RESPONSE 10

UNDERDRAIN SEEPAGE CALCULATION

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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 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 version 8): (i) 4 ft thick Stratum II underlying the liner system, and (ii) 8 ft thick Stratum II underlying the liner system. 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 where the depth of the excavation grade below the groundwater table is greatest and along the portion of the TRDF with the thickest layer of Stratum II underlying the compacted clay liner (CCL). Based on a review of the seasonal high groundwater table and the excavation grades, the maximum difference between the two occurs along the southern portion of the expansion area. The maximum thickest of Stratum II underlying the CCL is approximately 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 of 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

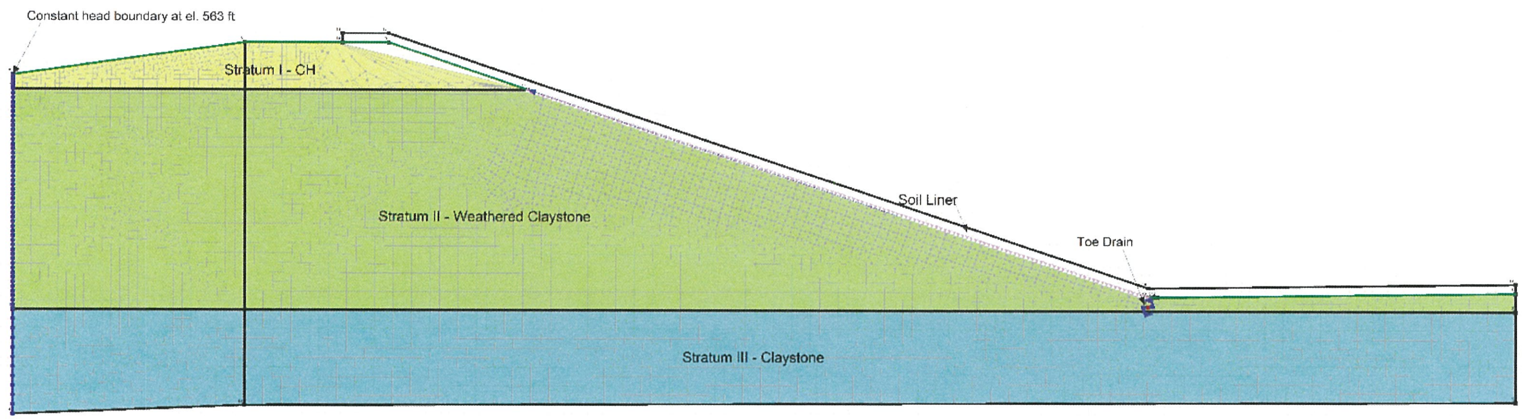
A total head boundary was set to represent hydrostatic groundwater conditions approximately 5 ft below existing grade (at el. 563 ft) near the southeastern portion of Tract 5. The average depth of the water level below existing grade is approximately 10 ft in Tract 5 and 11 ft in Tract 1C. Setting the total head boundary to represent 5 ft below existing grade creates a conservative analysis. The horizontal distance from the excavation slope crest to the total head boundary was varied 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

