. Rolls shall be handled utilizing a solid steel bar inserted through the core bar and slings or chains attached to the ends of the bar. The core bar shall be suspended from a spreader bar so that the edges of the liner are not damaged by the suspending straps or chains. Panels shall be placed with the non-woven side facing up.

F. Rolls shall be stored following all Manufacturer's recommendations and the requirements of ASTM D5888.

G. Acceptance at the Site

1. Construction Quality Assurance Consultant will perform inventory and surface inspection for defects and damage of all GCL rolls upon delivery.

2. Geosynthetics Installers shall unroll and inspect any GCL roll that may be damaged below surface layers.
3. Geosynthetics Manufacturer shall repair damage resulting from handling and transport of GCL to the Site at no cost to Owner. If irreparable, in the opinion of Construction Quality Assurance Consultant, damaged materials shall be replaced at no cost to Owner.

H. Contractor shall preserve integrity and readability of the GCL roll labels, and store such that Construction Quality Assurance Consultant shall have access to the package slips or roll labels for each roll to verify roll acceptance.

1.7 QUALIFICATIONS

A. The Geosynthetics Installer shall be experienced in the installation of at least 1 million square feet of geosynthetic clay liners. The Geosynthetics Installer shall provide documentation supporting this experience, including a list of the client, client contact, project name, and quantity of GCL installed.

PART 2: PRODUCTS

2.1 GEOSYNTHETIC CLAY LINER

A. The geosynthetic clay liner shall be Resistex® 200, as manufactured by Colloid Environmental Technologies Company (CETCO), 2870 Forbs Avenue, Hoffman Estates, Illinois (800) 527-9948, or Engineer-approved equal. The geosynthetic clay liner shall be formulated and manufactured from polypropylene geotextiles and high swelling, granular sodium bentonite.

B. Requirements for the properties of the geosynthetic clay liner are presented in Table 312450 below:

TABLE 312450

QUALITY CONTROL TESTING REQUIREMENTS AND MINIMUM AVERAGE ROLL VALUES OF GEOSYNTHETIC CLAY LINER

BENTONITE	**Procedure**	**Frequency**	**English Units**
Swell Index	ASTM D5890	1/100,000 lbs.	24 ml
Mass Per Unit Area	ASTM D5993	1/40,000 ft^2	0.75 lb./sq.ft
Fluid Loss(1)	ASTM D5891	1/100,000 lbs.	18 ml
FINISHED GCL			
Hydrated Internal Shear Strength	ASTM D6243	1/1,000,000 sq ft	500-psf
Grab Strength	ASTM D6768	1/200,000 ft^2	50-lns/in
Peel Strength	ASTM D6496	1/40,000 ft^2	3.5 lbs/in
Hydraulic Conductivity(1)	ASTM D5887	1/250,000 ft^2	3 x 10^{-9} cm/sec
Index Flux(1)	ASTM D5887	1/250,000 ft^2	1 x 10^{-8} m^3/m^2 /sec

Notes:

(1) These values are maximum (all others are minimum).

C. The geosynthetic clay liner shall be manufactured by the mechanical bonding of the two geotextile layers using the cross stitching needle-punch process to enhance the internal frictional characteristics of the GCL. No glues or adhesives shall be used in lieu of the needle-punch process.

D. The bentonite-geotextile liner shall be manufactured utilizing a high swelling sodium bentonite (also known as Wyoming bentonite).

E. Rolls shall be manufactured a minimum of 12 feet wide and 200 feet long. A minimum 6 inch lap line and a 9 inch match line shall be printed on both edges of the upper surface (as installed) geotextile of the geosynthetic clay liner to assist in overlap quality control.

F. All rolls shall be labeled and wrapped in packaging that is moisture proof and resistant to photodegradation by ultraviolet (UV) light.

PART 3: EXECUTION

3.1 INSTALLATION BY GEOSYNTHETICS INSTALLER

A. The subgrade surface shall be prepared by the Contractor in accordance with the recommendations of the GCL Manufacture. The Contractor shall repair rough areas and any damage to the subgrade and fill and properly compact any ruts caused by equipment prior to geosynthetic clay liner deployment. Geosynthetics Installer shall verify in writing that the subgrade on which the geosynthetic clay liner will be installed is acceptable. In so doing the Geosynthetics Installer shall assume full liability for the accepted surface. The Geosynthetics Installer shall then be responsible for maintenance of the geosynthetic clay liner once installation begins.

B. Install the geosynthetic clay liner so that panel seams are parallel to the dip of the slope.

C. Work on the slopes shall be undertaken before work on the cell bottom to permit drainage in the event of rainfall.

D. Panel end seams shall be perpendicular to toe of slope at all times.

E. Panel end seams at the base of the slope shall be a minimum of 5 feet from the toe.

F. Pull geosynthetic clay liner panels from roll suspended at the crest of the slope and install with the Manufacturer recommended side facing up.

G. Do not install the geosynthetic clay liner over saturated subgrade, in standing water, or during precipitation events. Geomembrane shall not be placed on a geosynthetic clay liner that is hydrated.

H. The geosynthetic clay liner shall be overlapped in accordance with the Manufacturer's recommendations. Panel end (horizontal) seams on side slopes shall be shingled downslope (rainflap configuration).

I. Contacting surfaces shall be clean and free from dirt or native soil with all edges pulled tight to maximize contact and to smooth out any wrinkles or creases.

J. All seams shall be augmented with granular bentonite per the Manufacturer's recommendations to ensure seam integrity. Granular bentonite shall be dispersed evenly from the panel edge to the lap line at a minimum rate of ¼ pound per lineal foot continuously along all seams of overlap area. Accessory bentonite shall be of the same type of material as within the composite geosynthetic clay liner itself.

K. Place only as much geosynthetic clay liner each day as can be covered with geomembrane liner. The geosynthetic clay liner shall be covered by geomembrane liner at the end of each working day.

L. Do not drag textured geomembranes across previously installed GCL. Use a smooth rub sheet between mat and geomembrane, or other methods, to prevent damage. Remove rub sheet when geomembrane is in position.

M. The geosynthetic clay liner materials shall not be allowed to become wetted (except by the subgrade) prior to the placement of the geomembrane. All hydrated GCL shall be removed and replaced by the Geosynthetics Installer at no additional cost to the Owner.

N. For any penetrations or in locations where the geosynthetic clay liner will contact structures, a shallow notch (approximately 3 inches deep and 8 inches wide) shall be cut along the edge of the area. The liner shall be brought up to the structure and trimmed to fit into the notch. The Geosynthetics Installer shall then hand apply a layer of pure bentonite, or a mixture of 1 part bentonite to 4 parts soil (by volume), blended dry, into the lower half of the notch. The liner shall then be placed into the notch, with the remaining volume of the notch backfilled with the pure bentonite or the 1 to 4 mixture and compacted using a hand tamper.

O. To avoid sharp bends in the geosynthetic clay liner, bevel the leading edges of the anchor trench.

P. No equipment shall be operated directly on the GCL.

Q. Additional geosynthetic layers placed over the GCL shall be placed in such a manner as to ensure that the GCL and other geosynthetic materials are not damaged, that there is no slippage, movement, or wrinkling of the underlying material, and that no excess tensile stresses occur within the GCL.

3.2 REPAIR

A. Repair cuts, tears, or holes in the geosynthetic clay liner by covering with a geosynthetic clay liner patch, per the Manufacturer's recommendations. On slopes greater than 5 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 ft in all directions. On slopes 5 percent or flatter, the patch shall overlap the edges of the damaged area by a minimum of 1 ft in all directions. Accessory bentonite shall be placed between the patch and the base GCL at a rate of 1/4 pound per lineal foot of edge.

B. All repairs shall be made at no additional cost to the Owner.

3.3 CONFORMANCE TESTING

A. Material shall be made available to the Construction Quality Assurance Consultant after notice to proceed for sampling and conformance testing by the Construction Quality Assurance Consultant at a minimum frequency of one per 100,000 sf of geosynthetic clay liner continuously produced and supplied to the project with a minimum of one sample per lot. GCL will be tested for bentonite moisture content (ASTM D4643), GCL hydraulic conductivity (ASTM D6766), and mass per unit area (ASTM D5993). Test results shall conform to values presented in Table 312450-1.

B. If a test result is in non-conformance with the Specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the non-conforming material with additional passing tests conducted by the geosynthetic CQA laboratory. Additional tests and replaced material shall be provided at no additional cost to the Owner. No material shall be shipped until confirmation is received from the Construction Quality Assurance Consultant that samples have passed conformance testing.

3.4 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed in accordance with the CQA Manual and as indicated in the Specifications. The Geosynthetics Installer shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the Construction Quality Assurance Consultant.

B. The Construction Quality Assurance Consultant will examine deployed GCL to identify defects, holes, hydrated areas, areas damaged during installation, and whether overlaps are as specified.

C. No geomembrane shall be placed over the GCL until the Construction Quality Assurance Consultant has examined and approved the GCL installation in the subject area. The Construction Quality Assurance Consultant will not accept GCL installation until all noted defects have been repaired.

3.5 ANCHOR TRENCH

A. The anchor trenches shall be excavated by the Contractor to the lines, grades, and width shown on the Drawings, prior to any geosynthetic material placement. Construction Quality Assurance Consultant shall verify that the anchor trench has been constructed according to the Drawings.

B. The anchor trench shall be backfilled and compacted by the Contractor as approved by the Construction Quality Assurance Consultant. Trench backfill material shall be placed in 9- to 12-inch-thick loose lifts and compacted by wheel rolling with light, rubber-tired or other light compaction equipment, as approved by Construction Quality Assurance Consultant.

C. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetic materials. At no time shall construction equipment come into direct contact with the geosynthetic materials. If damage occurs, it shall be repaired by the Contractor prior to the completion of backfilling, at no cost to Owner.

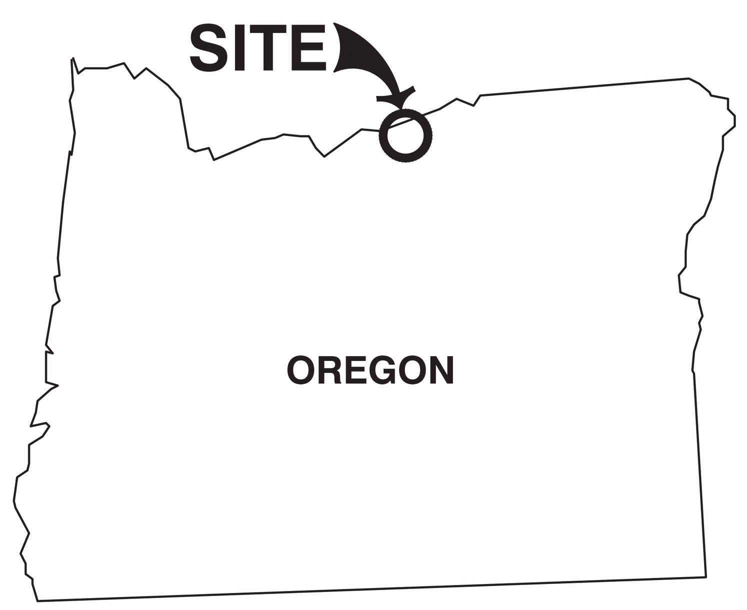
D. Geosynthetics Installer shall extend geosynthetic materials into the anchor trench as shown on the Drawings. The geosynthetic materials shall be seamed, bonded, or attached along the entire distance of the anchor trench, using approved methods described in this Section.

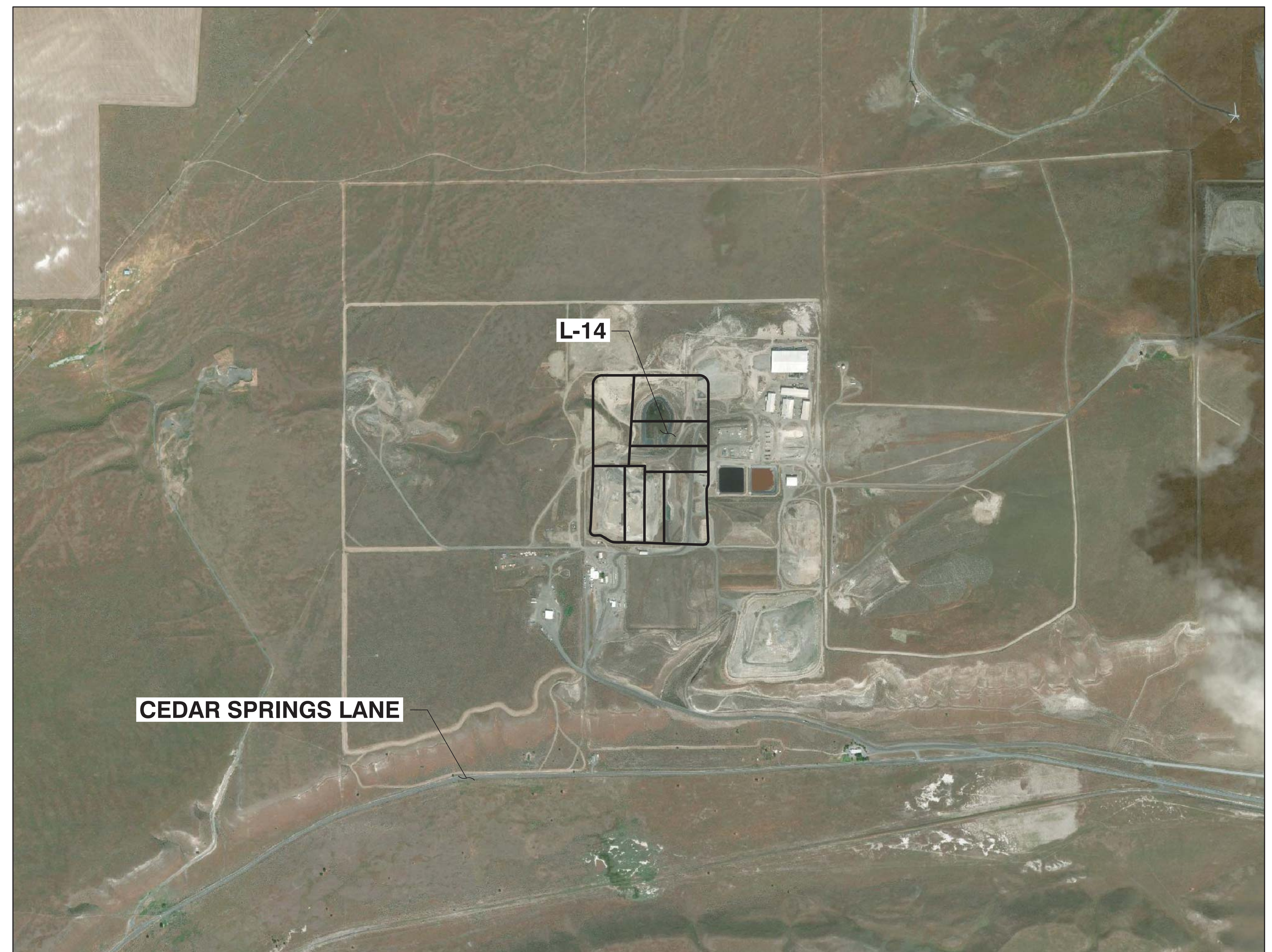
[END SECTION]

PERMIT DRAWING SET

PART B - PERMIT MODIFICATION APPLICATION FOR LANDFILL L-14

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST ARLINGTON, OREGON





REFERENCE

1. AERIAL PHOTOGRAPHY BY EARTHSTAR GEOGRAPHICS SIO, PROVIDED BY AUTODESK, ACCESSED ON 01/21/2020.

SCALE IN FEET
0 1000 2000

SHEET INDEX	
DRAWING NO.	DRAWING TITLE
P–000	TITLE SHEET
P–300	SUBGRADE PLAN
P–301	TOP OF PROTECTIVE COVER
P–302	TOP OF WASTE GRADING PLAN
P–303	LANDFILL CROSS SECTIONS
P–304	LANDFILL CROSS SECTIONS
P–800	LINER SYSTEM AND ANCHOR TRENCH DETAILS
P–801	RISER PIPE DETAILS
P–802	SUMP AND LEACHATE COLLECTION SYSTEM DETAILS
P–803	SUMP AND SIDESLOPE RISER PIPE LAYOUT
P–804	SUMP LAYOUT DETAILS
P–805	LINER TERMINATION DETAILS

PREPARED FOR

WASTE MANAGEMENT

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST, INC.
18177 CEDAR SPRINGS LANE
ARLINGTON, OREGON 97812
(541) 454–2630

REFERENCE

1. THE HORIZONTAL COORDINATES ARE BASED ON OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FOOT, NAD83.
2. VERTICAL COORDINATES ARE BASED ON NAVD88.
3. EXISTING TOPOGRAPHY COLLECTED BY MILLER CREEK ASSOCIATES ON APRIL 24, 2019.

