**RESPONSE 43**

# APPENDIX III-3F-3A

# UNDERDRAIN SEEPAGE CALCULATION

## UNDERDRAIN SEEPAGE CALCULATION

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**INTENDED FOR PERMITTING PURPOSES ONLY**

### 1.0 OBJECTIVE

Use finite element analyses to model seepage and estimate the potential water pressure buildup beneath the Temple Recycling and Disposal Facility (TRDF) expansion area liner system. Design the underdrain system to limit build-up of water pressure under the worst-case seepage conditions.

### 2.0 METHOD

### 2.1 Site Conditions

The subsurface stratigraphy of the site includes three units, Stratum I, II, and III. These units are comprised of: stiff to hard, low to high plasticity clays (Stratum I); weathered, extremely weak to weak claystone (Stratum II); and slightly weathered to fresh, weak to strong claystone (Stratum III). Based upon an evaluation of the soil boring and groundwater data from site investigations, there is a preferential flow pathway for groundwater at and above the Stratum II/III interface because Stratum III is not hydraulically connected to Stratum II and acts as the local aquaclude dividing the upper water bearing unit from lower aquifers. The Stratum II thickness below the Proposed Tract 5 area of the landfill floor varies from 0 to 8 ft with an average thickness of 4 ft. Stratum II thickness below the Tract 1C Cell 1 varies from 0 to 3 ft.

### 2.2 Finite Element Analysis Methodology

Two generalized stratigraphies were modeled using a finite element program (SEEP/W): (i) 4 ft thick Stratum II underlying the liner system on the cell floor, and (ii) 8 ft thick Stratum II underlying the liner system on the cell floor. Each model was run with varying boundary conditions to compare the effect the hydraulic head varying in distance from the sideslope excavation.

### 3.0 CALCULATIONS

### 3.1 Soil Parameters

Permeability parameters were determined by measuring the hydraulic conductivity of the soils with a flexible wall permeameter (ASTM Test Method D5084). Details on TRDF's soil stratum properties are available in the Geology Report in Part III, Attachment 4.

| Stratum Number | Horizontal Permeability, $K_x$ (cm/s) | Horizontal Permeability, $K_x$ (ft/s) | Vertical Permeability, $K_y$ (cm/s) | Vertical Permeability, $K_y$ (ft/s) | $K_y/K_x$ Ratio |
|---|---|---|---|---|---|
| I | 3.91E-08 | 1.28E-09 | 1.10E-07 | 3.61E-09 | 2.820 |
| II | 9.10E-07 | 2.98E-08 | 1.57E-08 | 5.15E-10 | 0.017 |
| III | 2.29E-09 | 7.51E-11 | 1.69E-08 | 5.55E-10 | 7.390 |

## 3.2 Critical Cross Sections

The critical cross-section will occur along the portion of the TRDF with the thickest layer of Stratum II underlying the Compacted Clay Liner (CCL). The thickest layer of Stratum II underlying the CCL is 8 ft, but does not extend evenly along the entire length of the TRDF floor. Two SEEP/W simplified configurations were modeled, assuming that the Stratum II layer is a consistent thickness. These critical cross sections have 4-ft and 8-ft thick Stratum II layers underlying the TRDF floor, conservatively representing the average and worst-case conditions, respectively.

## 3.3 Boundary Conditions

### *3.3.1 Sideslope Underdrain and Compacted Clay Liner (CCL)*

A geocomposite underdrain layer will be placed along the sideslope to intercept, collect, and transmit groundwater to the toe of the slope. The sideslope underdrain was modeled as a seepage face; i.e. a free draining surface with no positive pore pressures. The CCL was modeled as an impenetrable boundary.