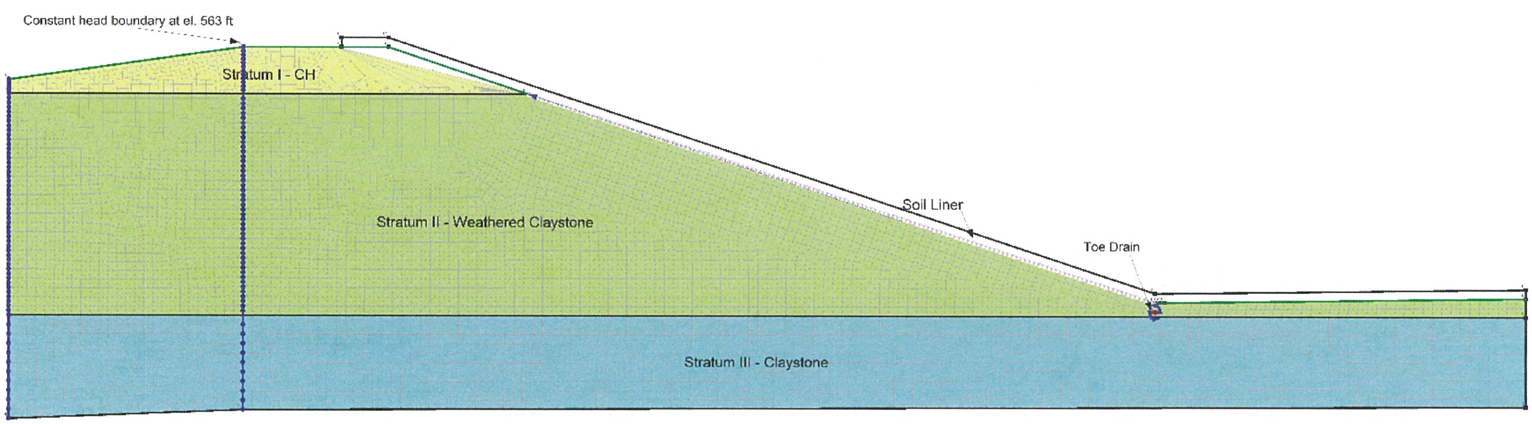
The toe drain was modeled as a sink (a node assigned P=0). A sink models a condition in which all water seeping into it is removed before creating a presure condition.

3.4 SEEP/W MODEL CONFIGURATIONS

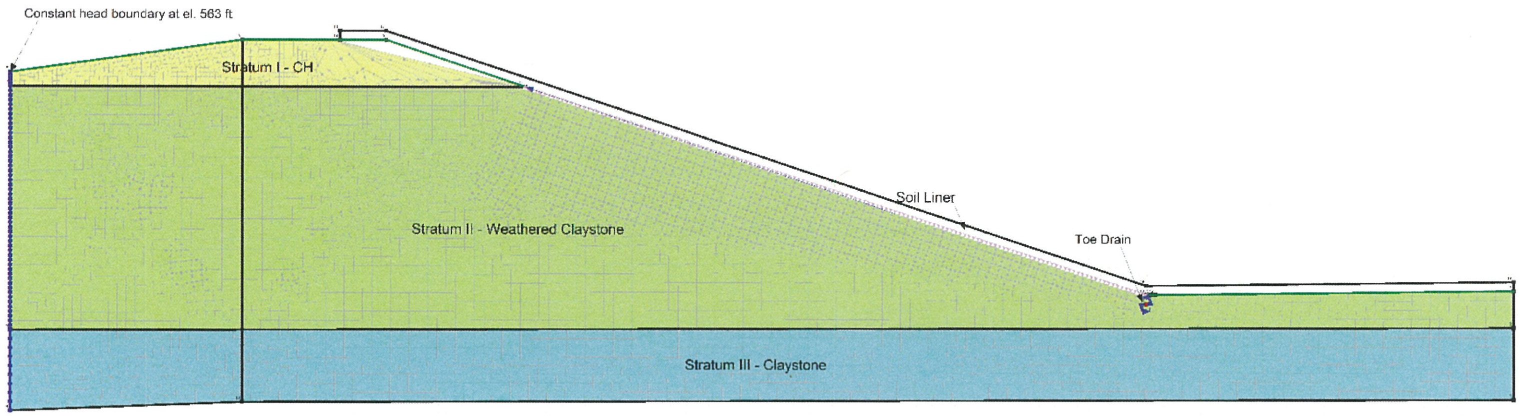
3.4.1 *4ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 80 ft.*