PRELIMINARY
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92360PE
Jeff A. Shepherd
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

REVISION RECORD

NO	DATE	DESCRIPTION

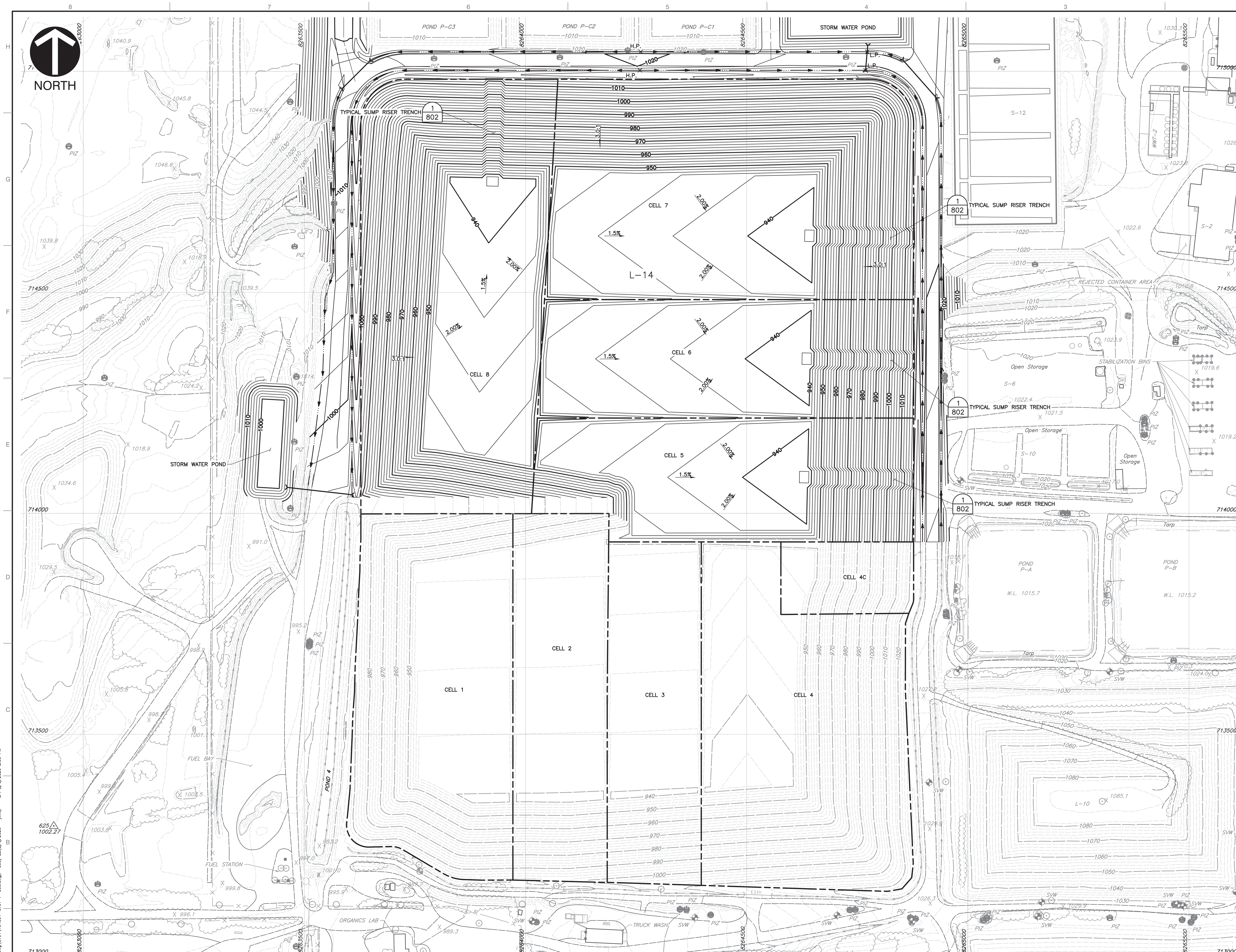
Civil & Environmental Consultants, Inc.
4045 NW 64th Street · Suite 415 · Oklahoma City, OK 73116
Ph: 405.246.9411
www.cecinc.com

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST ARLINGTON, OR

TITLE SHEET

DATE:	12/11/19	DRAWN BY:	JRW
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991	APPROVED BY:	JS

DRAWING NO.: P-000



LEGEND

- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- EXISTING SPOT ELEVATION (X 999.5)
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING TREELINE
- EXISTING POND
- EXISTING STREAM
- EXISTING DITCH
- EXISTING CULVERT
- EXISTING UTILITY POLE
- EXISTING LIGHT POLE
- EXISTING POST
- EXISTING GUIDE RAIL
- EXISTING TRAIL
- EXISTING SOIL VAPOR WELL (SVW)
- EXISTING PIEZOMETER (PIZ)
- LANDFILL CELL LIMITS
- SUBGRADE INDEX CONTOUR
- SUBGRADE INTERMEDIATE CONTOUR
- DRAINAGE CHANNEL
- CULVERT

NOTE

1. CONTOURS SHOWN FOR CELLS 1 THROUGH 4 ARE AS-BUILT TOP OF PROTECTIVE COVER GRADING.
2. CONTOURS FOR CELLS 4C, 5, 6, 7, AND 8 ARE TOP OF SUBGRADE.

REFERENCE

1. THE HORIZONTAL COORDINATES ARE BASED ON OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FOOT, NAD83.
2. VERTICAL COORDINATES ARE BASED ON NAVD88.
3. EXISTING TOPOGRAPHY COLLECTED BY MILLER CREEK ASSOCIATES ON APRIL 24, 2019.

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE IN FEET
0 100 200

REGISTERED PROFESSIONAL ENGINEER
92360PE
Jeff A. Shepherd
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

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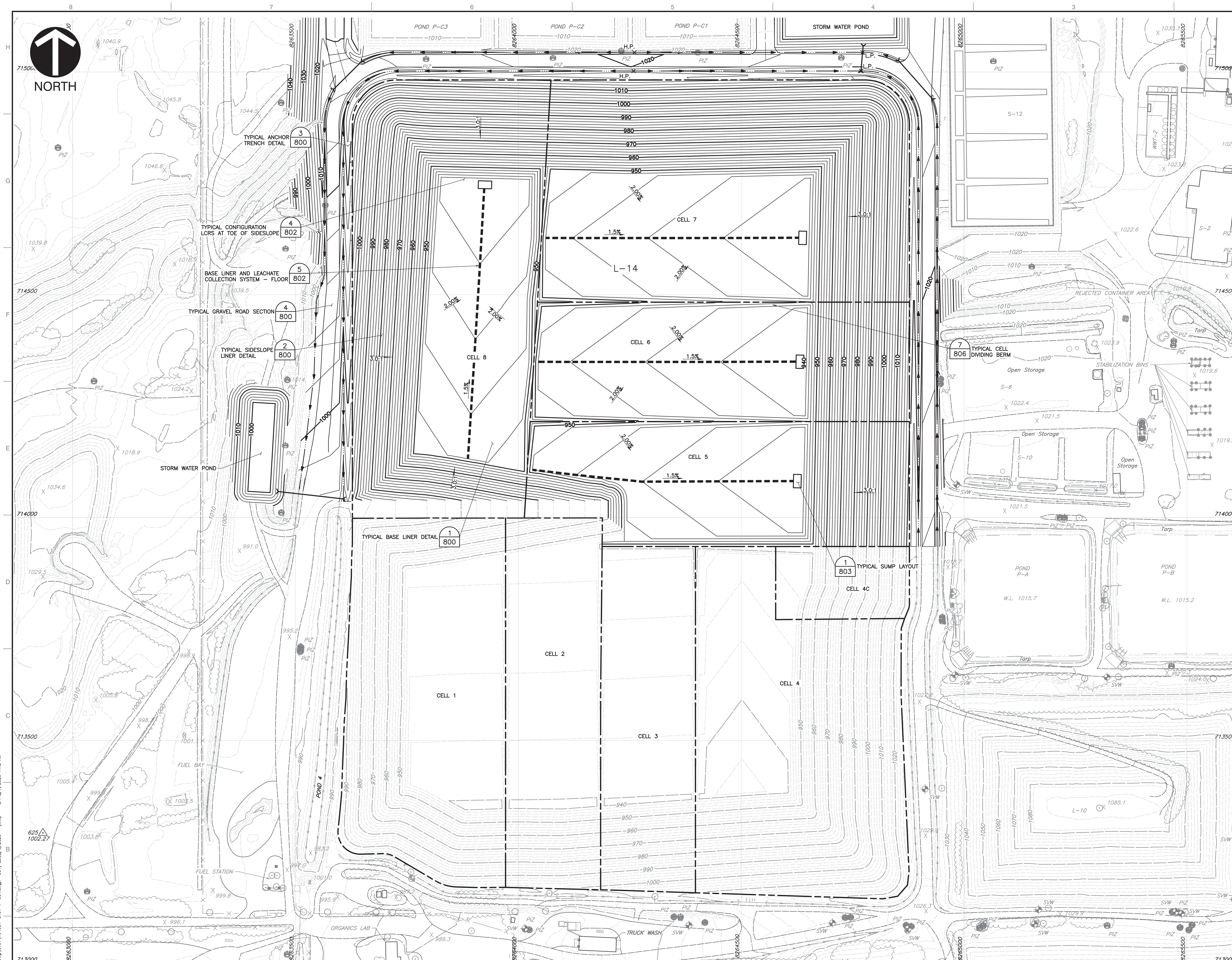
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST ARLINGTON, OR

SUBGRADE PLAN

DATE:	12/11/19	DRAWN BY:	JRW
DWG SCALE:	1"=100'	CHECKED BY:	DVS
PROJECT NO:			194-991
APPROVED BY:			JS

DRAWING NO.: **P-300**



LEGEND

- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- EXISTING SPOT ELEVATION (X 999.5)
- EXISTING UNPAVED ROAD
- EXISTING FENCE
- EXISTING TREELINE
- EXISTING POND
- EXISTING STREAM
- EXISTING DITCH
- EXISTING CULVERT
- EXISTING UTILITY POLE
- EXISTING LIGHT POLE
- EXISTING POST
- EXISTING GUIDE RAIL
- EXISTING TRAIL
- EXISTING SOIL VAPOR WELL (SVW)
- EXISTING PIEZOMETER (PIZ)
- LANDFILL CELL LIMITS
- TOP OF PROTECTIVE COVER INDEX CONTOUR
- TOP OF PROTECTIVE COVER INTERMEDIATE CONTOUR
- PERFORATED LEACHATE COLLECTION PIPE
- DRAINAGE CHANNEL
- CULVERT

NOTES

1. PRIMARY, SECONDARY, AND TERTIARY SUMP RISER PIPES ARE NOT SHOWN ON PLAN SHEET FOR CLARITY. PLEASE SEE DETAILS ON SHEETS 801, 802, 803, AND 804 FOR PLAN AND SECTIONS FOR THE PRIMARY, SECONDARY, AND TERTIARY RISER PIPES AND SUMPS.

REFERENCE

1. THE HORIZONTAL COORDINATES ARE BASED ON OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FOOT, NAD83.
2. VERTICAL COORDINATES ARE BASED ON NAVD88.
3. EXISTING TOPOGRAPHY COLLECTED BY MILLER CREEK ASSOCIATES ON APRIL 24, 2019.

PRELIMINARY NOT FOR CONSTRUCTION

SCALE IN FEET: 0 100 200

REVISION RECORD

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4045 NW 64th Street · Suite 415 · Oklahoma City, OK 73116
Ph: 405.246.9411
www.cecinc.com

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST ARLINGTON, OR

TOP OF PROTECTIVE COVER

DATE:	12/11/19	DRAWN BY:	JRW
DWG SCALE:	1"=100'	CHECKED BY:	DVS
PROJECT NO:	194-991		
APPROVED BY:			JS

REGISTERED PROFESSIONAL ENGINEER 92360PE Jeff A. Shepherd OREGON JULY 13, 2017 JEFF A. SHEPHERD 02/07/20 EXPIRES: 06-30-2020

DRAWING NO.: **P-301**

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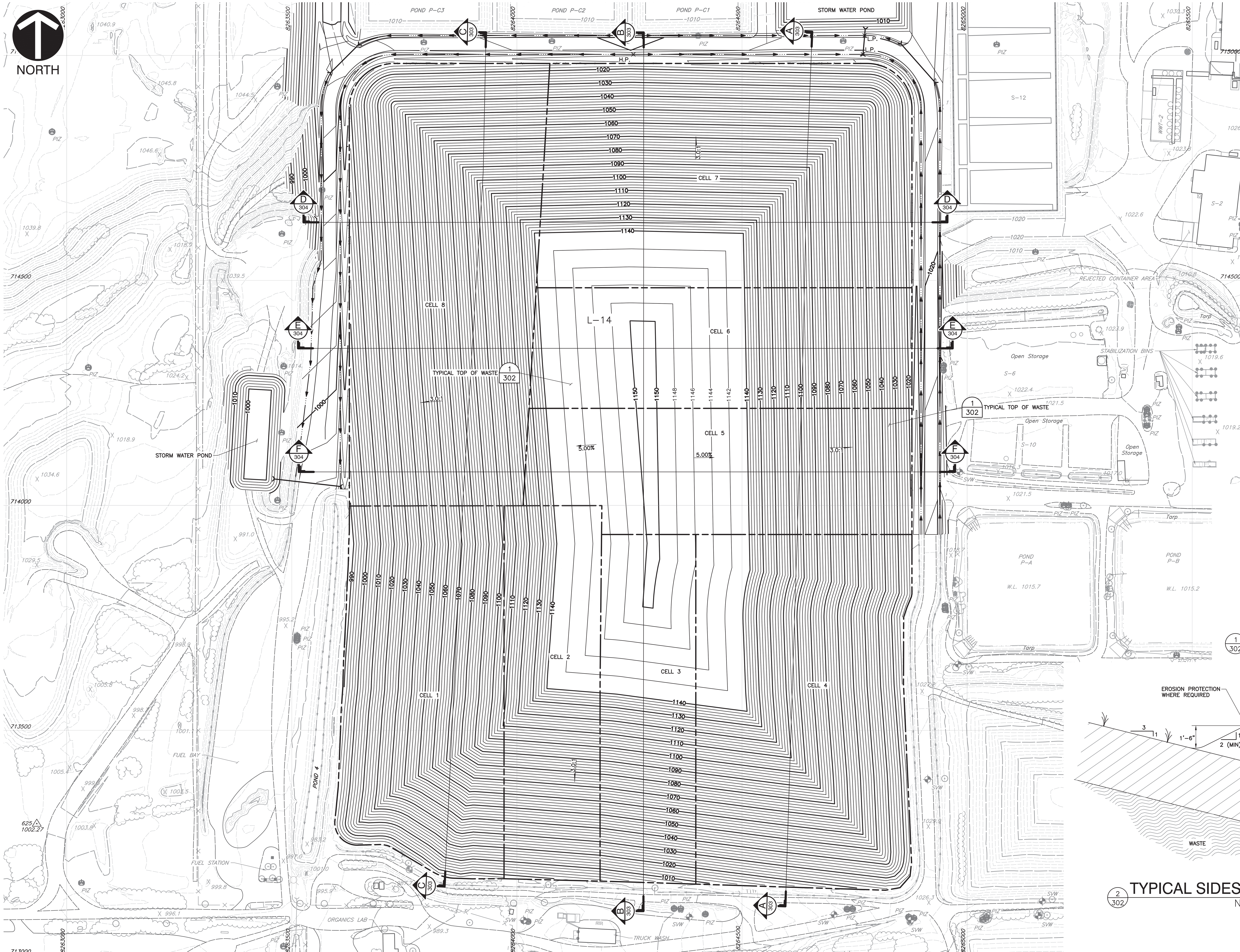