### *3.3.2 Total Head*

A total head boundary was set to represent hydrostatic groundwater conditions 8 ft below existing grade (at el. 560 ft). The average depth of the water level below existing grade is 10 ft in Tract 5 and 11 ft in Tract 1C. Setting the total head boundary to represent 8 ft below existing grade creates a conservative analysis. The horizontal distance from the excavation slope crest to the total head boundary varies from 30 to 80 ft. This variation was introduced to identify the effect of the horizontal distance of the total head boundary from the excavation slope.

### *3.3.3 Toe Drain*

The toe drain was modeled as a sink (a node assigned P=0). A sink models a condition in which all water seeping into it is removed before creating a presure condition.

## 4.0 RESULTS

Two geometry configurations were used in the SEEP/W analyses: (i) 4-ft Stratum II thickness, and (ii) 8-ft Stratum II thickness. Each configuration was modeled with the constant head boundary 80 ft from the excavation crest as well as 30 ft from the excavation crest. Section 4.1 presents the groundwater flows that may occur along the excavated slope, at the toe, and combined flow into the toe drain for both configurations. Section 4.2 plots the pore-water pressure along the TRDF expansion floor for the four geometry and boundary condition combinations. Section 4.3 presents the SEEP/W output figures.

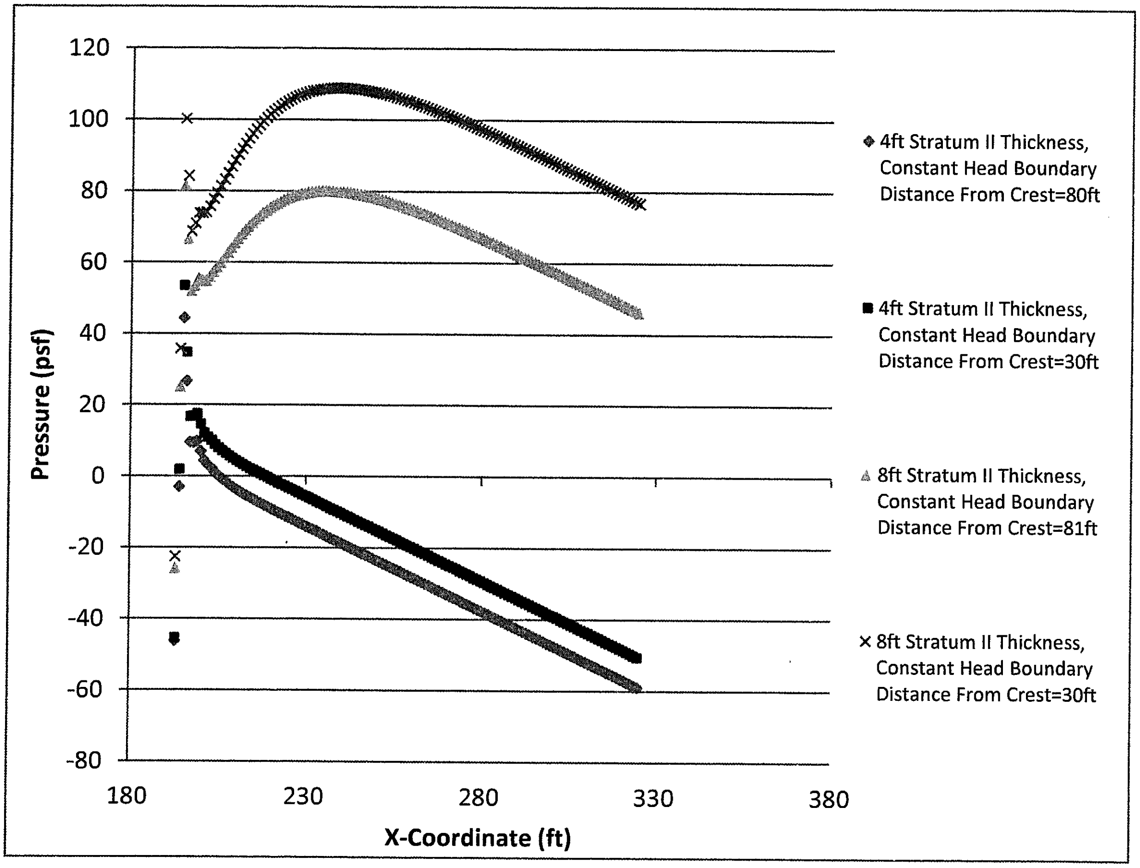
### 4.1 Groundwater Flow Summary

Flows along the slope and at the toe were determined using SEEP/W.