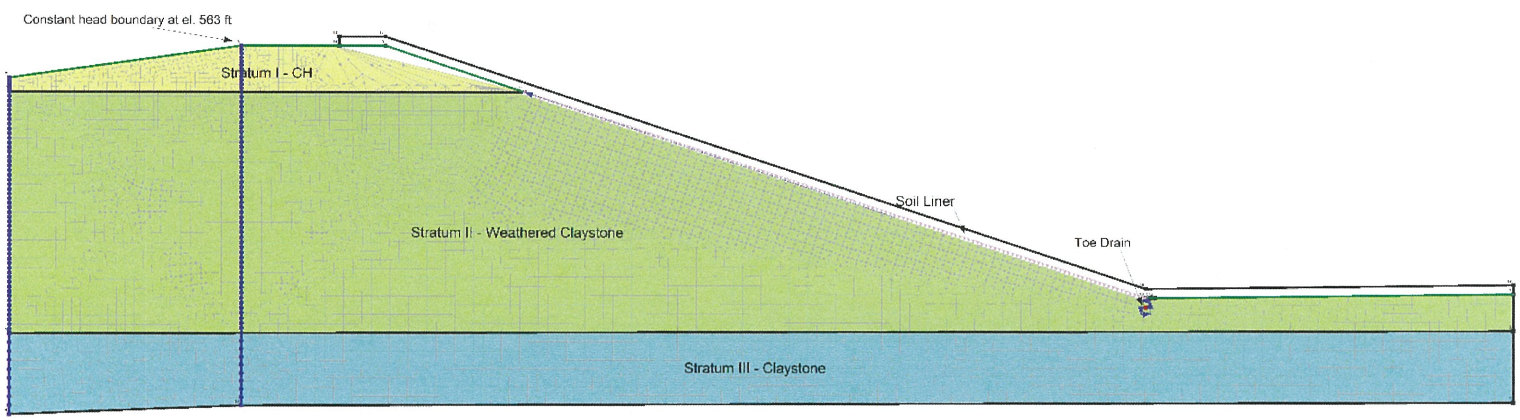
3.4.2 *4ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 30 ft*



3.4.3 8ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 80 ft



3.4.4 8ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 30 ft



4.0 RESULTS

Two geometry configurations were used in the SEEP/W analysis at the critical cross-section: (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 below the liner 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.

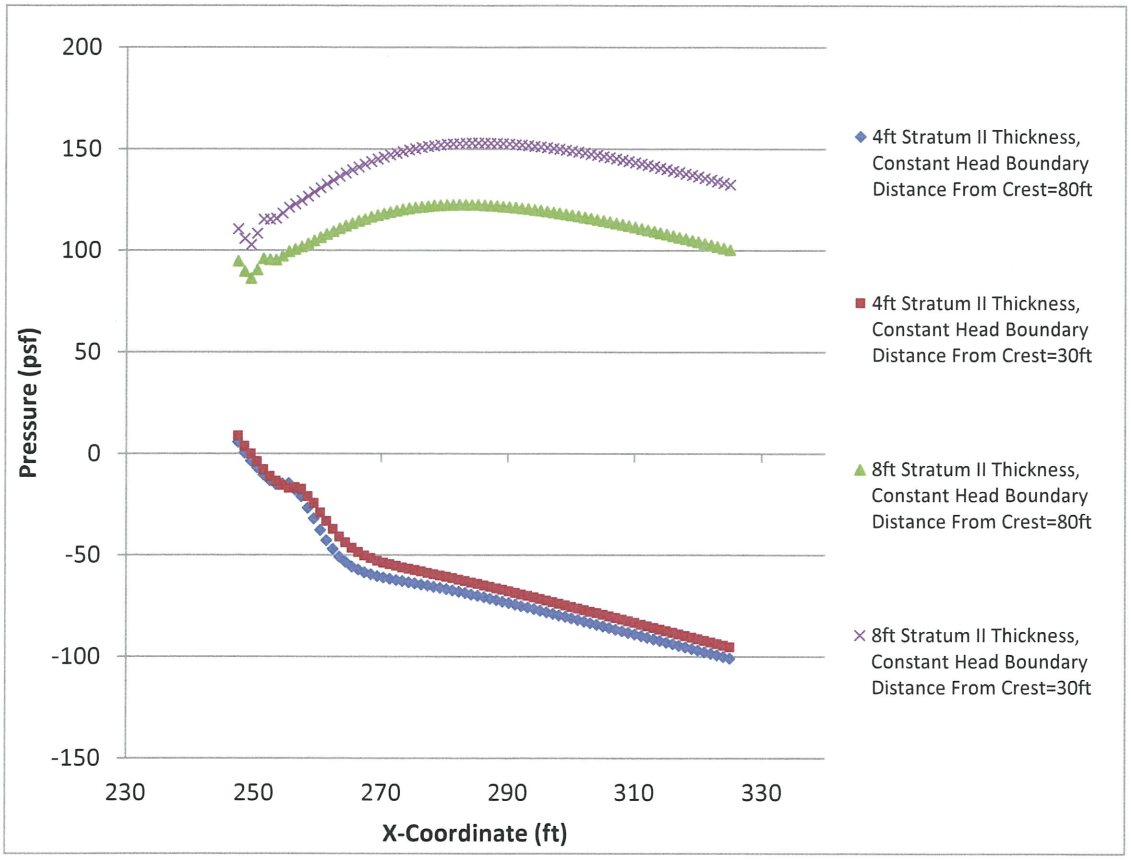
Total flow into the toe drain is the sum of flows into the sideslope and at the toe.

