CCR RULE 40CFR §257.70

DESIGN CRITERIA – NEW CCR LANDFILL

CERTIFICATION REPORT

ASH DISPOSAL FACILITY

COMANCHE STATION

PUEBLO, COLORADO

Prepared For:

Public Service Company of Colorado (PSCo)

Prepared by:

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Submitted: September 8, 2017

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Ash Disposal Facility
AMSL	Above Mean Sea Level
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
GCL	geosynthetic clay liner
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
MW	Megawatts
PSCo	Public Service Company of Colorado
RCRA	Resource Conservation and Recovery Act
Site	Comanche Station
Xcel	Xcel Energy

PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Colorado, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse by Xcel Energy/ Public Service Company of Colorado or others without specific verification or adaptation by the Engineer.

I hereby certify, as a Professional Engineer in the State of Colorado that this report has been prepared in accordance with requirements of 40 Code of Federal Regulations §257. I further certify that a satisfactory demonstration of the requirements of 40CFR Sections §257.70 have been made.

Respectfully submitted,

COLORADO REGISTERED PROFESSIONAL ENGINEER
DAVID JAMES BOHMANN
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9/8/17

David J. Bohmann

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Colorado Licensed Professional Engineer No. 37684
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1.0 INTRODUCTION

This Location Restriction Certification report has been prepared for the Ash Disposal Facility (ADF) located at Public Service Company of Colorado's (PSCo's) Comanche Station (the Site). This report conforms to 40 Code of Federal Regulations (CFR) Part 257. This report was prepared to address the new federal coal combustion residual (CCR) regulations for disposal of ash under subtitle D of the Resource Conservation and Recovery Act (RCRA). The final rule was published in the Federal Register, Volume 80 Number 74 on April 17, 2015, and became effective on October 19, 2015.

1.1 GENERAL INFORMATION

Comanche Station is located west of Lime Road approximately 3 miles south of Colorado Highway 50 in Pueblo County, Colorado (**Figure 1-1**). The facility is located in the west half of Section 20, Township 21 South, Range 64 West of the 6th Principal Meridian, Pueblo County, Colorado. The land-surface elevations range from approximately 4,830 feet above mean sea level (amsl) in the southwest and northwest corners of the Site to approximately 4,800 feet amsl in the southeast corner of the Site. The Site, including the ADF, was annexed by the City of Pueblo in 2005. The facility is located in an area zoned I-3 (Heavy Industrial) by the City of Pueblo Zoning Department. Ordinances with the City of Pueblo allow solid waste disposal in an industrial zone within city limits subject to review and issuance of a Special Use Permit. The Comanche Station ADF operates under an approved Special Use Permit (ZBA Case # 058-2005).

Comanche Station is a coal-fired plant that consists of three units (Units 1, 2 and 3) that burn Powder River Basin coal. Unit 1 was built in 1973 and is rated at 350 megawatts (MW), Unit 2 was built in 1975 and is rated at 350 MW, and Unit 3 was built in 2010 and is rated at 750 MW. The primary Site features are shown on **Figure 1-1**.

1.2 TYPE OF FACILITY

The ADF is an approximately 280 acre engineered ash monofill consisting of eight permitted disposal cells. Cell 1 was constructed in 2005 prior to the promulgation of the federal CCR regulations. Cell 2 East is planned for construction in 2017. Approximately 38.7 acres of the ADF will be used for surface water control structures, access roads, and borrow area. The wastes accepted at the ADF consist of coal ash, water treatment sludge, process water pond sediment, coal impurities, and excavation soils.

2.0 DESIGN CRITERIA NEW CCR LANDFILL 40 CFR §257.70

The 40 CFR §257.70 details design criteria for ash landfills. Design criteria are presented for: 1) A prescribed composite liner system; and 2) Alternative liner systems. It states the following:

> *"New CCR landfills and any lateral expansion of a CCR landfill must be designed, constructed, operated, and maintained with either a composite liner that meets the requirements of paragraph (b) of this section or an alternative composite liner that meets the requirements in paragraph (c) of this section, and a leachate collection and removal system that meets the requirements of paragraph (d) of this section.*

Xcel/PSCo will construct Cell 2 of the Comanche ADF with an alternative liner system that meets the requirements of 40 CFR §257.70. Details of the alternative liner system and leachate collection system design are provided below.

2.1 ALTERNATIVE COMPOSITE LINER 40 CFR §257.70 (c)

The 40 CFR §257.70 (c) details design criteria for alternative composite liner systems for ash landfills. It states the following:

> "*An alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. If the lower component of the alternative liner is compacted soil, the GM must be installed in direct and uniform contact with the compacted soil."*

The upper component of the liner system design for the ADF is a 60-mil high density polyethylene (HDPE) geomembrane. Therefore, the 60-mil HDPE upper component of the liner system is in compliance with 40 CFR §257.70 (c).

The lower component of the liner system design is a polymer-modified geosynthetic clay liner (GCL). The CCR design criteria states that an alternative lower liner component must have a liquid flow rate that is equal to or less than 2 feet of compacted soil with a permeability of 1×10^{-7} cm/sec. Section 40 CFR §257.70 (c) presents an equation for calculating the liquid flow rate for an alternative to the 2 feet of compacted soil. Based on this equation, the liquid flow rate through 2 feet of compacted 10^{-7} cm/sec soil, with 30 cm of head, is 1.5×10^{-7} cm/sec. The GCL manufacture (CETCO) is reporting a maximum permeability of 9.17×10^{-10} cm/sec when their polymer-modified GCL (Resistex) was tested with leachate from the ADF at Comanche. The GCL testing results are included in Appendix A. The GCL has a reported minimum thickness of 0.6 cm. The liner is designed to have less than 30 cm of liquid over the HDPE liner. Using the equation provided in 40 CFR §257.70 (c) and the design parameters presented above, the liquid flux rate through the GCL is 4.7 x 10^{-8} cm/sec. This liquid flow rate is more than a factor of three lower than the flow rate through the prescribed lower liner consisting of 2 feet of compacted 10^{-7} cm/sec soil.

Liner Chemical Properties and Strength 40 CFR §257.70 (b) (1)

The composite liner system consists of a GCL and a 60-mil HDPE liner. The 60-mil HDPE liner is specified in 40 CFR §257.70 (b) as one of the default liner materials and is generally considered chemically compatible with CCR waste. Underlying the HDPE liner is a GCL liner. The GCL has been permeability tested with leachate from the Comanche Station. There was no chemical compatibility issues identified with the GCL for Comanche Station leachate.

The HDPE liner will be covered with a geotextile fabric and 12 inches of protective sand. In addition, 2 feet of ash will be placed over the sand layer prior to allowing heavy equipment on an active ash cells. The liner material will have minimal exposure to climatic conditions prior to placement of 3 feet of cover. Similarly, the protective cover will help to shield the liner from potential damage due to daily operations.