LEGEND

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- EXISTING SPOT ELEVATION
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- EXISTING POST
- EXISTING GUIDE RAIL
- EXISTING TRAIL
- EXISTING SOIL VAPOR WELL
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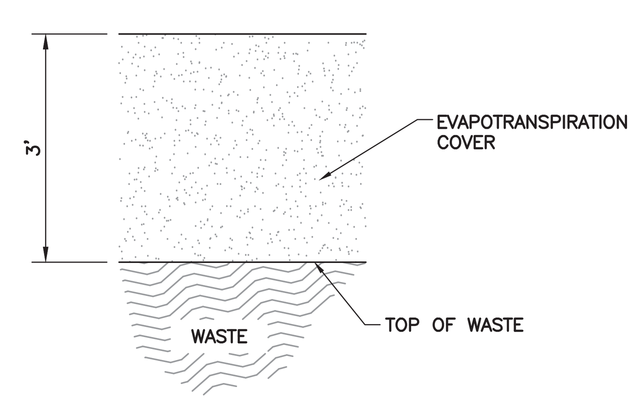
- LANDFILL CELL LIMITS
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- DRAINAGE CHANNEL
- CULVERT



1/302 FINAL COVER SYSTEM
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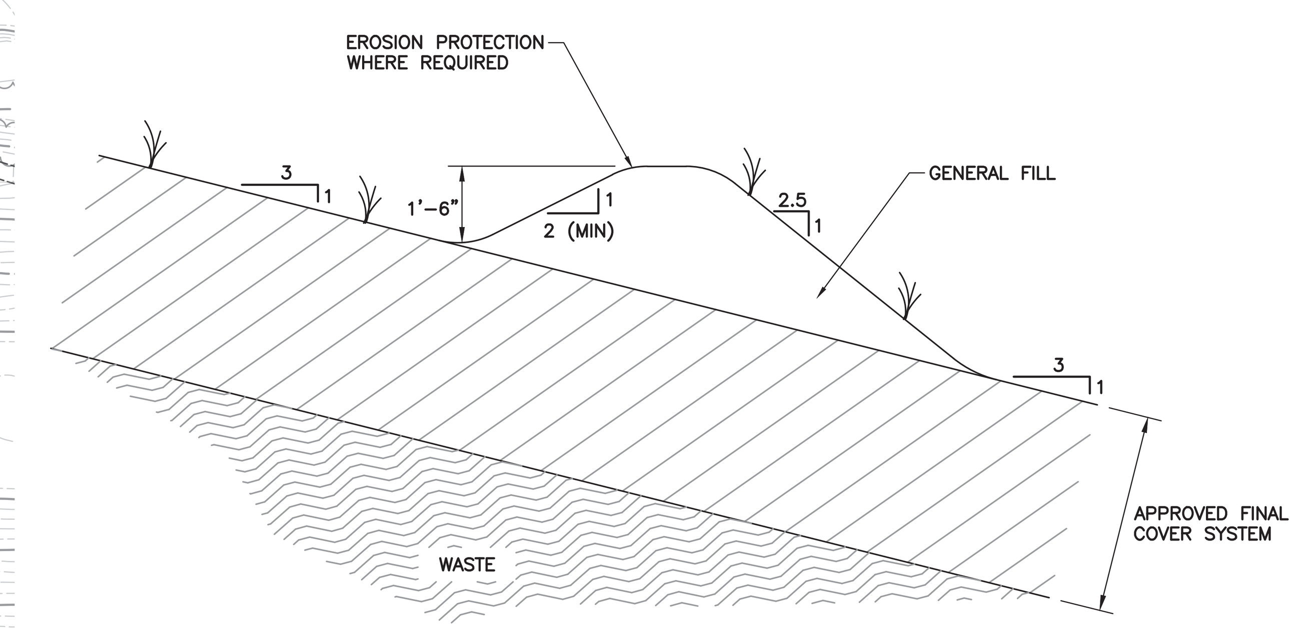

2/302 TYPICAL SIDESLOPE DRAINAGE BERM
NTS

REFERENCE

1. THE HORIZONTAL COORDINATES ARE BASED ON OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FOOT, NAD83.
2. VERTICAL COORDINATES ARE BASED ON NAVD88.
3. EXISTING TOPOGRAPHY COLLECTED BY MILLER CREEK ASSOCIATES ON APRIL 24, 2019.

PRELIMINARY
NOT FOR CONSTRUCTION

SCALE IN FEET
0 100 200

REGISTERED PROFESSIONAL ENGINEER 92360PE
Jeff A. Shepherd
OREGON JULY 13, 2017 JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

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C.A. #6429 EXP. 6/30/20

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

TOP OF WASTE GRADING PLAN

DATE:	12/11/19	DRAWN BY:	JRW
DWG SCALE:	1"=100'	CHECKED BY:	DVS
PROJECT NO:	194-991		
APPROVED BY:	JS		

DRAWING NO.: **P-302**

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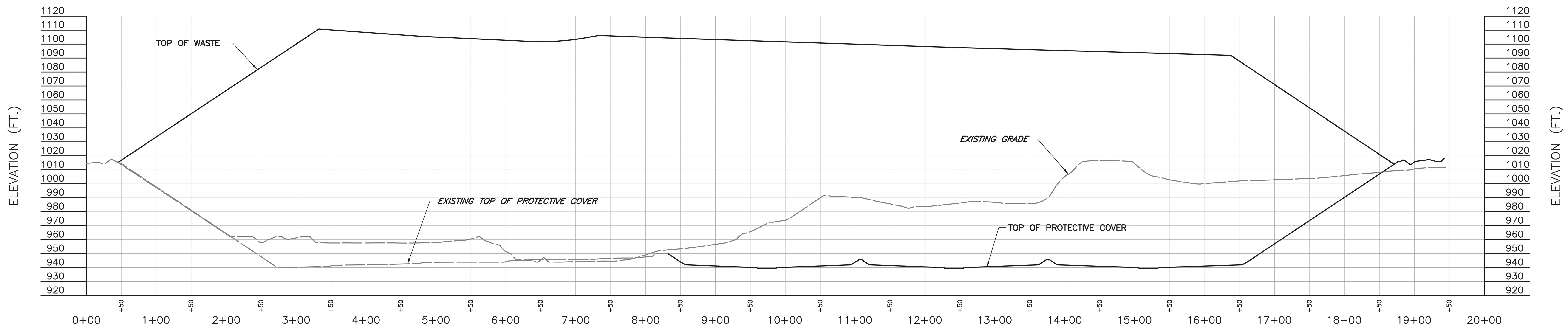

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NORTH/SOUTH CROSS SECTION
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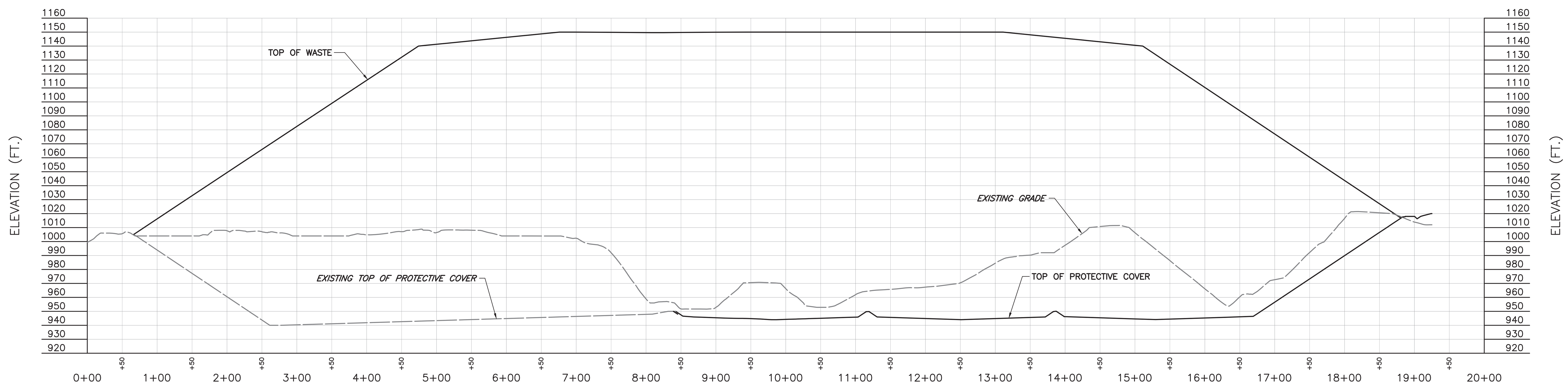

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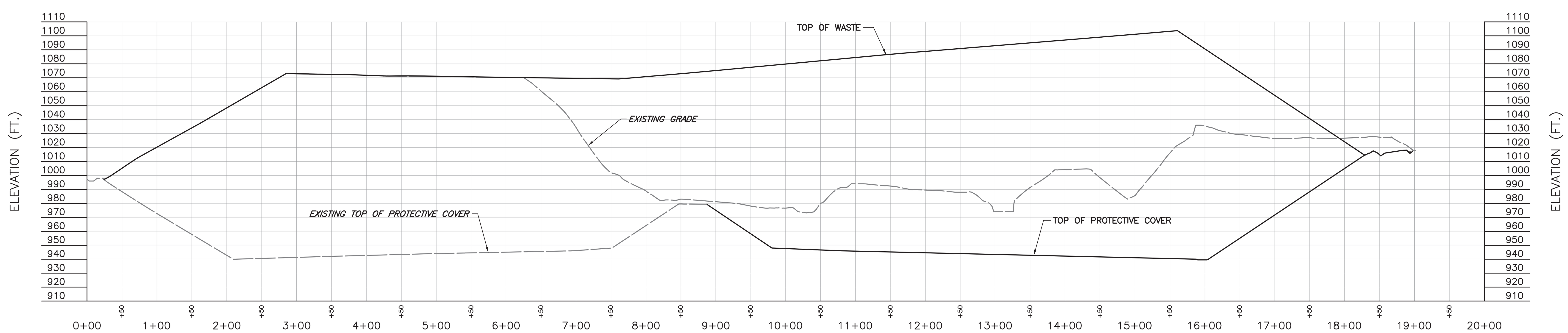

SECTION C
NORTH/SOUTH CROSS SECTION
SCALE H:1"=25'; V:1"=50'

PRELIMINARY
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER 92360PE
Jeff A. Shepherd
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

REVISION RECORD

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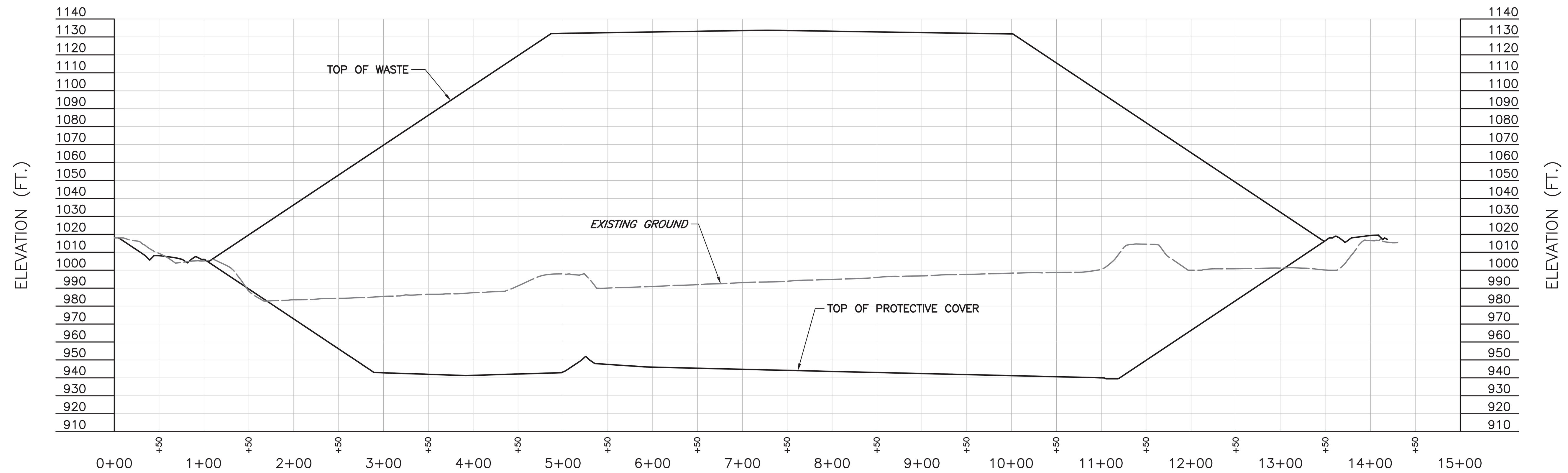
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

LANDFILL CROSS SECTIONS

DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991		
APPROVED BY:	JS		

DRAWING NO.: **P-303**



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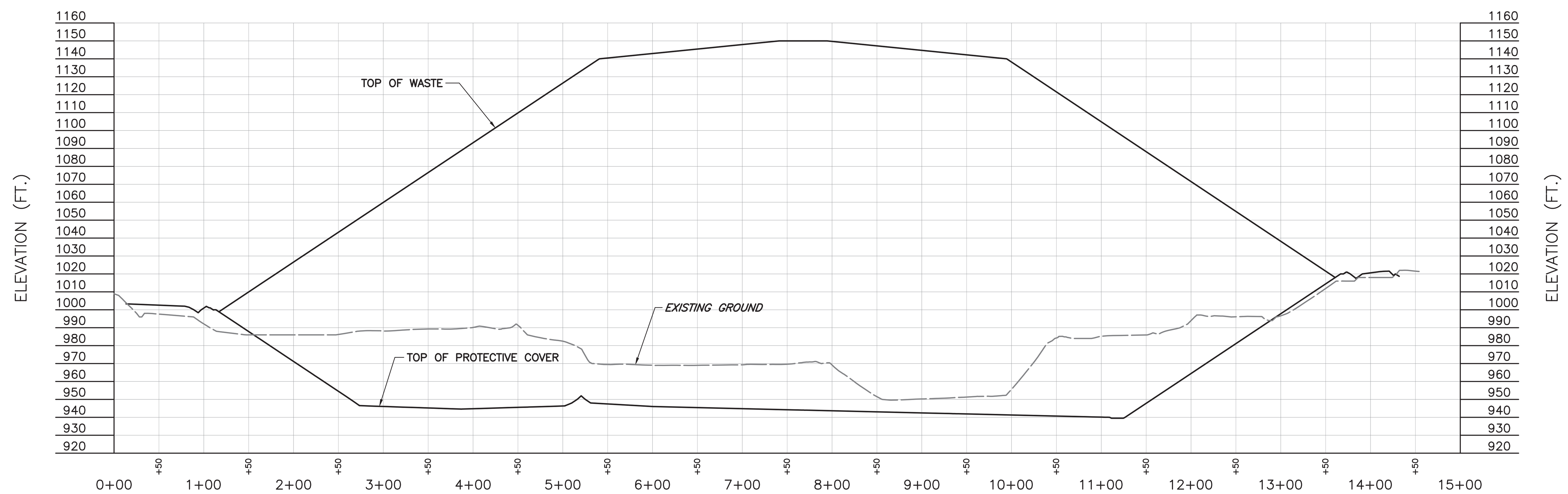