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.	3.24E-08	2.10E-08	5.33E-08	6.31E-08	2.23E-08	8.54E-08
8 ft.	3.25E-08	3.14E-08	6.39E-08	6.36E-08	3.46E-08	9.82E-08

Evaluation of the sideslope underdrain geocomposite calculation is provided in Appendix II-3F-3c.

4.2 Pore-Water Pressures Along TRDF expansion floor

The pore-water pressure at the interface of excavation surface and clay liner is presented below:



Maximum Pore Pressure = 153 psf

Stability against uplift during clay liner construction:

This condition is very conservative becasue prior to the clay liner construction no hydrostatic pressures would develop. Once the clay liner is placed it would take a long period of time for the maximum pore pressure to build up beneath the clay liner, by which time more off-setting ballast pressure would have been added. Nevertheless, a factor of safety is calculated as follows:

Off-Setting Ballast Pressure = 240 psf (2 ft of Clay Liner @ 120 pcf)

FS = 240/153= 1.57 > 1.2 OKAY

Stability against uplift during protective cover placement:

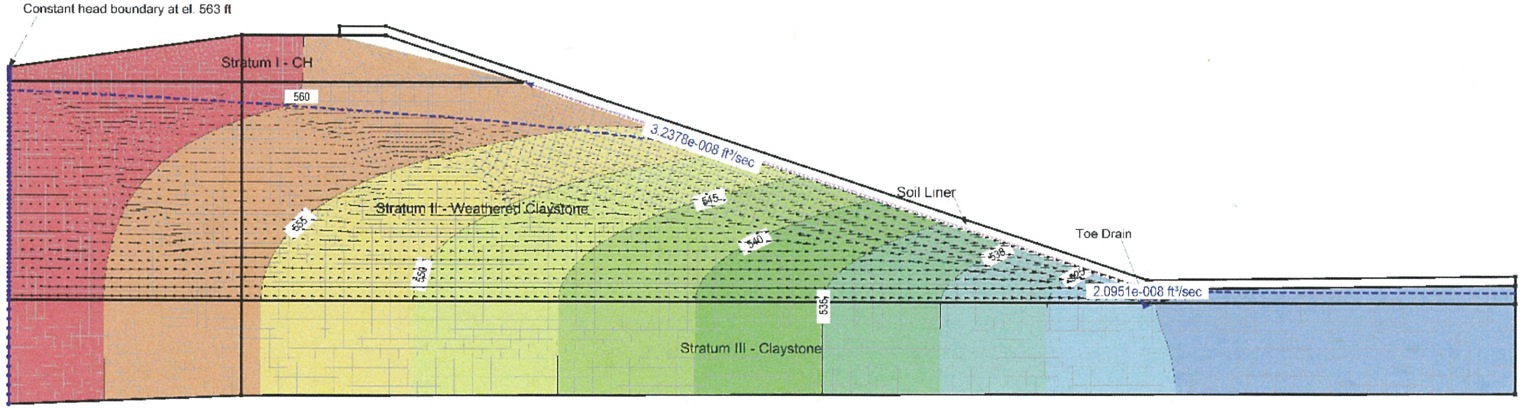
This condition conservatively ignores the ballast pressure provided by the clay liner and assumes that the above-calculated pore-water pressure is directly applied on the bottom of the protective cover soil layer.