Liner Shear Resistance and Foundation/Subgrade Stability 40 CFR §257.70 (b) (2) and (3)

Slope stability analyses were performed for the Comanche ADF in accordance with CFR 257 Subpart D – Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments. Two-dimensional limit equilibrium slope stability analyses were conducted utilizing SLIDE software version 6.0 from RocScience. Potential failures of the foundation support for the landfill was analyzed using circular type surfaces. Potential failures by sliding along the geosynthetic liner surface were analyzed using sliding block type surfaces. Spencer's method was used on all analyses which satisfies all conditions of equilibrium (horizontal and vertical force equilibrium, individual slice moment equilibrium, and overall moment equilibrium). The results of the stability analysis are provided in Appendix B.

The most critical locations in regards to slope stability during development of the landfill were identified in Appendix B cross-sections Cell 1-1, Cell 2-1, Cell 4-1, and Cell 7-1. The locations of these critical sections are presented on plan view drawings, Appendix B Figures H.1 and H.2. The rationale for selection of these critical sections for analysis are presented below:

Cell 1-1: Cell 1 was constructed without a geosynthetic liner, whereas geocomposite liners are planned for cells 2 through 8. This section represents the greatest planned height of ash in conjunction with the weakest foundation and toe support.

Cell 2-1: Cell 2 will be constructed with geocomposite liner with a 0.25% slope towards the north (towards Cell 7). This liner has a 1% slope towards the east but the landfill mass will be buttressed against the existing Cell 1 ash. Cell 3 will have nearly identical conditions.

Cell 4-1: Cell 4 will have a geocomposite liner with a 1% slope toward the east (Cell 7). Prior to construction of Cell 7, there will be no buttressing of the landfill mass in this direction. Cells 5 and 6 will have nearly identical conditions.

Cell 7-1: Cell 7 will have a geocomposite liner with a 1% slope toward the east (Cell 8). This cell will be constructed with a greater overall height of ash than Cell 4 but has slightly stronger foundation and toe conditions. Cell 8 will be buttressed in the direction of base slope on all sides thus was not analyzed.

The subsurface profiles used in the stability evaluation were based on information presented in this EDOP as well as previous geotechnical explorations (Woodward-Clyde Consultants, 1987; Tetra Tech, 2014). Laboratory strength testing of the ash and subsurface materials was not conducted specifically for these analyses. The strengths of the subsurface material, the bedrock in particular, is likely well under estimated. The strength of the ash is a conservative estimate based on experience on other project sites. The geosynthetic material interface strengths tend to control the design. These strengths are based on published data (Koerner, 2012; Triplett and Fox, 2001). When using a GCL and HDPE liner, the HDPE to GCL interface has the lowest interface strength. Seismic conditions were analyzed for the maximum expected horizontal acceleration having a 2% probability of being exceeded in a 50 year period as per CFR 257.53. An acceleration of 0.08g was used as indicated by the USGS Seismic-Hazards Maps for the Conterminous United States, 2008.

Graphical presentations of all slope stability analyses are included in Appendix B (Figures H.3 through H.16). The strength parameters utilized for each analysis are presented on the individual graphical presentations. Table 3-2 provides a summary of the results of the stability calculations.

Table 2-2. Slope Stability Analyses Calculated Factor of Safety.

	Foundation (Deep)		Liner (Block)		
Section	**Static**	**Pseudo-Static**	**Static**	**Pseudo-Static**	**Notes**
Cell 1-1	2.120	1.471	NA	NA	No Geomembrane
Cell 2-1	1.910	1.316	1.963	1.423	Textured HDPE
Cell 4-1	1.900	1.354	1.923	1.373	Textured HDPE
Cell 7-1	1.844	1.324	1.926	1.374	Textured HDPE

All calculated factors of safety exceed design requirements. As a general guideline, static factors of safety above 1.5 and pseudo-static factors of safety above 1.0 are considered safe.

The excavated areas of the subgrade will be prepared by scarification, moisture condition, and re-compacted to a minimum of 95 percent of maximum dry density with 2 percent of optimum moisture content as determined by ASTM D698, Standard Proctor. The berm fill and its supporting soils will be compacted to these same requirements.

Areal Extent of Liner Contacting Ash/Leachate 40 CFR §257.70 (b) (4)

The ADF was designed to contain all ash placed in Cells 2-8 and to capture all leachate generated within these cells.

Alternative Composite Liner System Compliance

The alternative composite liner system design is in compliance with 40 CFR §257.70 (c) and 40 CFR §257.70 (b) (1) through (4).

2.2 Leachate Collection System Design Criteria 40 CFR §257.70 (d)

The 40 CFR §257.70 (d) details design criteria for leachate collection systems for ash landfills. It states the following:

> *"The leachate collection and removal system must be designed, constructed, operated, and maintained to collect and remove leachate from the landfill during the active life and post- closure care period. The leachate collection and removal system must be: (1) Designed and operated to maintain less than a 30-centimeter depth of leachate over the composite liner or alternative composite liner; (2) Constructed of materials that are chemically resistant to the CCR and any non-CCR waste managed in the CCR unit and the leachate expected to be generated, and of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying waste, waste cover materials, and equipment used at the CCR unit; and (3) Designed and operated to minimize clogging during the active life and post-closure care period."*

Design Leachate Depth

The Hydrologic Evaluation of Landfill Performance (HELP) model, version 3, was used to estimate leachate generation from Cell 2 East. The HELP model was developed by the U.S. Environmental Protection Agency to analyze water balance in landfill lining and capping systems.

The maximum head on top of the HDPE liner for Cell 2 was 3.14 inches, located a distance of 48.9 feet from the leachate collection pipe. The estimated maximum leachate generation from Cell 2 East is 229 gallons per day. The results were offset 4 years to coincide with the estimated start of ash placement in Cell 2 West when the cover is placed on Cell 2 East.

This assumes Cell 2 West will have the same volume and contain the same materials modeled for Cell 2 East. The resulting maximum leachate generation is 405 gallons per day, which occurs in Year 4 when ash placement begins in Cell 2 West. A summary of the HELP model results are provided in Appendix C.

Chemical Compatibility to CCR Waste

The leachate collection system consists of a 12" drainage layer and perforated drain pipe. The drain pipe will consist of double-walled high-density polyethylene (HDPE) material. Literature and typical manufacturer data on chemical compatibility demonstrate acceptable compatibility of HDPE with CCR leachate waste.

Strength and Thickness

A 2-foot thick layer of waste ash will be dozer placed over the leachate collection system and the geomembrane. The estimated volume of ash is 42,000 cubic yards in-place. This will provide a total cover soil thickness of 3-feet (including the 1-foot thick layer of drainage sand) over the geomembrane upon completion of construction. Once this protective cover soil is in place, equipment used to place waste will be allowed to access the landfill area with negligible danger of damage to the leachate collection system and geomembrane.