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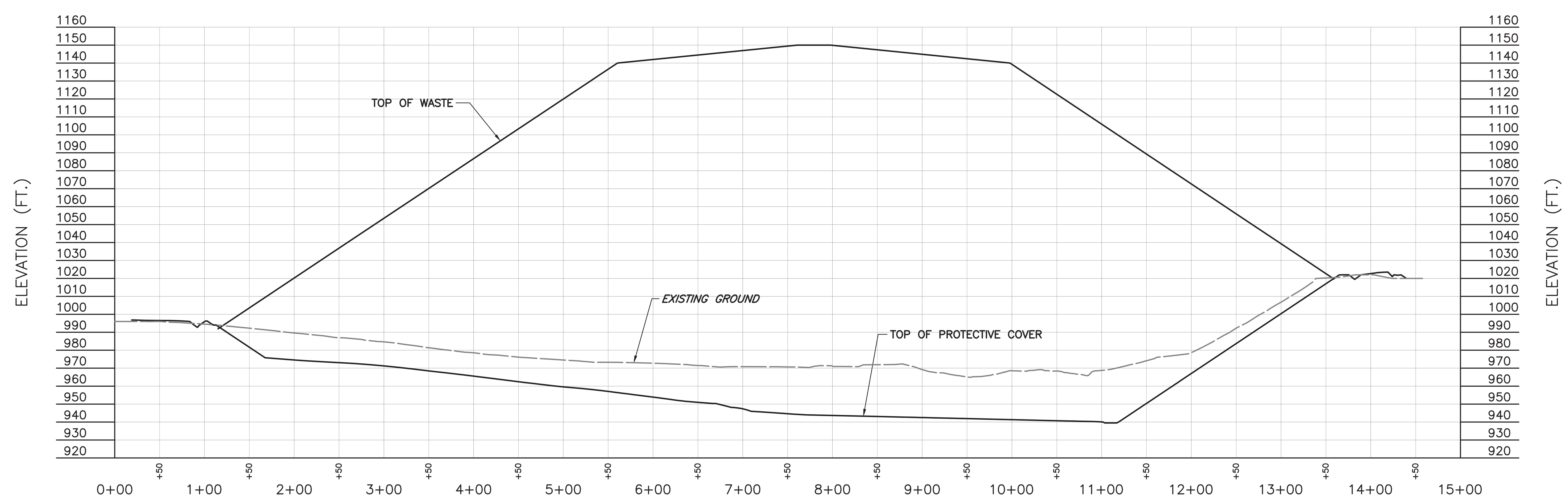

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EAST/WEST CROSS SECTION
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PRELIMINARY
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER 92360PE
Jeff A. Shepherd
OREGON JULY 13, 2017 JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

REVISION RECORD

NO	DATE	DESCRIPTION

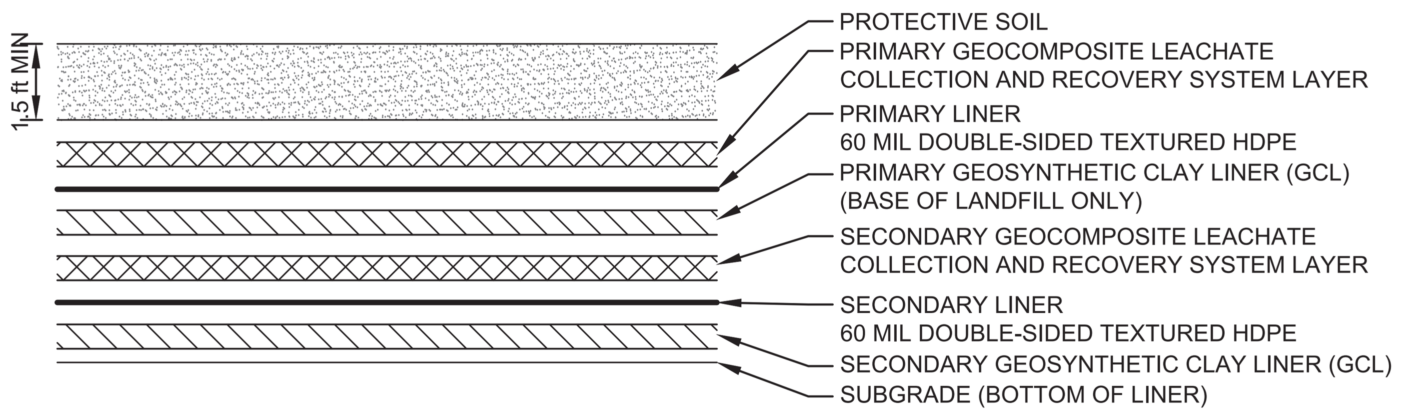
Civil & Environmental Consultants, Inc.
4045 NW 64th Street · Suite 415 · Oklahoma City, OK 73116
Ph: 405.246.9411
www.cecinc.com

CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

LANDFILL CROSS SECTIONS

DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991	APPROVED BY:	JS

DRAWING NO.: **P-304**



BASE LINER AND LEACHATE COLLECTION SYSTEM

1/800 TYPICAL BASE LINER DETAIL
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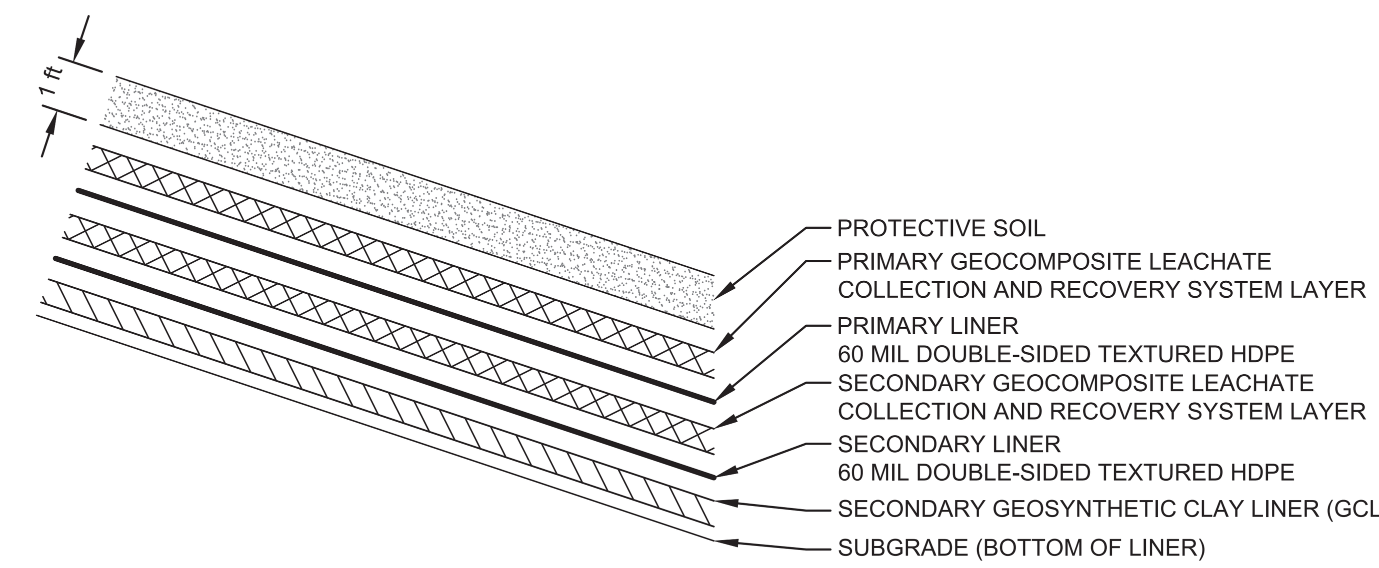

2/800 TYPICAL SIDESLOPE LINER DETAIL
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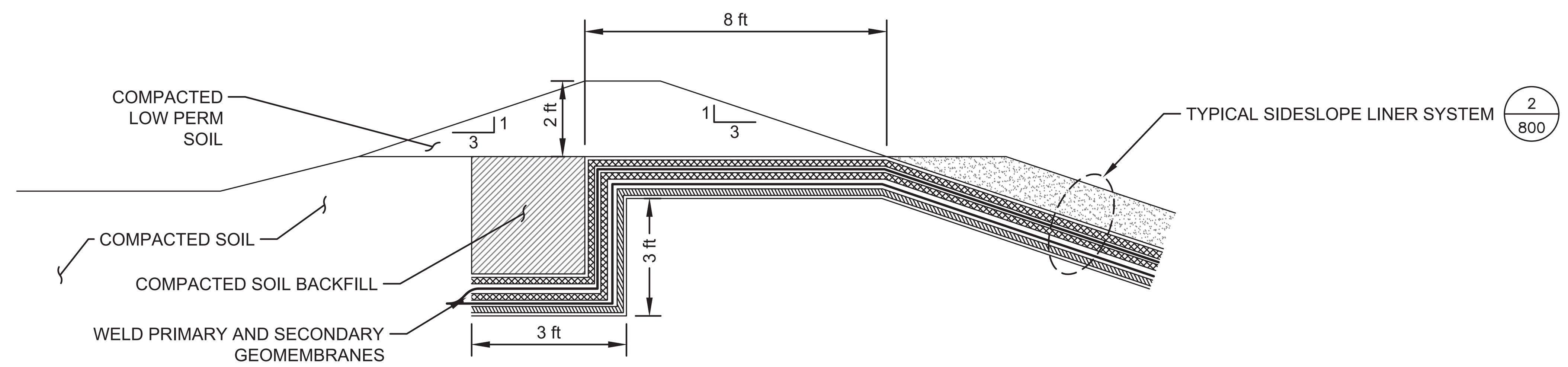

3/800 TYPICAL ANCHOR TRENCH DETAIL
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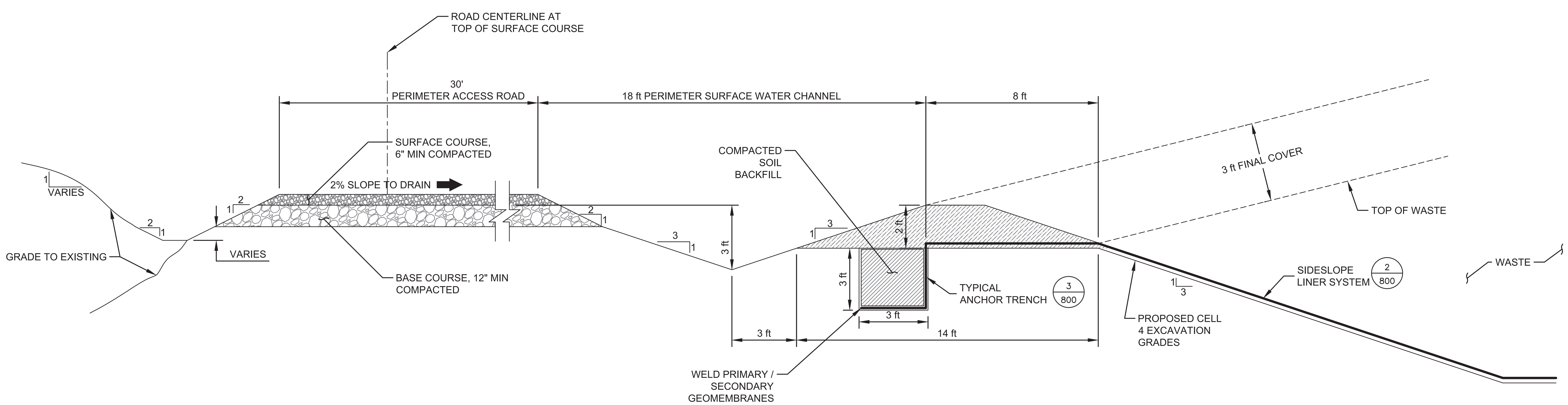


4/800 TYPICAL GRAVEL ROAD SECTION
NTS

PRELIMINARY
NOT FOR CONSTRUCTION

REVISION RECORD
NO	DATE	DESCRIPTION

Civil & Environmental Consultants, Inc.
4045 NW 64th Street · Suite 415 · Oklahoma City, OK 73116
Ph: 405.246.9411
www.cecinc.com

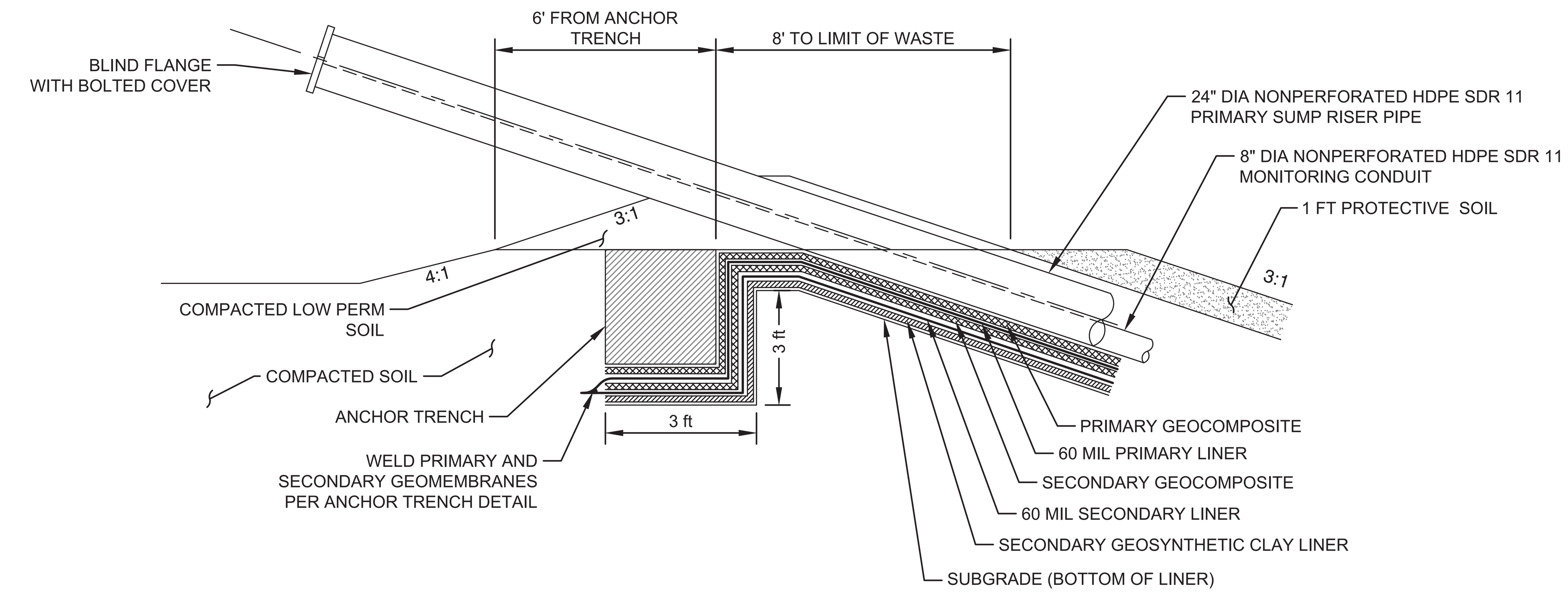
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

LINER SYSTEM AND ANCHOR TRENCH DETAILS

DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO.:	194-991	APPROVED BY:	JS