Off-Setting Ballast Pressure = 230 psf (2 ft of Protective Cover @ 115 pcf)

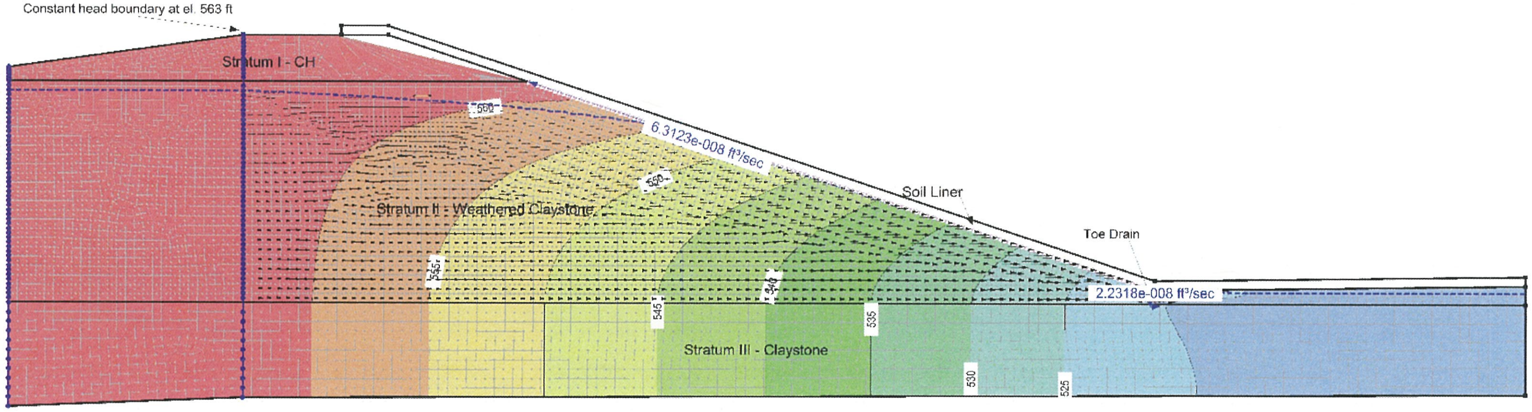
FS = 230/153= 1.50 > 1.2 OKAY

4.3 SEEP/W OUTPUTS

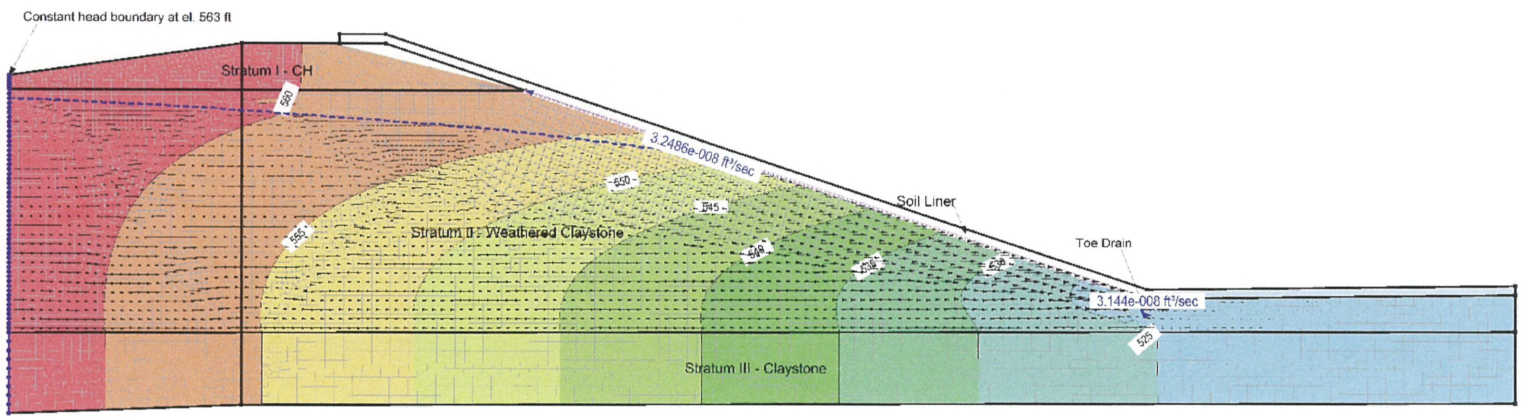
4.3.1 4ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 80 ft