The pipe is specified to meet ASTM F2846 which is a double-walled, corrugated polyethylene pipe. All typical properties for this pipe were obtained from the design manual table 5-1. The specified pipe meets the project requirements for strength. The analysis of the pipe was conducted per Chapter 5 of "Corrugated Polyethylene Pipe Design Manual and Installation Guide", Plastic Pipe Institute (http://plasticpipe.org/drainage/cppa-design-guide.html). The procedure uses Spangler's Modified IOWA Formula for Ring Deflection for the deformation calculation among other stress, strain, and bending checks. The design calculations for the pipe are included in Appendix D.

Therefore, the pipe and couplings are designed to withstand the pressures anticipated for the ADF.

Design for Minimizing Clogging

The leachate collection system design consists of a 1-foot thick layer of drainage sand, collection pipe, storage sump, and return system. The estimated quantity of sand is 20,500 cubic yards in-place. The drainage sand design consists of a clean (less than 5 percent passing No. 200 sieve) aggregate with a hydraulic conductivity of 1×10^{-3} cm/s or greater. The 1-foot thick drainage sand slopes from west to east at a 1 percent slope to a 6-inch diameter collection pipe. The 6-inch pipe is a double-walled polypropylene pipe capable of withstanding the full landfill overburden stresses without collapse. The collection pipe is sloped at a 0.25 percent slope to a leachate sump. The pipe has a maximum flow capacity of 150 gpm which is much greater than the calculated maximum leachate flow of approximately 0.3 gpm. The specified sand bedding for the collection pipe will act as a filter preventing infiltration of ash into the pipe. The designed leachate collection pipe underlies the geotextile fabric which acts as a filter preventing sand infiltration into the pipe.

The leachate sump design consists of a concrete tank with a full capacity of 10,000 gallons with a normal maximum operating capacity of 8,000 gallons. The leachate will be re-applied to the ash waste for dust control. Water will be pumped from the tank into water trucks using a transfer pump with appropriate secondary containment. The tank will provide approximately 20 days of leachate storage between pumping to allow flexibility in operations. In addition, an emergency return pump and pipeline are included in the design. When leachate levels within the sump exceed 8,000 gallons, the emergency return pump will activate to return to a 6,000 gallon storage level. The emergency return pump will transfer leachate through a permanent pipeline discharging to the west central area of the Cell 2 East waste. If leachate storage levels reach 9,000 gallons, a high level alarm will be activated.

<u>Leachate Collection System Compliance</u>

The leachate collection system design is in compliance with 40 CFR §257.70 (d).

3.0 SUMMARY

The Xcel Energy/PSCo Comanche ADF Cells 2-8 design meets and/or exceeds the following minimum design criteria:

40 CFR §257.70 (c) – Alternative Liner: The alternative composite liner system design is in compliance with 40 CFR §257.70 (c) and 40 CFR §257.70 (b) (1) through (4).

40 CFR §257.70 (d) – Leachate Collection: The leachate collection system design is in compliance with 40 CFR §257.70 (d).

4.0 References

Koerner, R.M., 2012. Designing with Geosynthetics – 6th Edition. Xlibris Publishing Co., United States. 914 pp. 16 Jan. 2012.

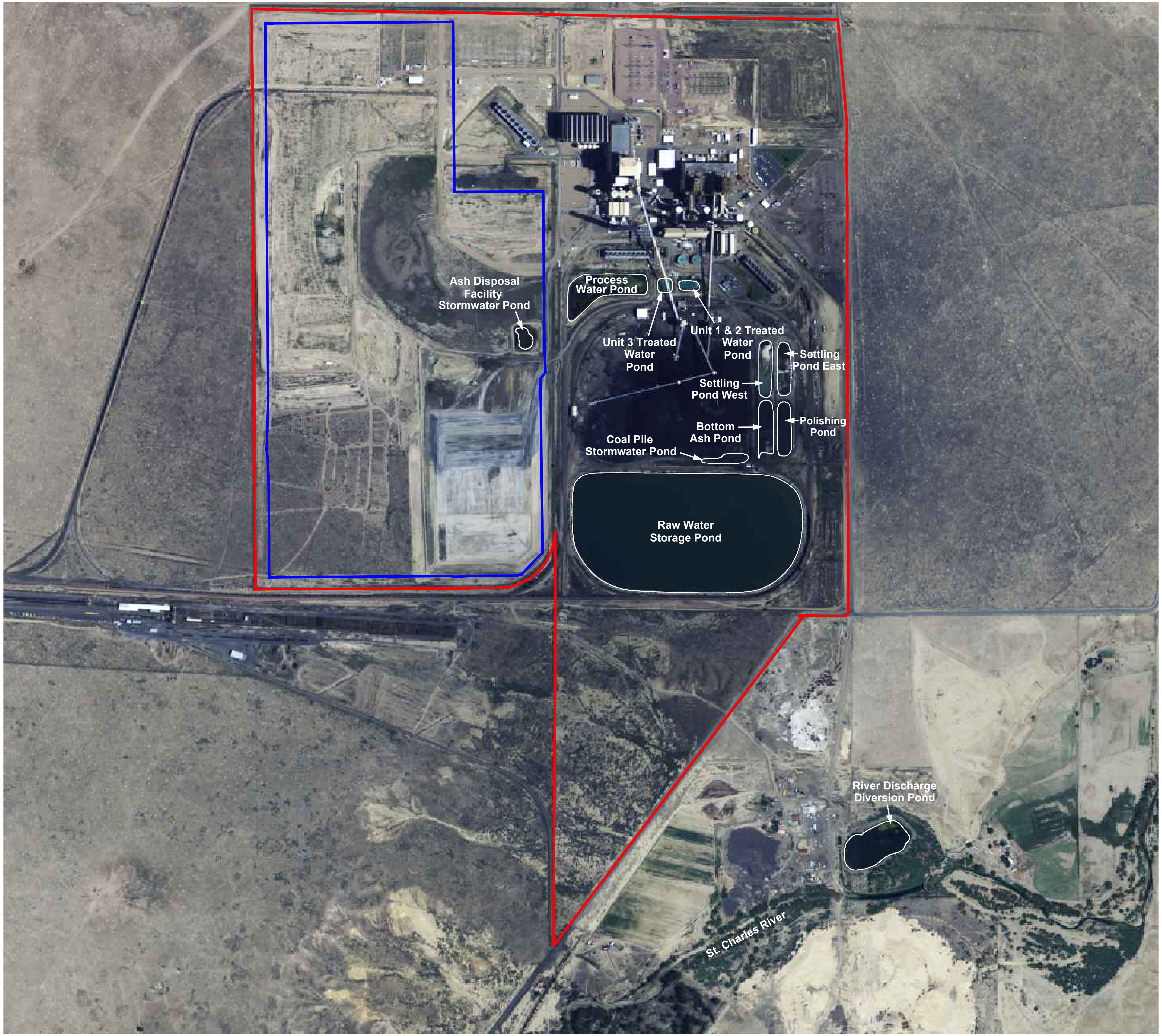
Ruffner, J. A. 1985. Climates of the states, National Oceanic and Atmospheric Administration narrative summaries, tables, and maps for each state, volume 1 Alabama -New Mexico and volume 2 New York - Wyoming and territories. Gale Research Company, Detroit, MI. 758 pp. and 1572 pp.