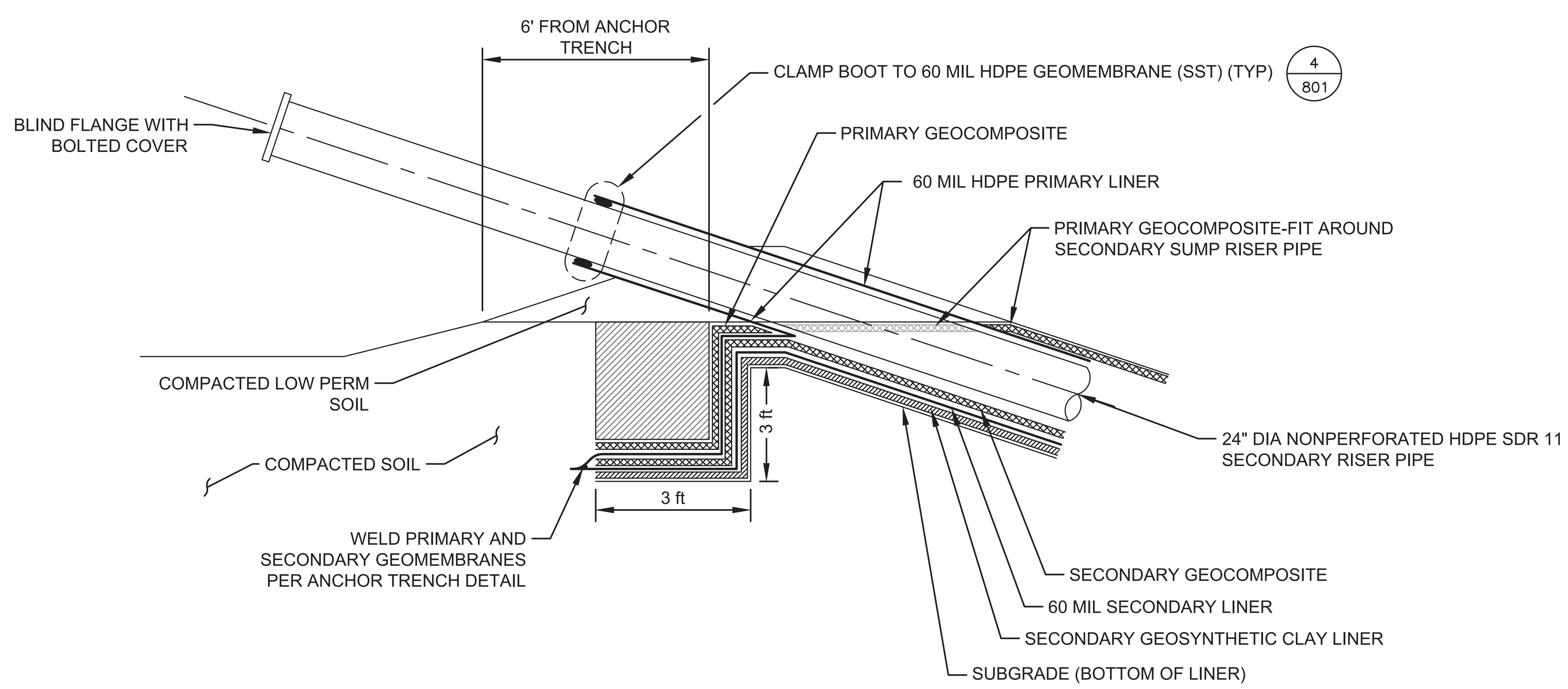
REGISTERED PROFESSIONAL ENGINEER 92360PE
Jeff A. Shepherd
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
EXPIRES: 06-30-2020
02/07/20

DRAWING NO.:
P-800



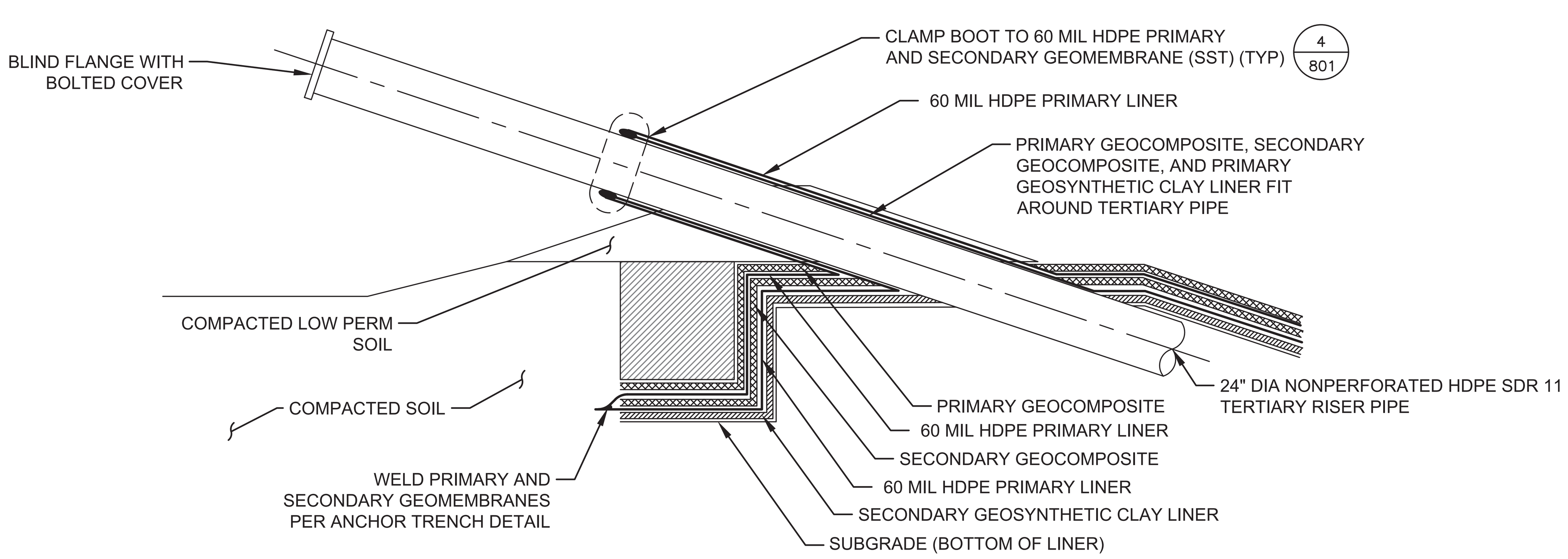
(1/801) TYPICAL PRIMARY SUMP RISER PIPE TERMINATION

NTS



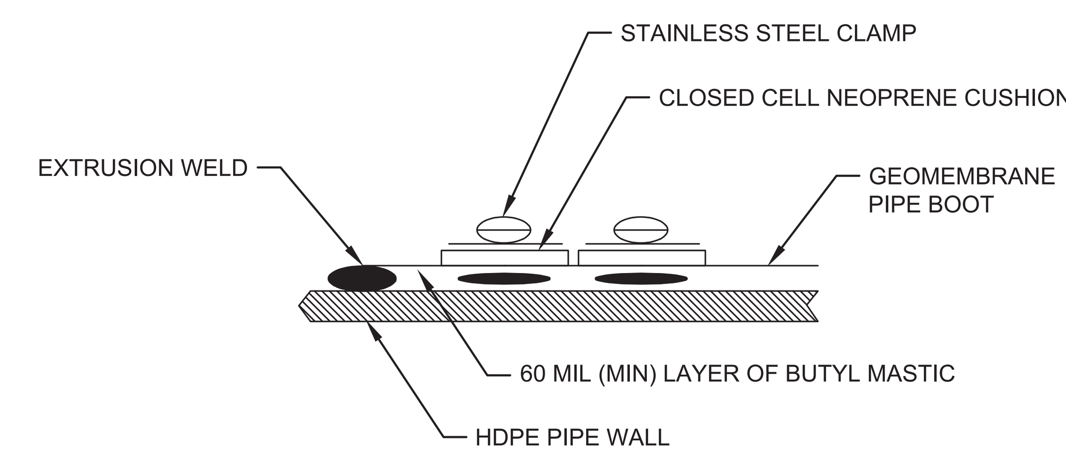
(2/801) TYPICAL SECONDARY SUMP RISER PIPE TERMINATION

NTS



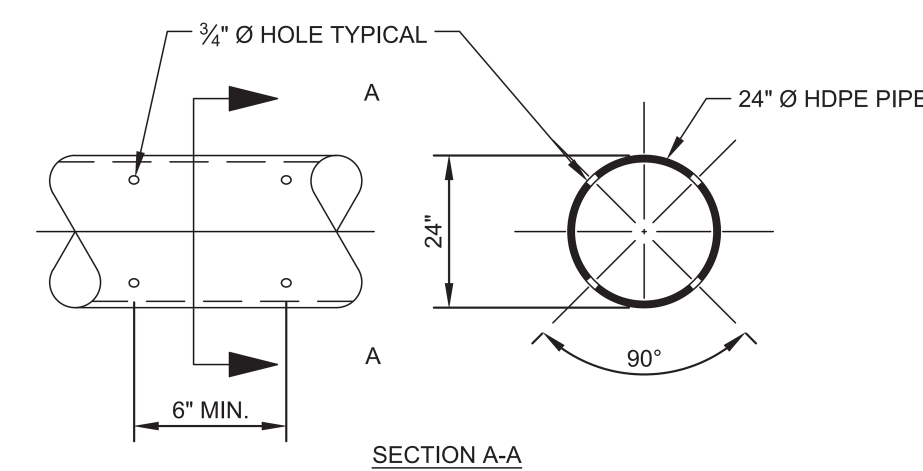
(3/801) TYPICAL TERTIARY SUMP RISER PIPE TERMINATION

NTS



(4/801) CLAMP ASSEMBLY

NTS



(5/801) SUMP PIPE PERFORATION DETAIL

NTS

PRELIMINARY
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER 92360PE OREGON JULY 13, 2017 JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

REVISION RECORD

NO	DATE	DESCRIPTION

Civil & Environmental Consultants, Inc.
4045 NW 64th Street · Suite 415 · Oklahoma City, OK 73116
Ph: 405.246.9411
www.cecinc.com

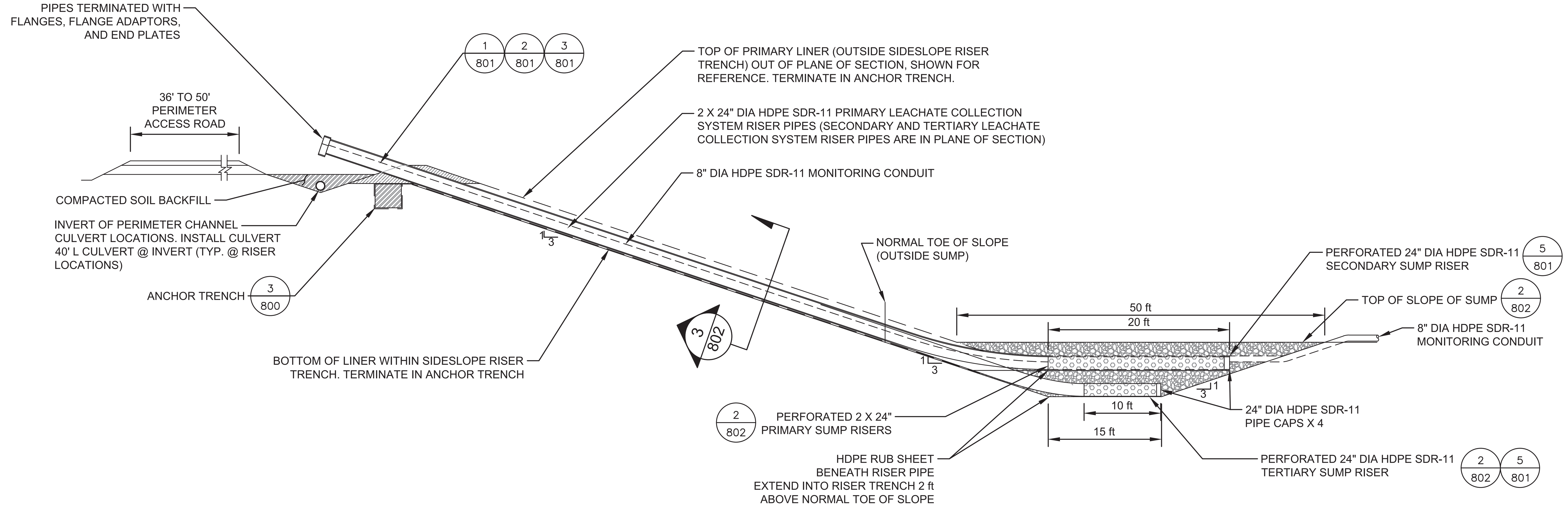
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

RISER PIPE DETAILS

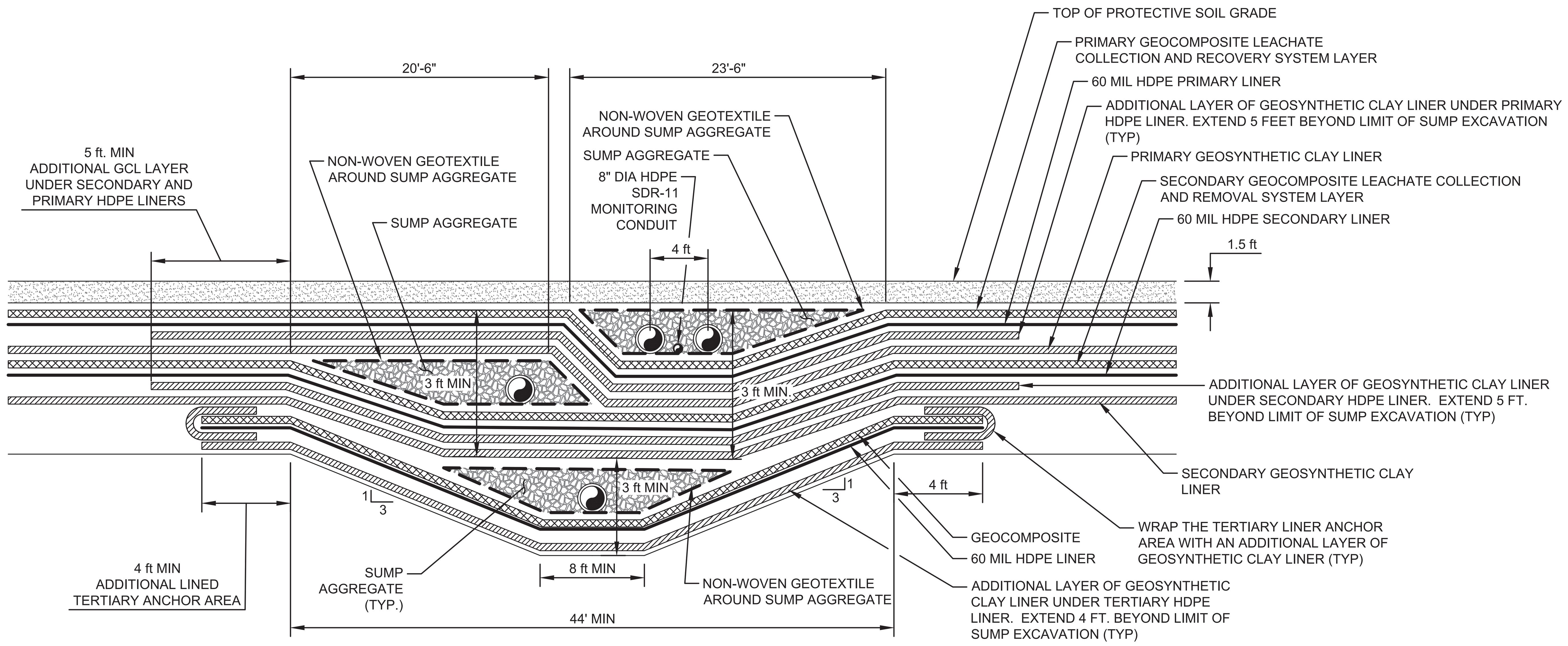
DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991	APPROVED BY:	JS

DRAWING NO.:
P-801

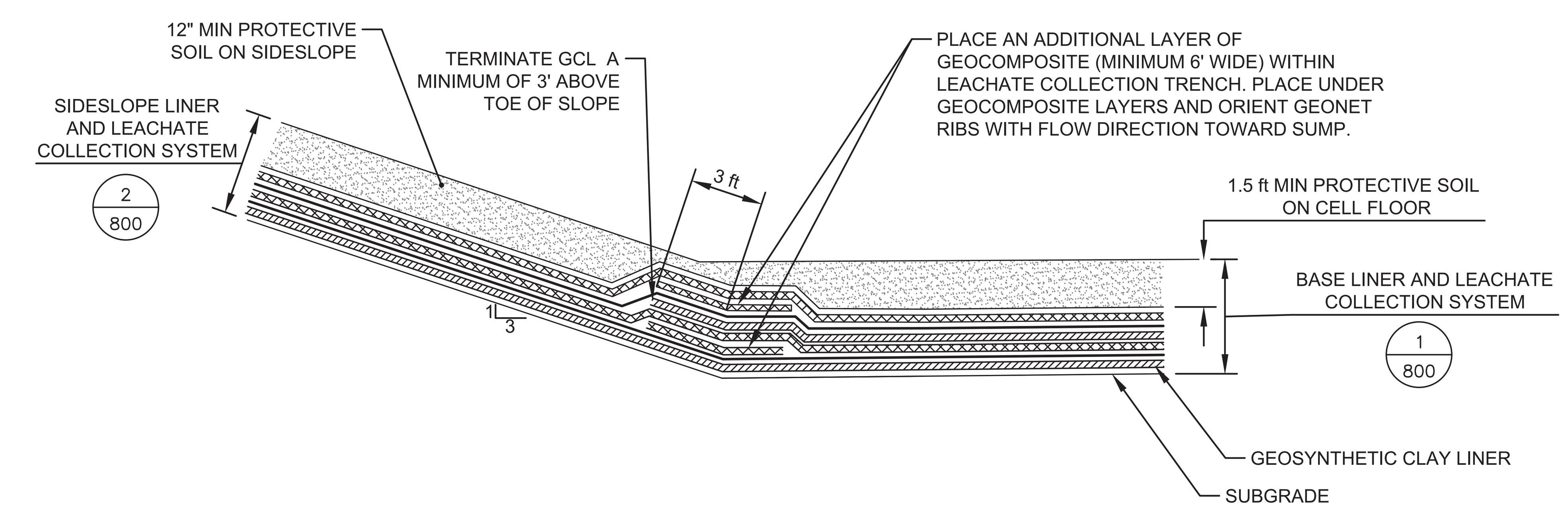
P:\2019\194-991\-CADD\Dwg\CH01\194991-CH01-P-800.dwg{P-801} LS:(2/6/2020 - jwitt) - LP: 2/6/2020 2:26 PM