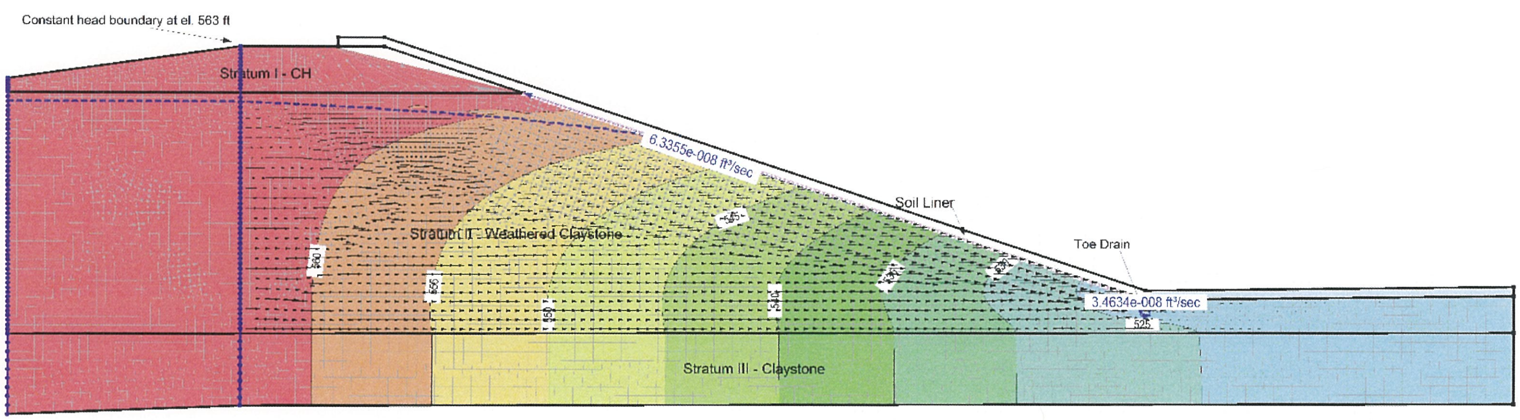
4.3.2 4ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 30 ft



4.3.3 8ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 80 ft



4.3.4 8ft Stratum II Thickness, Constant Head Boundary Distance From Crest = 30 ft



5.0 CONCLUSION

The maximum calculated steady-state flow of groundwater occurs where an 8-ft thickness of Stratum II remains below the CCL and when the constant head boundary is 30 ft from the crest of the excavation with 9.82×10^{-8} ft^3/sec/ft.

The maximum pore-water pressure below the liner along the floor is 153 psf, occuring approximately 40 ft horizontally away from the toe drain . These pressures are believed to be conservative and can be offset over the short-term by the 2-ft thick clay liner or protective cover layer with a factor of safety greater than 1.2 and later by overlying waste and/or soil ballast 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 toe drain will not exceed the capacity of the underdrain collection pipe. The underdrain pipe sizing calculation is included in Appendix III-3F-3b.