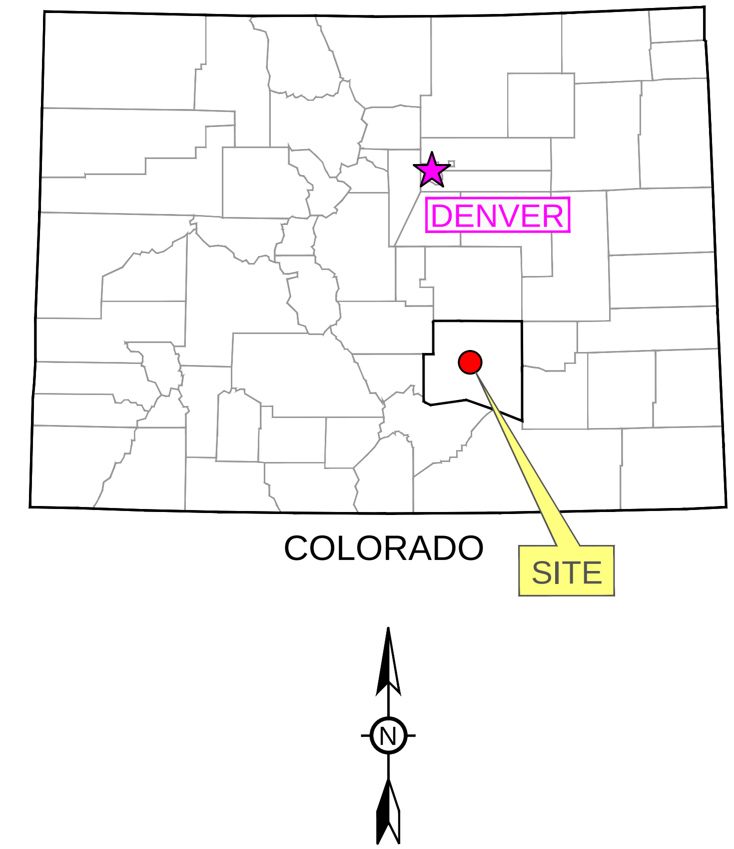
Tetra Tech, 2014. Design Report: Comanche Station Ash Disposal Facility Cell 2 East, Pueblo, Colorado. 4 Mar. 2014.

Triplett, E.J., and Fox, P.J. (2001). Shear Strength of HDPE Geomembrane/Geosynthetic Clay Liner Interfaces, Journal of Geotechnical and Geoenvironmental Engineering, 127(6): 543-552.

Woodward-Clyde Consultants. 1987. Feasibility Investigation, Two Ash Disposal Areas for Comanche Power Station, Pueblo, Colorado. March 1987.

FIGURE





Explanation:

Approximate PSCo Property Boundary

Ash Disposal Facility Boundary

0 900 1800

SCALE IN FEET

TITLE: **Comanche Site Map**

LOCATION: **Pueblo, Colorado**

TETRA TECH

APPROVED	JE
DRAFTED	CP, HF
PROJECT#	117-2827019
DATE	7-29-14

FIGURE 1-1

T:\XCEL_ENERGY\COMANCHE_LF_DESIGN_051013\CAD\FIG 1-1 SITE MAP.DWG

APPENDICES

APPENDIX A

GCL COMPATABILITY TESTING RESULTS

CETCO 2870 Forbs Avenue Hoffman Estates, IL 60192
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GCL COMPATIBILITY ANALYSIS
ASTM D6141 - 97

Project:	XCEL Energy Comanche Generating Station Coal Ash	Date:	July 12, 2013
Location:	Pueblo, CO	Project Type and Citation:	Compatibility BMG/LT-2-91 and 102
Requested By:	XCEL Energy	Sample ID:	LT-2-90
Sample Type:	Ash	Warranty:	n/a

Test Results:

	Combo Sample	**Bottom Ash**
Conductivity (µS/cm)	2804 µS/cm	826 µS/cm
pH	11.532	10.316

	Clay Blend	**Composite Sample**	**Bottom Ash**
Fluid Loss (mL)	CG-50 (Na^+ Bentonite)	25.1	21.5
	Resistex	16.0	14.1
Free Swell (mL / 2 grams)	CG-50 (Na^+ Bentonite)	26.5	25.5
	Resistex	22.0	25.5

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ICP Elemental Analysis

Element	SDA Composite Sample	Bottom Ash
Silver	≈0.0	≈0.0
Aluminum	5.876 ppm	8.414 ppm
Arsenic*	≈0.0	≈0.0
Barium	1.118 ppm	0.2963 ppm
Calcium	35.91 ppm	137.7 ppm
Cadmium	≈0.0	≈0.0
Chromium	0.1531 ppm	0.0561 ppm
Copper	≈0.0	≈0.0
Iron*	≈0.0	≈0.0
Mercury*	≈0.0	≈0.0
Potassium	38.92 ppm	5.439 ppm
Magnesium	≈0.0	0.2071 ppm
Sodium	379.8 ppm	58.53 ppm
Nickel	≈0.0	≈0.0
Phosphorus	0.1103 ppm	≈0.0
Lead*	≈0.0	0.0011 ppm
Selenium*	0.0485 ppm	≈0.0
Zinc	≈0.0	0.0471 ppm

1) Accuracy is ±0.005 ppm except for arsenic, iron, mercury, lead and selenium which have accuracy limits of 0.02 ppm.
2) The sample was not diluted or otherwise modified prior to testing.
3) Samples were filtered through a 2μm paper.

Analyst: GP

CETCO

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Flux and Hydraulic Conductivity Measurement of GCL
Using a Flexible Wall Permeameter

Project Name:
Sample I.D. Bentomat DN roll 11085 lot 201345 LO
Start Date: 12/2/2013

Test Parameters

Method:	ASTM D6766		Cell Pressure =	80.0	psi
Permeation Liquid:	Commanche XCEL leachate (customer's formula)		Inflow Pressure =	77.0	psi
Hydration Liquid:	Commanche XCEL leachate (customer's formula)		Outflow Pressure =	75.0	psi
Panel No.	311		Pressure Difference =	2.0	psi
Type of Liquid Reservoir:	annulua		Max. Effective Stress =	5.0	psi
Volume Correction Factor R (if pipet only, R=1):			Hydraulic Gradient, i =	209.0	
$R_{in} =$	4.3		Area of influent reservoir, a_{in} =	3.7391	cm^2
$R_{out} =$	3.8		Area of effluent reservoir, a_{out} =	3.3043	cm^2
Diameter of Sample, D =	10.2	cm	Specific Gravity:	2.7	
Length of Sample, L =	0.7	cm	Total Volume:	54.6	cm^3
Area of Sample, A =	81.07	cm^2	Volume of Solids:	20.4	cm^3
Sample Volume, V =	55.7	cm^3	Void Ratio:	1.7	
Dry Weight:	55.79	grams	Porosity:	62.7	%
Wet Weight:	84.992	grams	Pore Volume:	34.2	cm^3
Initial Height of Sample:	0.6	cm			
Final Height of Sample:	0.7	cm			