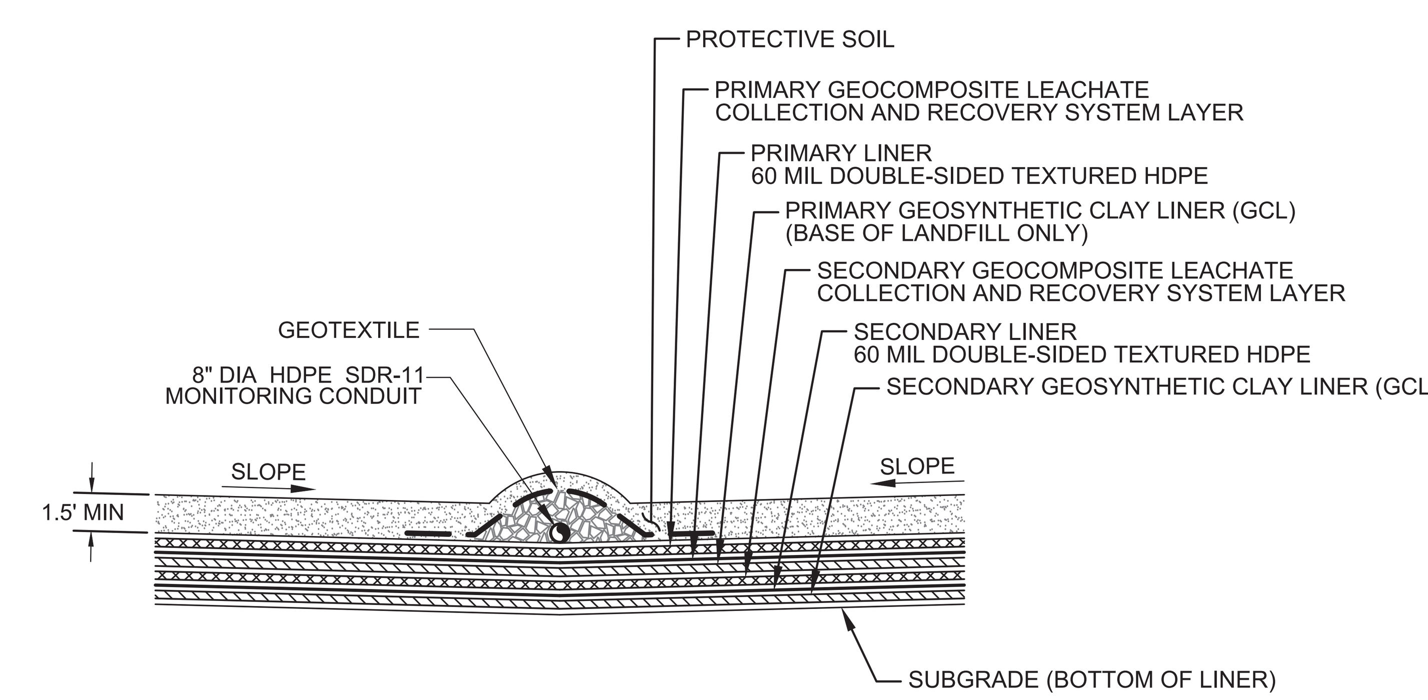
1/802 TYPICAL SUMP RISER TRENCH
NTS



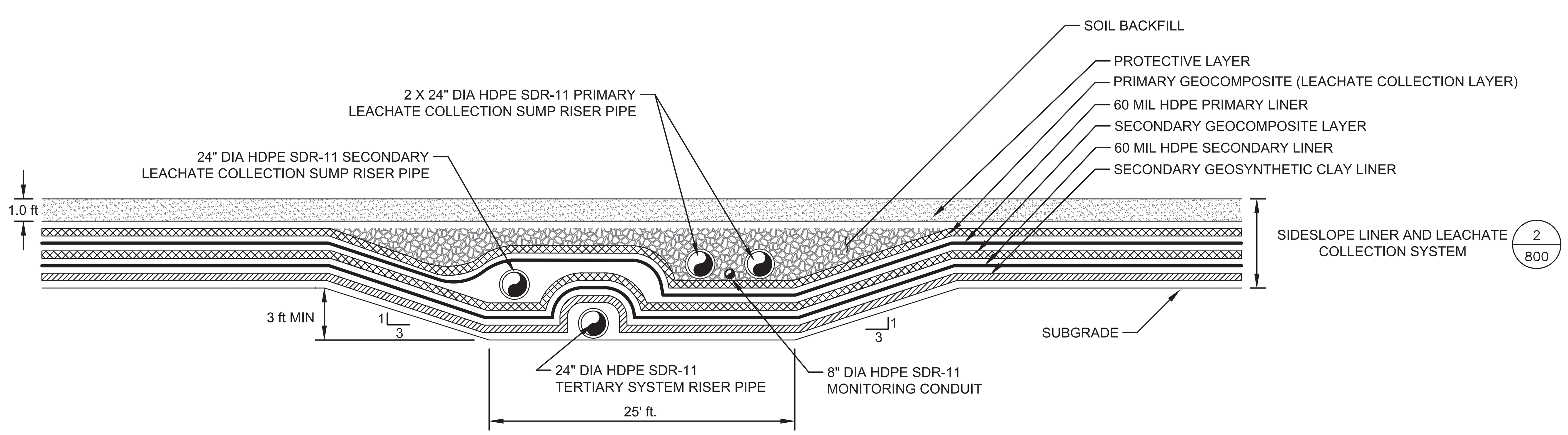
2/802 TYPICAL SUMP CROSS SECTION DETAILS
NTS



4/802 TYPICAL LCRS AT TOE OF SIDESLOPE
NTS



5/802 BASE LINER AND LEACHATE COLLECTION SYSTEM - FLOOR
NTS



3/802 TYPICAL LEACHATE COLLECTION SUMP RISER TRENCH
NTS

PRELIMINARY
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REVISION RECORD

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CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

SUMP AND LEACHATE COLLECTION SYSTEM DETAILS

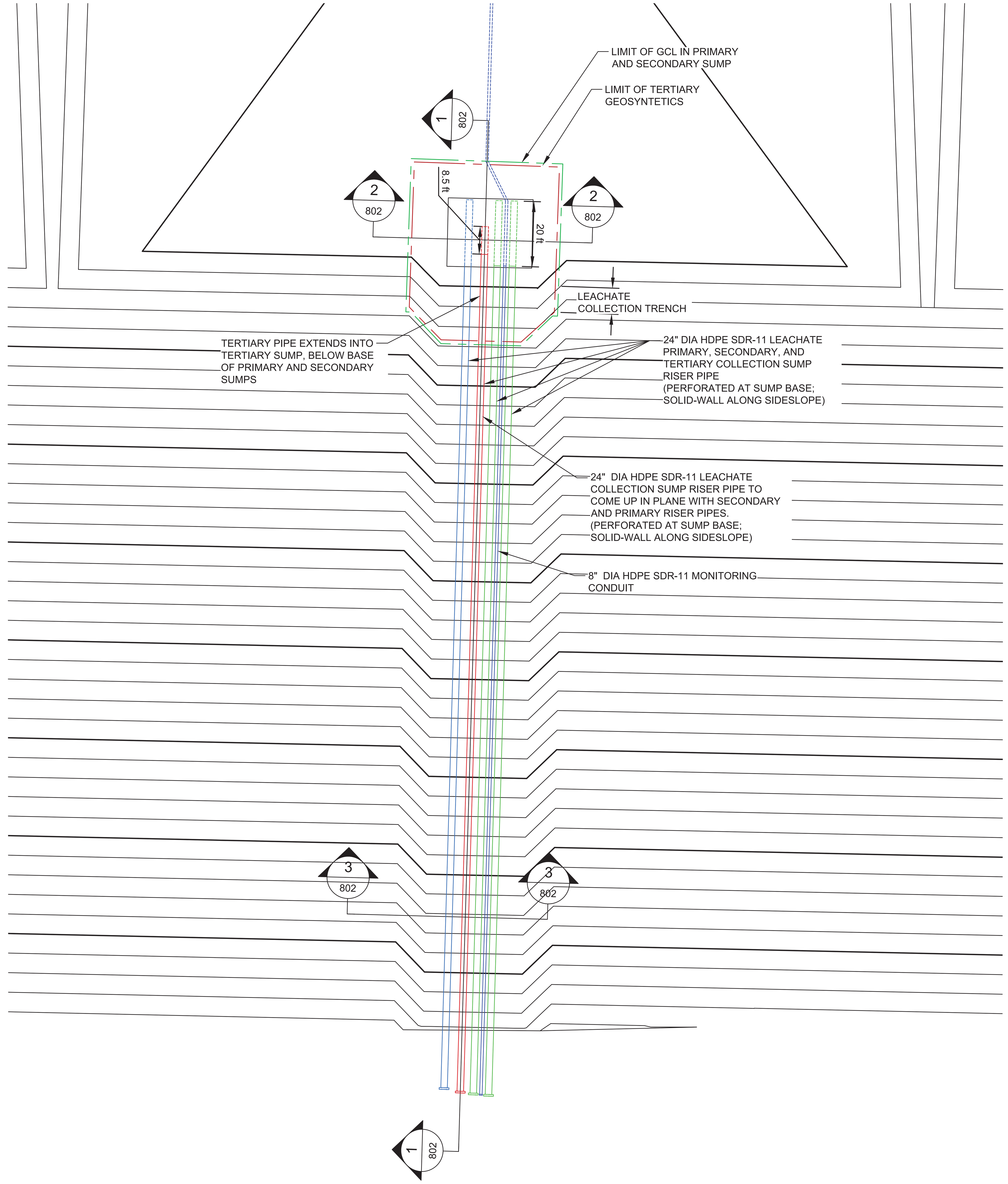
DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991	APPROVED BY:	JS

REGISTERED PROFESSIONAL ENGINEER 92360PE OREGON JULY 13, 2017 JEFF A. SHEPHERD
EXPIRES: 06-30-2020
02/07/20

DRAWING NO.: P-802

LEGEND

- PROPOSED GRADE (2' AND 10' CONTOURS)
- TERTIARY SUMP GEOSYNTHETIC LIMITS
- PRIMARY AND SECONDARY SUMP GEOSYNTHETIC LIMITS
- 24" PRIMARY SUMP RISER PIPE (DASHED WHERE PERFORATED)
- 24" SECONDARY SUMP RISER PIPE (DASHED WHERE PERFORATED)
- 24" TERTIARY SUMP RISER PIPE (DASHED WHERE PERFORATED)
- 8" MONITORING CONDUIT (DASHED WHERE PERFORATED)



1/803 TYPICAL SUMP LAYOUT

SCALE IN FEET: 0 20 40

PRELIMINARY NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER 92360PE OREGON JULY 13, 2011 JEFF A. SHEPHERD — Jeff A. Shepherd — 02/07/20 — EXPIRES: 06-30-2020

REVISION RECORD — NO | DATE | DESCRIPTION

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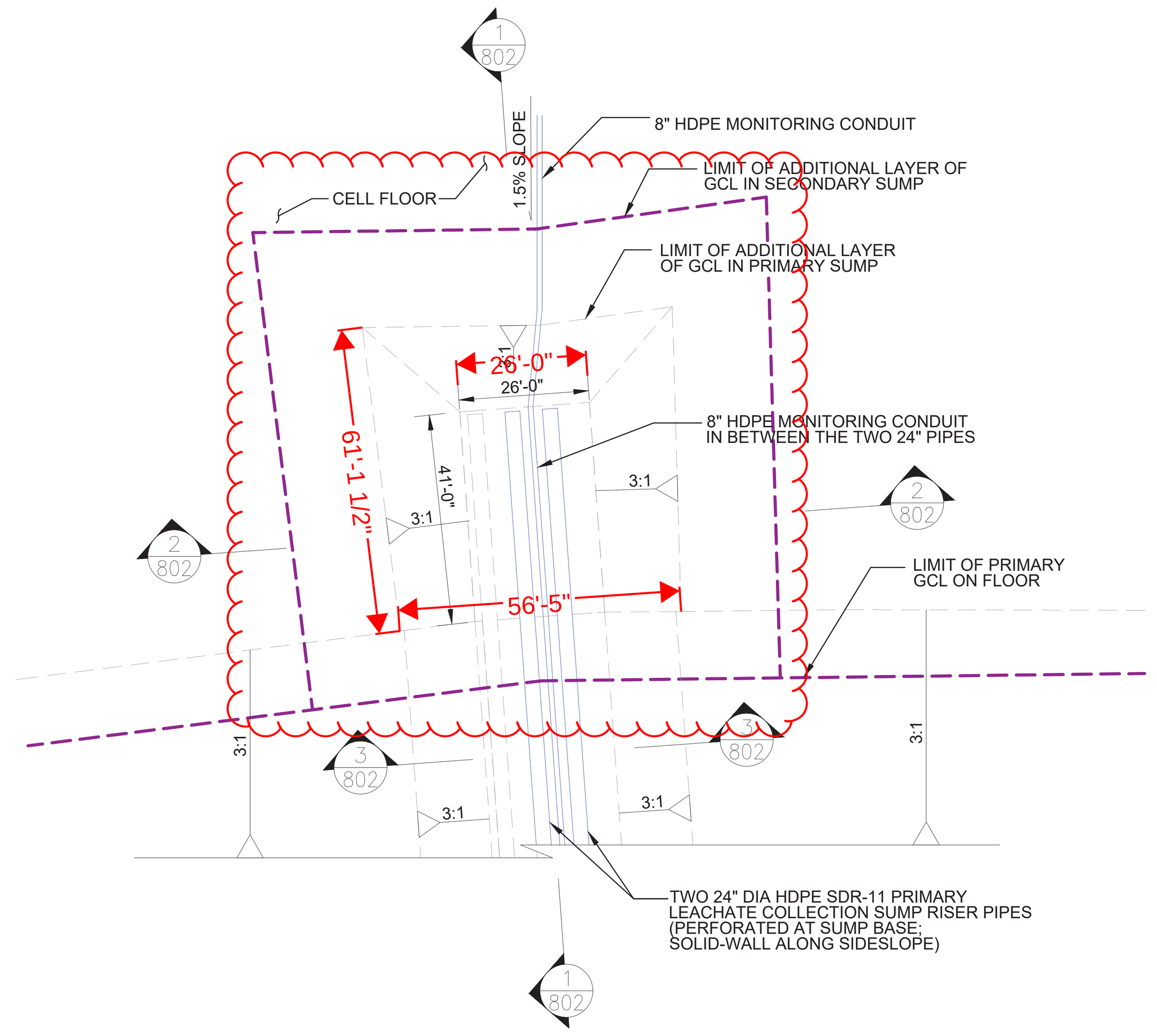
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