Total flow into the toe drain is the sum of flows into the sideslope and at the toe.

| Stratum II Thickness | Constant Head Boundary Distance From Crest = 80 ft. | | | Constant Head Boundary Distance From Crest = 30 ft. | | |
|---|---|---|---|---|---|---|
| | Along Slope | At Toe | Total Flow into Toe Drain | Along Slope | At Toe | Total Flow into Toe Drain |
| | Flow ($ft^3$/sec/ft) | | | | | |
| 4 ft. | 3.62E-08 | 1.50E-08 | 5.12E-08 | 5.65E-08 | 1.63E-08 | 7.28E-08 |
| 8 ft. | 3.91E-08 | 2.37E-08 | 6.28E-08 | 6.11E-08 | 2.68E-08 | 8.78E-08 |

## 4.2 Pore-Water Pressures Along TRDF expansion floor




| | | |
|---|---|---|
| Maximum Pore Pressure = | 109 psf | |
| Off-Setting Ballast Pressure = | 210 psf (2 ft of Protective Cover @ 105 pcf) | |
| FS = | 1.93 > 1.2 | OKAY |

## 5.0 CONCLUSION

The maximum calculated steady-state flow of groundwater occurs when when the constant head boundary is 30 ft from the crest of the excavation with an 8 ft thick Stratum II. The flow at the toe is 2.68 E-08 $ft^3$/sec/ft, along the ecavated slope is 6.11 E-08 $ft^3$/sec/ft, and the total maximum calculated steady-state flow into the toe drain is 8.78 E-08 $ft^3$/sec/ft.

The maximum pore-water pressure along the floor is 109 psf, occuring 46 ft horizontally away from the toe drain when assuming an 8 ft thick layer of Stratum II underlying the CCL. These pressures are believed to be conservative and can be offset over the short-term by the 2-ft thick protective cover layer with a factor of safety greater than 1.2 and later by overlying waste with a factor of safety greater than 1.5.

The average depth of Stratum II after excavation in Tract 1C Cell 1 is 3 ft with, on average, lower head values than those in Tract 5. Considering the similarity of material properties, Stratum II thickness, average head, and smaller size,Tract 1C Cell 1 pressures are expected to be less than those determined in the Tract 5 analysis.

Based on the selected foundation soil parameters, cross-section geometry, and assumptions discussed above, the maximum calculated steady-state flow of groundwater into the underdrain geocomposite and the toe drain will not exceed the capacity of the system. The underdrain pipe sizing calculation is included in Appendix III-3F-3b and the underdrain geocomposite transmissivity calculation is included in Appendix III-3F-3c.

**APPENDIX III-3F-4**

**BALLAST CALCULATIONS**

## BALLAST CALCULATIONS

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### 1.0 OBJECTIVE

Provide example ballast calculations in accordance with the section on Special Conditions-Excavations Below the Seasonal High Groundwater Table of the Liner Quality Control Plan (LQCP) for the Temple Recycling and Disposal Facility (TRDF). This LQCP incorporates methods that will be used to maintain the integrity of liner systems during construction below the seasonal high water table.

### 2.0 APPROACH

Example ballast thickness calculations have been performed per the outlined in the Ballast Thickness Calculations section of the LQCP. calculations have been performed for various points within worst-case conditions where the difference between the seasonal high potentiometric surface and the design basegrade is the greatest. The cells examined include Tract 5 Cell 5, Tract 5 Cell 7, Tract 5 Cell 9, Tract 5 Cell 11, Tract 5 Cell 17, and Tract 5 Cell 2. A total of six (6) points were selected for the calculation, as shown in Figures III-3F-7 through III-3F-9. All points are located along the toe of sideslopes where the ballast required to offset the hydrostatic pressure is the greatest.