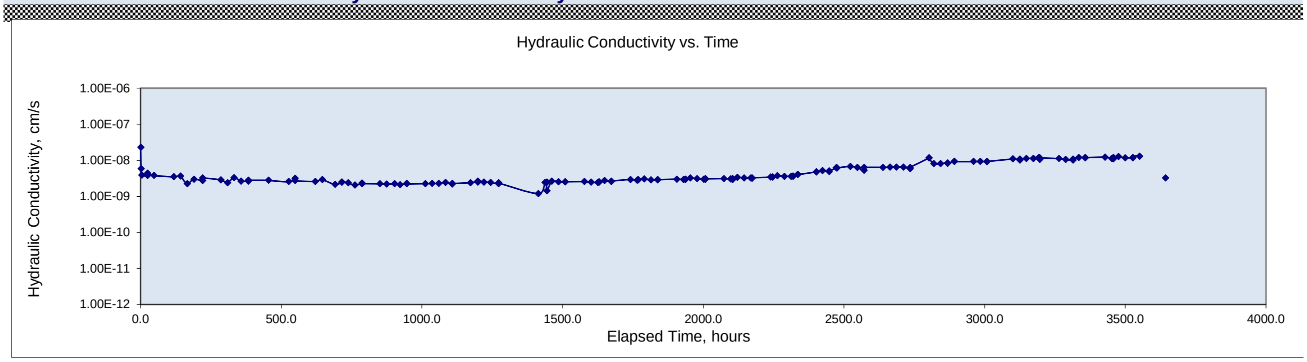
Leachate Characteristics

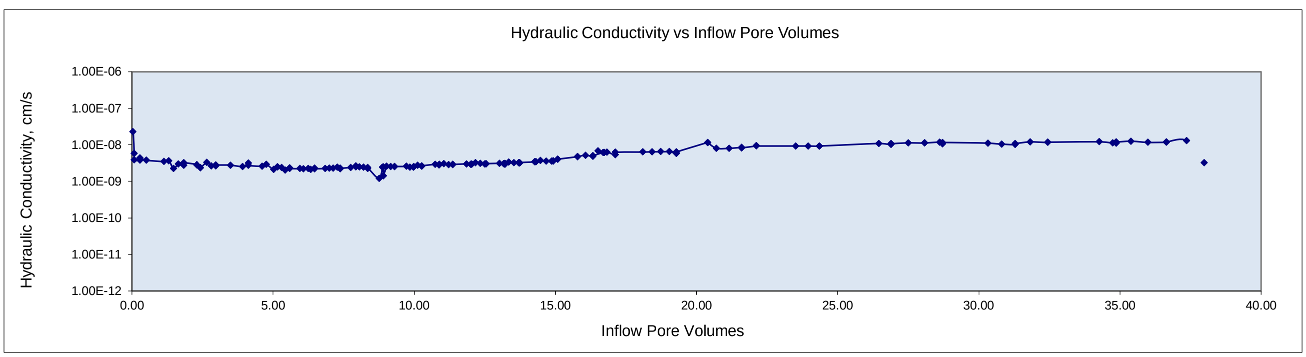
Target Ionic Strength, I		M	Initial Electrical Conductivity	4900.00	µS/cm
Target RMD			Final Electrical Conductivity	4930.00	µS/cm
			Initial pH	4.90	
			Final pH		

Note: Length of Sample, L, is equal of Initial Height of Sample, while the test is in progress and to Final Height of Sample after completion of the test.

$$Flux = \frac{(Inflow + Outflow)/2}{A * \Delta t} \qquad K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Final Flux	**2.46E-08**	$m^3/m^2/sec$
Final Hydraulic Conductivity	**9.39E-09**	cm/sec