SUMP AND SIDESLOPE RISER PIPE LAYOUT

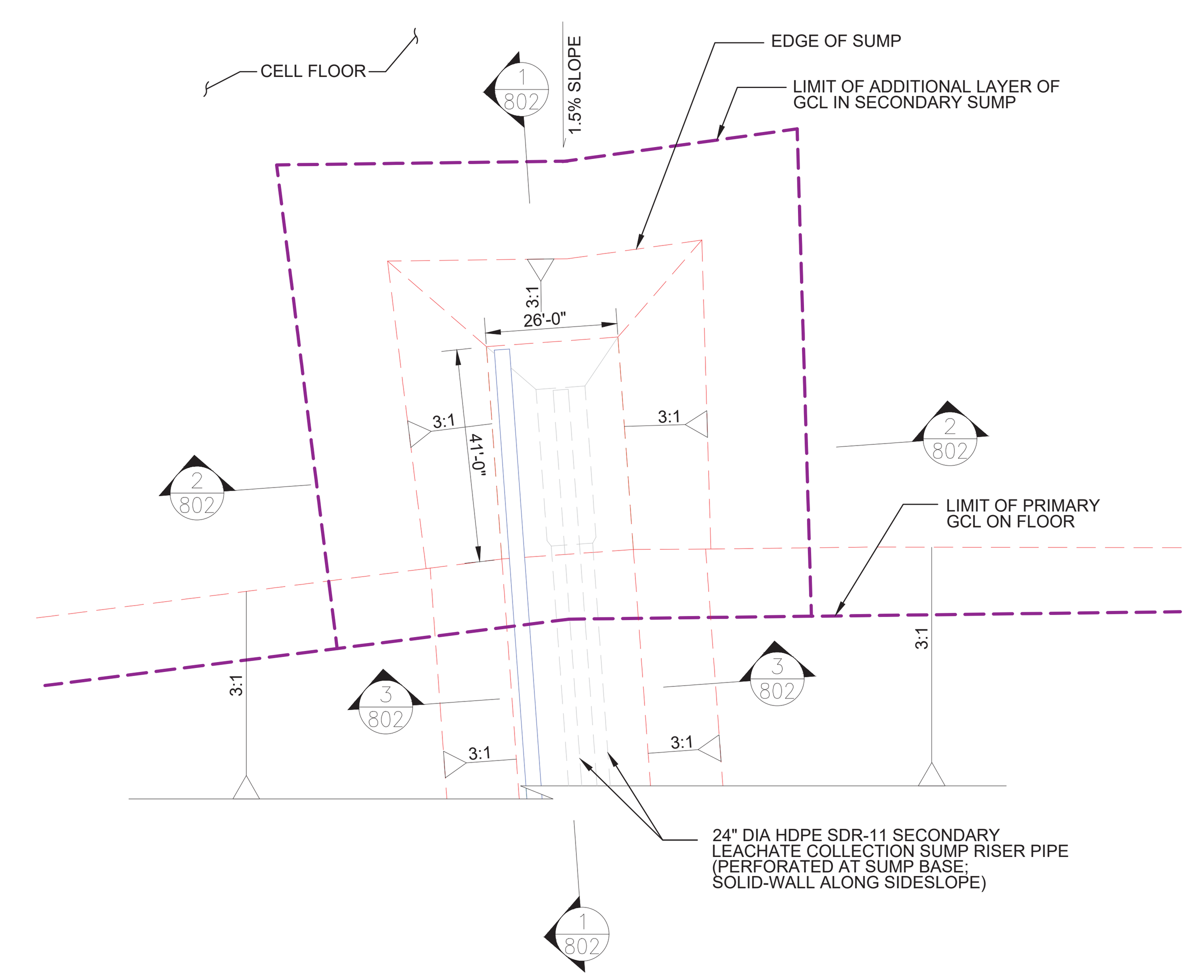
DATE:	12/11/19	DRAWN BY:	DVS
DWG SCALE:	AS SHOWN	CHECKED BY:	DVS
PROJECT NO:	194-991	APPROVED BY:	JS

DRAWING NO.: P-803

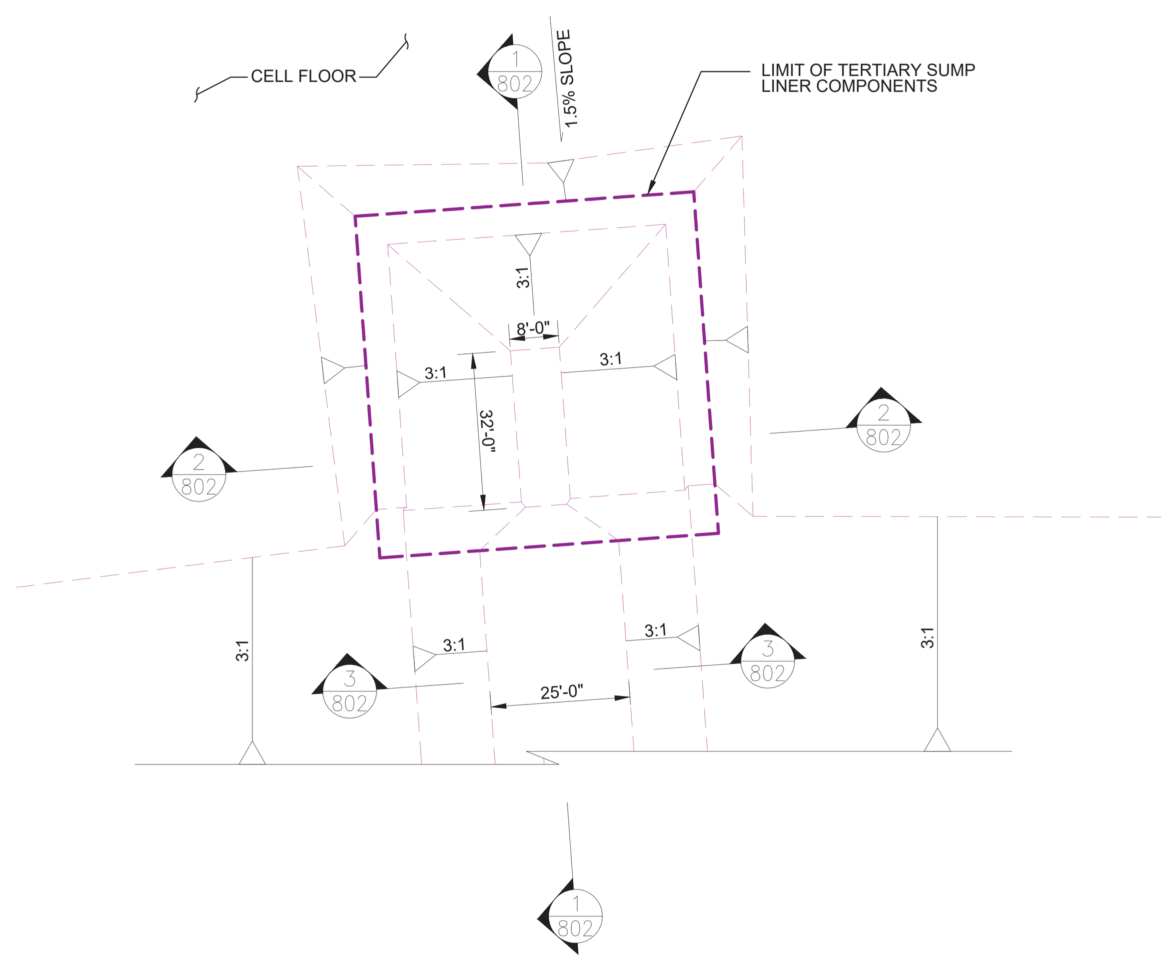


① 805 PRIMARY COLLECTION SYSTEM SUMP
NTS

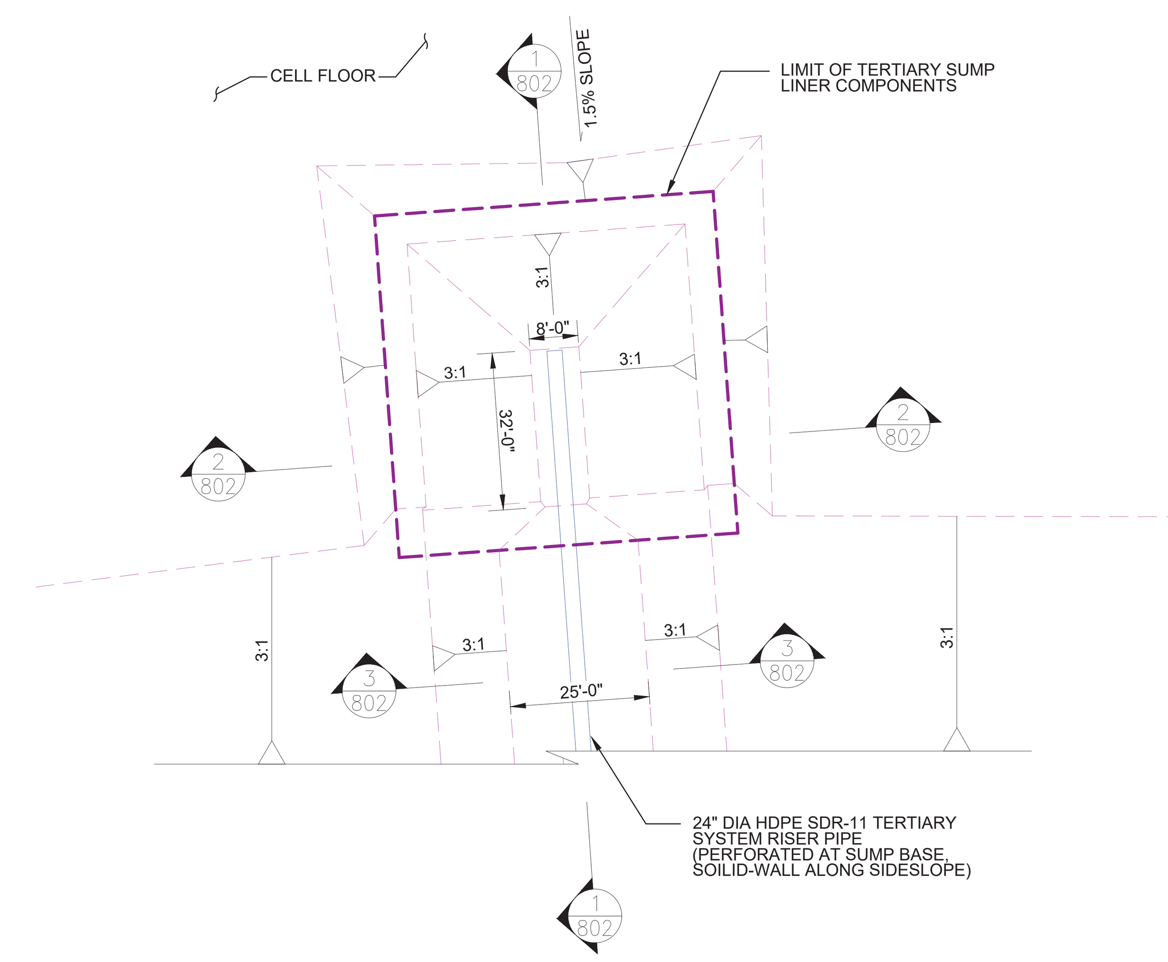
NOTE
1. SECONDARY PIPING AND BREAK LINES SHOWN 50% FOR REFERENCE.



② 805 SECONDARY LINER SYSTEM SUMP
NTS



③ 805 TOP OF SUBGRADE
NTS



④ 805 TERTIARY SUMP
NTS

NOTE
1. THE SUMPS ARE THE SAME SIZE IN CELLS 5, 6, 7, AND 8.

PRELIMINARY
NOT FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER 92360PE Jeff A. Shepherd OREGON JULY 13, 2017 JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

REVISION RECORD

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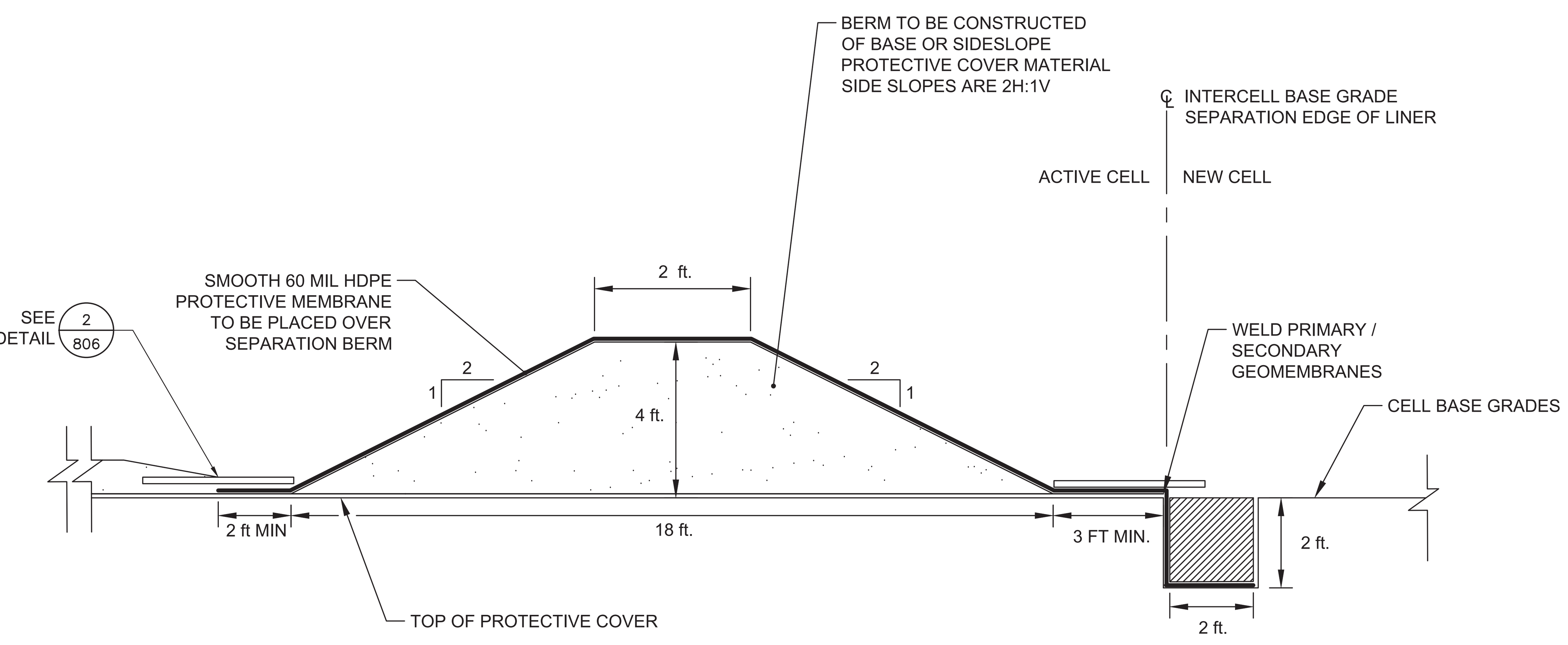
CHEMICAL WASTE MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