Three figures are attached. All three figures contain the seasonal high potentiometric surface, existing monitoring wells, 2015 piezometers, and locations of the existing and proposed cells. Figure III-3F-7 presents the detailed locations of TRDF's existing and proposed cells, Figure III-3F-8 presents the entire facility's proposed final cover grades, and Figure III-3F-9 presents the TRDF expansion area excavation grades.

The factor of safety against hydrostatic uplift is defined as the sum of the resisting forces provided by the overlying materials including protective soil cover, solid waste, and final cover, divided by the hydrostatic uplift forces acting at the base of the geomembrane liner. As described in the LQCP, a factor of safety of 1.5 is required when waste is being applied as the ballast material.

### 3.0 CALCULATIONS

The points selected, as well as final cover and subgrade grades and seasonal high groundwater contours, are shown on Figures III-3F-7 through III-3F-9. Each ballast calculation point selected is labeled 'BC-#' in the figures. The calculations for Points BC-1 through BC-6 were performed per the methods outlined in the Ballast Thickness Calculations section of the LQCP, and the resulting factors of safety are presented in Table 1 below.

**Table 1: Ballast Calculation**

| Point | Final Cover Elev | FC Thickness | FC Unit Weight | FC Offset Ballast | Waste Elev | Waste Thickness | Waste Unit Weight | Waste Offset Ballast | PC Elev | PC Thickness | PC Unit Weight | PC Offset Ballast | GW Elev[(1)] | GM Elev | Sum Ballast Offset | Hydrostatic Force | Factor of Safety |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BC-1 | 605 | 3.0 | 115 | 311 | 602 | 69 | 44 | 2762 | 533 | 2.0 | 115 | 207 | 566 | 531 | 3279 | 2184 | 1.5 |
| BC-2 | 607 | 3.0 | 115 | 311 | 604 | 74 | 44 | 2944 | 531 | 2.0 | 115 | 207 | 565 | 529 | 3462 | 2303 | 1.5 |
| BC-3 | 613 | 3.0 | 115 | 311 | 610 | 85 | 44 | 3397 | 525 | 2.0 | 115 | 207 | 565 | 523 | 3915 | 2608 | 1.5 |
| BC-4 | 648 | 3.0 | 115 | 311 | 645 | 109 | 44 | 4349 | 536 | 2.0 | 115 | 207 | 578 | 534 | 4866 | 2746 | 1.8 |
| BC-5 | 608 | 3.0 | 115 | 311 | 605 | 70 | 44 | 2786 | 535 | 2.0 | 115 | 207 | 568 | 533 | 3304 | 2172 | 1.5 |
| BC-6 | 617 | 3.0 | 115 | 311 | 614 | 75 | 44 | 2979 | 540 | 2.0 | 115 | 207 | 571 | 538 | 3496 | 2062 | 1.7 |

NOTES

(1) Based on Seasonal High Potentiometric Surface.

(2) Design elevations are approximate and should be confirmed during cell construction.

**Table 2: Summary of of Ballast Calculation Results**

| Point | Long-Term Factor of Safety at Final Covered Condition | Thickness of Waste (ft) Required to Achieve FS = 1.5 |
|---|---|---|
| BC-1 | 1.5 | * |
| BC-2 | 1.5 | * |
| BC-3 | 1.5 | * |
| BC-4 | 1.8 | 97.9 |
| BC-5 | 1.5 | * |
| BC-6 | 1.7 | 72.2 |

* Final buildout waste thickness is required.

## 4.0 CONCLUSION

Review of the results indicates the ballasting is adequate for the proposed design.