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Date	Time (min)	Inflow Reading	Outflow Reading	H (cm)	Inflow Volume (cm^3)	Outflow Volume (cm^3)	Flux ($m^3/m^2/sec$)	Avg Flux ($m^3/m^2/sec$)	Elapsed Time (hrs)	Total Cumulative Inflow (cm^3)	Inflow Pore Volumes	K (cm/sec)
12/4/13	0	0.0	24.0	164.7	0.00	91.2			0.0	0.0	0.0	
	31	0.3	23.8	164.2	1.29	90.4	6.8E-08	6.80E-08	0.5	1.3	0.04	2.30E-08
	130	0.6	23.7	163.8	2.58	90.1	1.7E-08	4.27E-08	2.2	2.6	0.08	5.77E-09
	242	0.6	23.4	163.5	2.58	88.9	1.0E-08	3.19E-08	4.0	2.6	0.08	3.83E-09
12/5/13	1495	2.2	21.7	160.2	9.46	82.5	1.1E-08	1.29E-08	24.9	9.5	0.29	3.81E-09
	0	0.0	24.0	164.7	0.00	91.2	1.3E-08	1.13E-08	24.9	9.5	0.29	4.34E-09
12/6/13	1332	1.7	22.2	161.2	7.31	84.4	1.1E-08	1.15E-08	47.1	16.8	0.52	3.77E-09
12/9/13	5545	6.3	17.0	151.4	27.09	64.6	9.6E-09	1.10E-08	117.3	36.6	1.13	3.49E-09
12/10/13	6966	7.7	15.1	148.1	32.90	57.2	9.6E-09	1.00E-08	141.0	42.4	1.31	3.63E-09
12/11/13	8423	8.9	14.2	146.0	38.06	54.0	5.9E-09	8.37E-09	165.3	47.5	1.47	2.24E-09
12/12/13	9860	10.2	12.9	143.4	43.65	48.8	7.7E-09	7.72E-09	189.3	53.1	1.65	2.98E-09
12/13/13	11727	11.6	11.2	140.3	49.88	42.6	6.9E-09	6.82E-09	220.4	59.3	1.84	2.74E-09
	0	0.0	24.0	164.7	0.00	91.2	8.6E-09	7.73E-09	220.4	59.3	1.84	3.20E-09
12/16/13	3838	3.5	20.0	157.1	15.05	75.8	8.2E-09	7.89E-09	284.3	74.4	2.31	2.86E-09
12/17/13	5285	4.4	18.6	154.8	18.92	70.5	6.5E-09	7.77E-09	308.5	78.3	2.43	2.39E-09
12/18/13	6700	6.1	17.2	151.8	26.23	65.4	9.0E-09	7.91E-09	332.0	85.6	2.65	3.29E-09
12/19/13	8198	7.3	15.9	149.2	31.39	60.2	7.1E-09	7.54E-09	357.0	90.7	2.81	2.65E-09
12/20/13	9722	8.5	14.5	146.7	36.55	55.1	6.9E-09	7.68E-09	382.4	95.9	2.97	2.65E-09
	0	0.0	24.0	164.7	0.00	91.2	7.7E-09	7.23E-09	382.4	95.9	2.97	2.79E-09
12/23/13	4326	3.9	19.7	156.5	16.77	74.9	7.9E-09	7.50E-09	454.5	112.7	3.49	2.76E-09
12/26/13	8593	7.2	15.9	149.4	30.75	60.2	6.9E-09	7.48E-09	525.6	126.6	3.93	2.55E-09
12/27/13	9959	8.7	14.7	146.7	37.41	55.9	8.3E-09	7.69E-09	548.4	133.3	4.13	3.13E-09
	0	0.0	24.0	164.7	0.00	91.2	7.5E-09	7.57E-09	548.4	133.3	4.13	2.72E-09
12/30/13	4343	3.6	19.9	157.0	15.48	75.6	7.4E-09	7.72E-09	620.8	148.8	4.61	2.58E-09
12/31/13	5801	4.7	18.2	154.2	20.21	69.2	7.9E-09	7.58E-09	645.1	153.5	4.76	2.89E-09
1/2/14	8544	6.7	16.4	150.4	28.60	62.1	5.8E-09	7.01E-09	690.8	161.9	5.02	2.13E-09
1/3/14	9979	7.8	15.2	148.1	33.33	57.8	6.5E-09	6.73E-09	714.7	166.6	5.17	2.46E-09
	0	0.0	24.0	164.7	0.00	91.2	6.9E-09	6.39E-09	714.7	166.6	5.17	2.48E-09
1/8/14	1379	1.1	22.8	162.4	4.73	86.6	6.9E-09	6.77E-09	737.7	171.4	5.31	2.39E-09
1/9/14	2804	2.0	21.7	160.4	8.60	82.5	5.8E-09	6.54E-09	761.4	175.2	5.43	2.04E-09
1/10/14	4299	3.2	20.5	158.0	13.55	77.9	6.5E-09	6.42E-09	786.4	180.2	5.59	2.31E-09
	0	0.0	24.0	164.7	0.00	91.2	6.4E-09	6.25E-09	786.4	180.2	5.59	2.24E-09
1/13/14	3847	2.8	20.9	158.8	11.83	79.2	6.4E-09	6.44E-09	850.5	192.0	5.95	2.22E-09
1/14/14	5279	3.7	19.7	156.7	15.91	74.9	6.1E-09	6.28E-09	874.3	196.1	6.08	2.18E-09
1/15/14	7000	5.0	18.4	154.1	21.29	69.9	6.2E-09	6.20E-09	903.0	201.5	6.25	2.23E-09
1/16/14	8154	5.7	17.5	152.5	24.30	66.5	5.7E-09	5.99E-09	922.3	204.5	6.34	2.12E-09
1/17/14	9588	6.7	16.4	150.4	28.60	62.3	6.1E-09	5.99E-09	946.2	208.8	6.47	2.26E-09
	0	0.0	24.0	164.7	0.00	91.2	6.2E-09	5.99E-09	946.2	208.8	6.47	2.21E-09
1/20/14	3928	2.9	20.8	158.6	12.26	78.9	6.4E-09	6.23E-09	1011.6	221.0	6.85	2.25E-09
1/21/14	5355	3.9	19.6	156.4	16.56	74.3	6.4E-09	6.33E-09	1035.4	225.3	6.99	2.29E-09