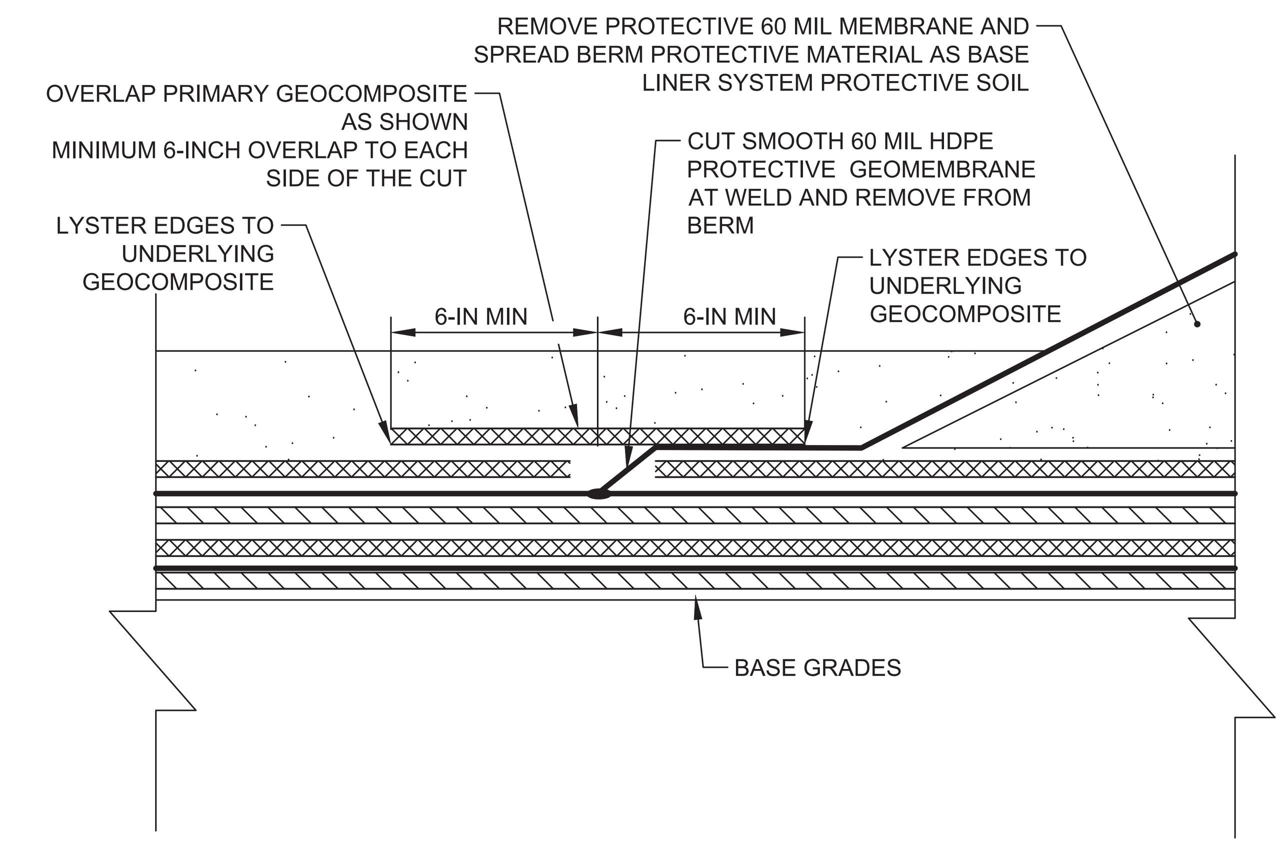
SUMP LAYOUT DETAILS

DATE: 12/11/19	DRAWN BY: DVS	DWG SCALE: AS SHOWN	CHECKED BY: DVS
PROJECT NO: 194-991	APPROVED BY: JS		

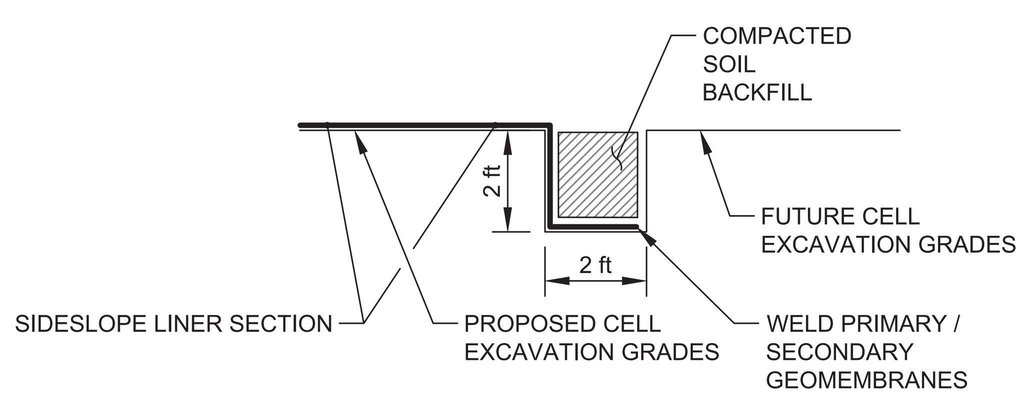
DRAWING NO.: P-804



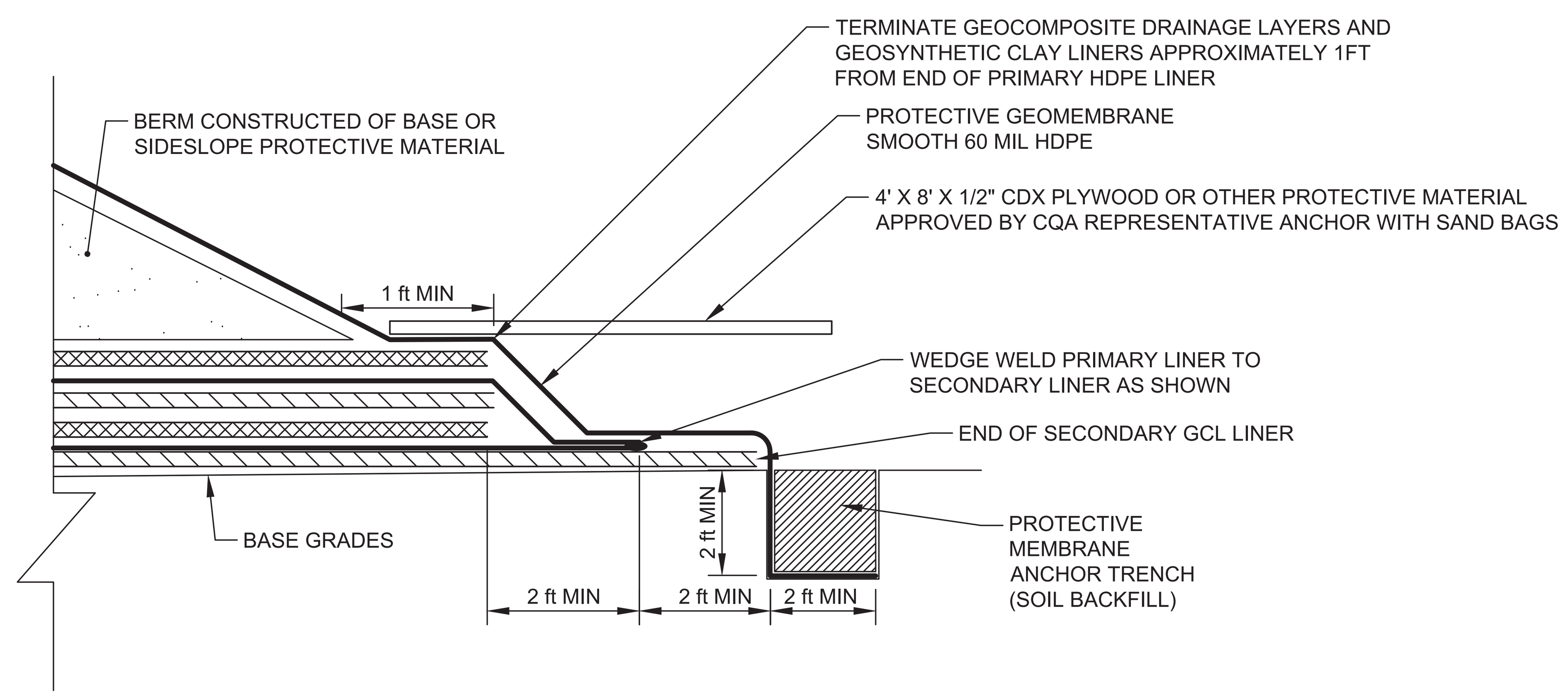
1/806 TYPICAL INTERCELL BERM
NTS



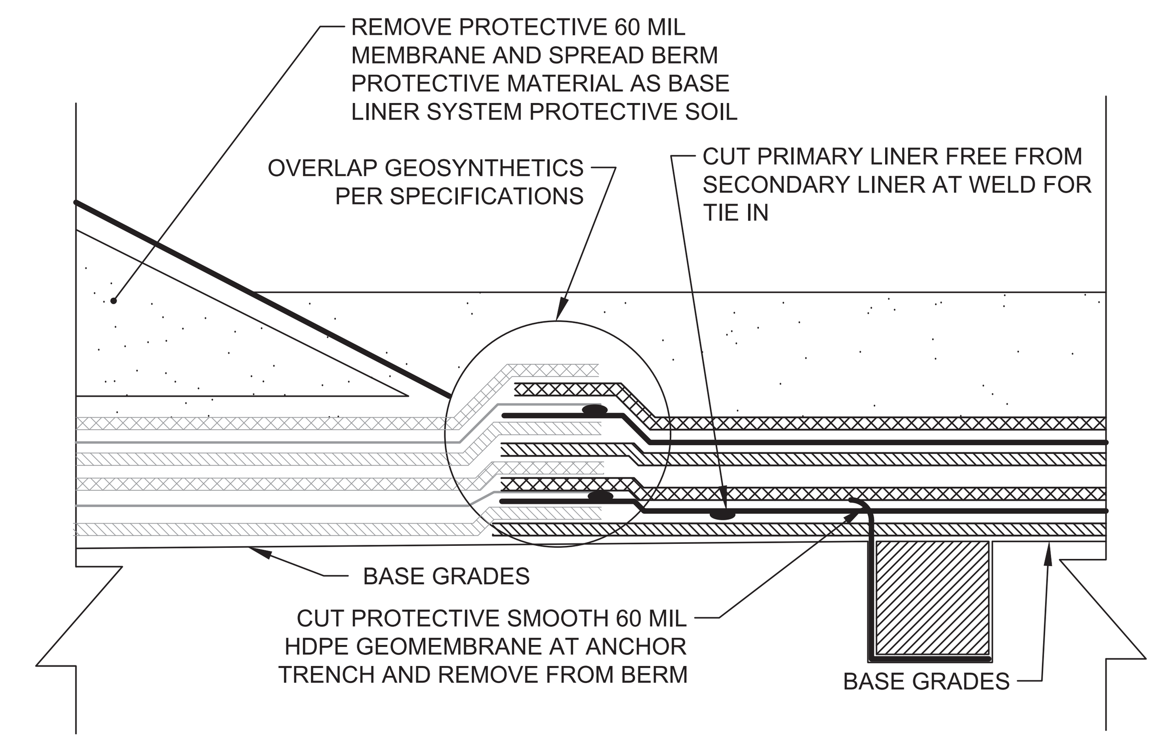
2/806 TYPICAL INTERCELL BERM TERMINTATION AND PRIMARY GEOCOMPOSITE REPAIR
NTS



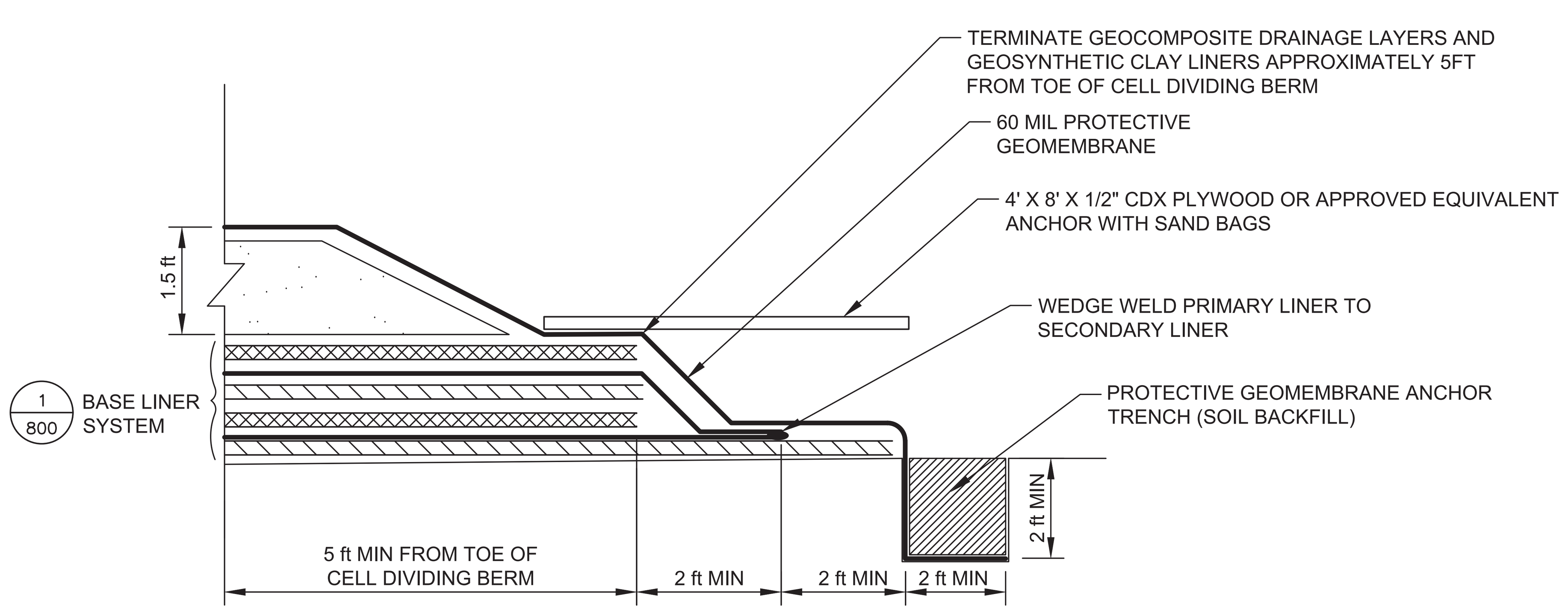
TYPICAL INTERCELL AND CELL SIDESLOPE TERMINATION
3/806
NTS



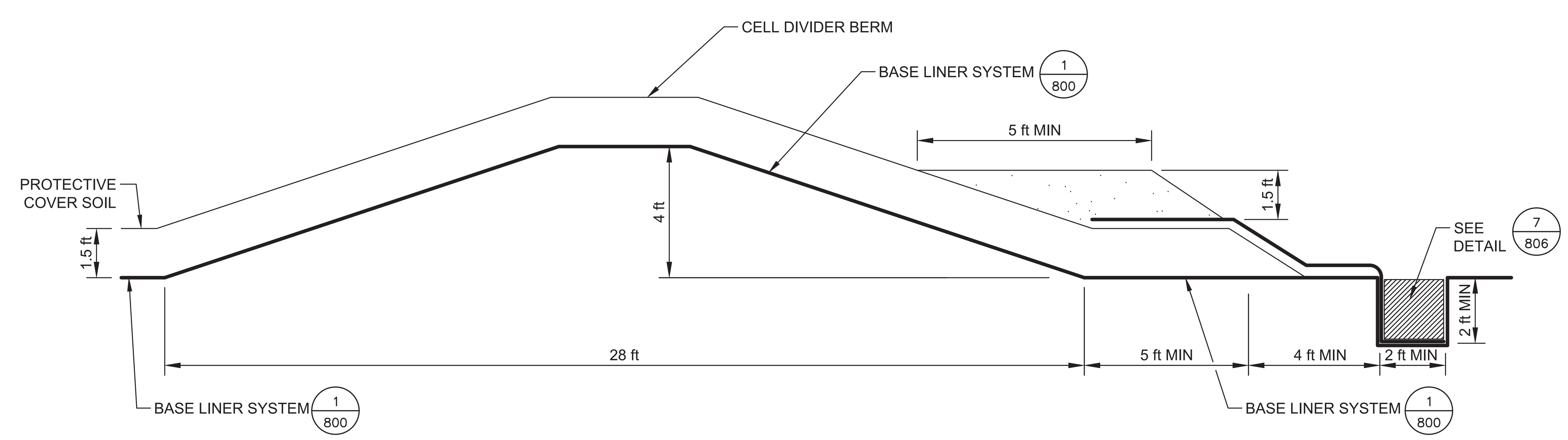
4/806 TYPICAL INTERCELL BASE LINER TERMINATION DETAIL
NTS



5/806 TYPICAL BASE LINER TIE IN
NTS



6/806 TYPICAL BASE LINER TERMINATION - CELL DIVIDING BERM
NTS



7/806 TYPICAL CELL DIVIDING BERM
NTS

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CHEMICAL WASTE
MANAGEMENT OF THE NORTHWEST
ARLINGTON, OR

LINER TERMINATION DETAILS

DATE: 12/11/19	DRAWN BY: DVS	DWG SCALE: AS SHOWN	CHECKED BY: DVS
PROJECT NO: 194-991	APPROVED BY: JS		

REGISTERED PROFESSIONAL ENGINEER
92360PE
Jeff A. Shepherd
OREGON
JULY 13, 2017
JEFF A. SHEPHERD
02/07/20
EXPIRES: 06-30-2020

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWING NO.:
P-805