1/22/14	6785	4.9	18.4	154.2	20.86	69.9	6.2E-09	6.35E-09	1059.2	229.6	7.12	2.27E-09
1/23/14	8238	6.0	17.2	151.9	25.59	65.4	6.6E-09	6.40E-09	1083.5	234.4	7.27	2.42E-09
1/24/14	9662	6.9	16.1	149.9	29.46	61.2	5.8E-09	6.20E-09	1107.2	238.2	7.39	2.18E-09
	0	0.0	24.0	164.7	0.00	91.2	6.3E-09	6.24E-09	1107.2	238.2	7.39	2.27E-09
1/27/14	3896	12.0	11.5	140.2	11.95	11.5	2.4E-08	1.21E-08	1172.1	250.2	7.76	2.39E-09
1/28/14	5479	17.3	7.2	130.6	17.30	7.2	6.3E-09	1.23E-08	1198.5	255.5	7.92	2.61E-09
	0	0.0	24.0	164.7	0.00	24.0	6.4E-09	1.23E-08	1198.5	255.5	7.92	2.46E-09
1/29/14	1278	4.2	19.4	155.9	4.20	19.4	7.1E-09	6.58E-09	1219.8	259.7	8.05	2.49E-09
1/30/14	2734	8.8	14.9	146.7	8.80	14.9	6.5E-09	6.64E-09	1244.1	264.3	8.19	2.41E-09
1/31/14	4412	13.7	10.6	137.6	13.70	10.6	5.6E-09	6.38E-09	1272.0	269.2	8.35	2.23E-09
	0	0.0	24.0	164.7	0.00	24.0	6.3E-09	6.13E-09	1272.0	269.2	8.35	2.36E-09
2/3/14	8471	13.1	10.8	138.4	13.05	10.8	3.2E-09	5.03E-09	1413.2	282.3	8.75	1.19E-09
	9931	17.2	6.7	130.2	17.20	6.7	5.8E-09	5.10E-09	1437.6	286.4	8.88	2.44E-09
2/4/14	10292	18.2	5.7	128.2	18.20	5.7	5.7E-09	4.90E-09	1443.6	287.4	8.91	2.49E-09
	0	0.0	24.0	164.7	0.00	24.0	3.6E-09	5.05E-09	1443.6	287.4	8.91	1.41E-09
2/5/14	1053	3.7	20.1	157.1	3.70	20.1	7.4E-09	5.59E-09	1461.1	291.1	9.03	2.60E-09
2/6/14	2487	8.5	15.4	147.6	8.45	15.4	6.8E-09	5.96E-09	1485.0	295.9	9.17	2.52E-09
2/7/14	3921	12.9	10.9	138.7	12.90	10.9	6.4E-09	6.87E-09	1508.9	300.3	9.31	2.52E-09
	0	0.0	24.0	164.7	0.00	24.0	6.8E-09	6.67E-09	1508.9	300.3	9.31	2.54E-09
2/10/14	4053	13.4	10.4	137.7	13.40	10.4	6.8E-09	6.68E-09	1576.5	313.7	9.73	2.56E-09
2/11/14	5489	17.5	6.4	129.6	17.45	6.4	5.8E-09	6.49E-09	1600.4	317.8	9.85	2.45E-09
2/12/14	6944	21.3	2.6	122.0	21.30	2.6	5.4E-09	6.00E-09	1624.7	321.6	9.97	2.41E-09
	7235	22.0	1.8	120.5	22.00	1.8	5.3E-09	5.49E-09	1629.5	322.3	9.99	2.47E-09
	0	0.0	24.0	164.7	0.00	24.0	6.3E-09	5.65E-09	1629.5	322.3	9.99	2.51E-09
2/13/14	1156	4.2	19.5	156.0	4.15	19.5	7.7E-09	6.44E-09	1648.8	326.5	10.12	2.72E-09
	2577	8.9	14.7	146.5	8.90	14.7	6.9E-09	6.96E-09	1672.5	331.2	10.27	2.57E-09
2/17/14	0	0.0	24.0	164.7	0.00	24.0	7.3E-09	7.29E-09	1672.5	331.2	10.27	2.64E-09
	4110	15.4	8.5	133.8	15.40	8.5	7.7E-09	7.29E-09	1741.0	346.6	10.75	2.93E-09
2/18/14	5559	19.9	4.0	124.8	19.85	4.0	6.3E-09	7.11E-09	1765.1	351.1	10.88	2.77E-09
	5698	20.3	3.6	124.0	20.30	3.6	6.3E-09	6.79E-09	1767.4	351.5	10.90	2.85E-09
	0	0.0	24.0	164.7	0.00	24.0	7.3E-09	6.66E-09	1767.4	351.5	10.90	2.89E-09
2/19/14	1301	5.2	18.4	153.9	5.15	18.4	8.5E-09	7.37E-09	1789.1	356.7	11.06	3.01E-09
2/20/14	2788	10.6	13.0	143.1	10.60	13.0	7.5E-09	7.78E-09	1813.9	362.1	11.23	2.85E-09
2/21/14	4175	15.3	8.3	133.7	15.30	8.3	7.0E-09	7.65E-09	1837.0	366.8	11.37	2.84E-09
	0	0.0	24.0	164.7	0.00	24.0	7.6E-09	7.37E-09	1837.0	366.8	11.37	2.90E-09
2/24/14	4090	15.5	8.3	133.4	15.50	8.3	7.9E-09	7.48E-09	1905.2	382.3	11.85	2.98E-09
2/25/14	5559	20.3	3.5	123.9	20.30	3.5	6.7E-09	7.39E-09	1929.7	387.1	12.00	2.93E-09
	5986	21.6	2.2	121.2	21.60	2.2	6.4E-09	6.97E-09	1936.8	388.4	12.04	2.94E-09
	0	0.0	24.0	164.7	0.00	24.0	7.5E-09	6.84E-09	1936.8	388.4	12.04	2.97E-09
2/26/14	965	4.1	19.6	156.1	4.10	19.6	9.1E-09	7.65E-09	1952.9	392.5	12.17	3.21E-09
2/27/14	2422	9.9	13.7	144.5	9.85	13.7	8.2E-09	8.26E-09	1977.1	398.3	12.35	3.09E-09
2/28/14	3860	15.0	8.6	134.3	15.00	8.6	7.3E-09	8.21E-09	2001.1	403.4	12.51	2.95E-09

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	4224	16.2	7.3	131.8	16.20	7.3	7.1E-09	7.52E-09	2007.2	404.6	12.54	3.00E-09
	0	0.0	24.0	164.7	0.00	24.0	8.0E-09	7.45E-09	2007.2	404.6	12.54	3.06E-09
3/3/14	3928	15.5	8.2	133.4	15.45	8.2	8.2E-09	7.75E-09	2072.6	420.1	13.02	3.11E-09
3/4/14	5385	20.3	3.3	123.7	20.30	3.3	6.9E-09	7.69E-09	2096.9	424.9	13.17	3.02E-09
	5800	21.6	2.1	121.1	21.60	2.1	6.3E-09	7.12E-09	2103.8	426.2	13.21	2.91E-09
	0	0.0	24.0	164.7	0.00	24.0	7.7E-09	6.97E-09	2103.8	426.2	13.21	3.07E-09
3/5/14	1010	4.5	19.1	155.3	4.45	19.1	9.6E-09	7.87E-09	2120.7	430.7	13.35	3.38E-09
3/6/14	2442	10.5	13.2	143.4	10.45	13.2	8.5E-09	8.61E-09	2144.5	436.7	13.54	3.23E-09
3/7/14	3884	15.9	7.7	132.4	15.90	7.7	7.8E-09	8.64E-09	2168.6	442.1	13.71	3.20E-09
	4134	16.8	6.8	130.6	16.80	6.8	7.4E-09	7.92E-09	2172.7	443.0	13.73	3.18E-09
	0	0.0	24.0	164.7	0.00	24.0	8.5E-09	7.89E-09	2172.7	443.0	13.73	3.25E-09
3/10/14	3988	17.1	6.7	130.3	17.10	6.7	8.9E-09	8.24E-09	2239.2	460.1	14.26	3.41E-09
	4375	18.6	5.3	127.3	18.60	5.3	7.8E-09	8.39E-09	2245.7	461.6	14.31	3.43E-09
	0	0.0	24.0	164.7	0.00	24.0	8.8E-09	8.49E-09	2245.7	461.6	14.31	3.41E-09
3/11/14	1044	5.2	18.6	154.1	5.15	18.6	1.0E-08	9.02E-09	2263.1	466.8	14.47	3.70E-09
3/12/14	2537	11.9	11.8	140.5	11.90	11.8	9.3E-09	9.51E-09	2287.9	473.5	14.68	3.58E-09
3/13/14	3937	17.7	5.9	128.9	17.70	5.9	8.6E-09	9.44E-09	2311.3	479.3	14.86	3.59E-09
	4391	19.5	4.2	125.3	19.50	4.2	8.0E-09	8.64E-09	2318.8	481.1	14.92	3.57E-09
	0	0.0	24.0	164.7	0.00	24.0	9.2E-09	8.60E-09	2318.8	481.1	14.92	3.61E-09
3/14/14	1001	5.3	18.3	153.6	5.30	18.3	1.1E-08	9.53E-09	2335.5	486.4	15.08	4.03E-09
	0	0.0	24.0	164.7	0.00	24.0	1.1E-08	1.06E-08	2335.5	486.4	15.08	4.03E-09
3/17/14	3935	22.7	1.3	119.3	22.65	1.3	1.2E-08	1.15E-08	2401.1	509.1	15.78	4.75E-09
	0	0.0	24.0	164.7	0.00	24.0	1.2E-08	1.17E-08	2401.1	509.1	15.78	4.75E-09
3/18/14	1313	8.9	14.8	146.5	8.90	14.8	1.4E-08	1.26E-08	2423.0	518.0	16.06	5.16E-09
3/19/14	2751	17.3	6.5	129.9	17.25	6.5	1.2E-08	1.26E-08	2447.0	526.3	16.32	4.85E-09
	0	0.0	24.0	164.7	0.00	24.0	1.3E-08	1.30E-08	2447.0	526.3	16.32	5.00E-09
3/21/14	1472	11.8	12.0	140.9	11.75	12.0	1.7E-08	1.38E-08	2471.5	538.1	16.68	6.14E-09
	1663	13.1	10.6	138.1	13.10	10.6	1.5E-08	1.49E-08	2474.7	539.4	16.72	6.10E-09
3/24/14	0	0.0	24.0	164.7	0.00	24.0	1.6E-08	1.60E-08	2474.7	539.4	16.72	6.13E-09
3/26/14	2863	5.9	17.3	152.1	25.37	65.7	2.4E-08	1.85E-08	2522.4	564.8	16.51	6.75E-09
3/27/14	4314	8.4	14.2	146.5	35.91	53.8	1.6E-08	1.88E-08	2546.6	575.3	16.82	6.28E-09
3/28/14	5763	10.7	12.0	141.9	46.01	45.4	1.3E-08	1.77E-08	2570.7	585.4	17.12	5.29E-09
	0	0.0	24.0	164.7	0.00	91.2	1.6E-08	1.51E-08	2570.7	585.4	17.12	6.26E-09
3/31/14	4063	7.8	15.1	148.0	33.33	57.4	1.7E-08	1.55E-08	2638.4	618.8	18.09	6.37E-09
4/1/14	5518	10.4	12.1	142.4	44.51	46.0	1.6E-08	1.64E-08	2662.7	629.9	18.42	6.43E-09
4/2/14	6934	12.8	9.2	137.1	54.83	35.0	1.5E-08	1.61E-08	2686.3	640.3	18.72	6.50E-09
4/3/14	8376	15.2	6.5	131.9	65.36	24.5	1.5E-08	1.55E-08	2710.3	650.8	19.03	6.51E-09
4/4/14	9819	17.3	4.0	127.4	74.18	15.2	1.3E-08	1.45E-08	2734.4	659.6	19.29	5.84E-09
	0	0.0	24.0	164.7	0.00	91.2	1.6E-08	1.45E-08	2734.4	659.6	19.29	6.34E-09
4/7/14	4040	8.8	3.9	135.8	37.63	14.8	2.9E-08	1.92E-08	2801.7	697.2	20.39	1.16E-08
	0	0.0	24.0	164.7	0.00	91.2	2.9E-08	2.46E-08	2801.7	697.2	20.39	1.16E-08
4/8/14	1057	2.6	20.9	159.0	10.97	79.4	2.2E-08	2.67E-08	2819.3	708.2	20.71	8.02E-09
4/9/14	2493	6.1	17.0	151.6	26.02	64.6	2.1E-08	2.42E-08	2843.3	723.2	21.15	8.05E-09
4/10/14	3935	9.6	13.1	144.2	41.28	49.8	2.1E-08	2.16E-08	2867.3	738.5	21.59	8.48E-09
	0	0.0	24.0	164.7	0.00	91.2	2.2E-08	2.15E-08	2867.3	738.5	21.59	8.20E-09
4/11/14	1433	4.1	19.3	155.9	17.63	73.3	2.5E-08	2.28E-08	2891.2	756.1	22.11	9.30E-09
	0	0.0	24.0	164.7	0.00	91.2	2.5E-08	2.42E-08	2891.2	756.1	22.11	9.30E-09
4/14/14	4128	11.2	11.2	140.7	47.95	42.4	2.4E-08	2.50E-08	2960.0	804.1	23.51	9.26E-09
4/15/14	5583	14.7	7.1	133.1	63.00	26.8	2.2E-08	2.37E-08	2984.2	819.1	23.95	9.26E-09
4/16/14	7021	17.8	3.2	126.1	76.54	12.2	2.0E-08	2.20E-08	3008.2	832.7	24.35	9.12E-09
4/17/14	0	0.0	24.0	164.7	0.00	91.2	2.3E-08	2.15E-08	3008.2	832.7	24.35	9.23E-09
4/21/14	5515	16.8	4.7	128.6	72.03	17.7	2.7E-08	2.33E-08	3100.1	904.7	26.45	1.09E-08
4/22/14	6972	20.2	0.6	121.0	86.86	2.1	2.1E-08	2.38E-08	3124.4	919.5	26.89	1.01E-08
	0	0.0	24.0	164.7	0.00	91.2	2.6E-08	2.48E-08	3124.4	919.5	26.89	1.07E-08
4/23/14	1419	4.9	18.4	154.2	20.86	69.7	3.1E-08	2.60E-08	3148.0	940.4	27.50	1.13E-08
4/24/14	2860	9.5	13.1	144.3	40.64	49.6	2.8E-08	2.84E-08	3172.1	960.2	28.07	1.12E-08
	0	0.0	24.0	164.7	0.00	91.2	3.0E-08	2.96E-08	3172.1	960.2	28.07	1.12E-08
4/25/14	1164	4.2	19.2	155.6	18.06	72.8	3.2E-08	3.01E-08	3191.5	978.2	28.60	1.18E-08
	1430	5.0	18.2	153.8	21.50	69.0	2.8E-08	2.99E-08	3195.9	981.7	28.70	1.06E-08
	0	0.0	24.0	164.7	0.00	91.2	3.1E-08	3.05E-08	3195.9	981.7	28.70	1.16E-08
4/28/14	4028	12.9	9.1	136.9	55.26	34.6	2.9E-08	2.93E-08	3263.0	1036.9	30.32	1.11E-08
4/29/14	5480	16.7	4.7	128.6	71.81	17.7	2.4E-08	2.79E-08	3287.2	1053.5	30.80	1.05E-08
4/30/14	7071	20.5	0.2	120.4	88.15	0.8	2.1E-08	2.46E-08	3313.7	1069.8	31.28	1.01E-08
	0	0.0	24.0	164.7	0.00	91.2	2.6E-08	2.37E-08	3313.7	1069.8	31.28	1.08E-08
5/1/14	1190	4.3	18.9	155.3	18.28	71.6	3.3E-08	2.67E-08	3333.6	1088.1	31.81	1.20E-08
5/2/14	2618	9.2	13.5	145.0	39.35	51.1	3.0E-08	2.95E-08	3357.4	1109.2	32.43	1.17E-08
	0	0.0	24.0	164.7	0.00	91.2	3.1E-08	3.13E-08	3357.4	1109.2	32.43	1.18E-08
5/5/14	4200	14.5	7.3	133.4	62.35	27.6	3.1E-08	3.07E-08	3427.4	1171.5	34.25	1.22E-08
5/6/14	5626	18.4	2.6	124.9	78.91	9.9	2.5E-08	2.89E-08	3451.1	1188.1	34.74	1.12E-08
	5993	19.4	1.6	122.9	83.21	5.9	2.3E-08	2.62E-08	3457.3	1192.4	34.86	1.09E-08
5/7/14	0	0.0	24.0	164.7	0.00	91.2	2.9E-08	2.56E-08	3457.3	1192.4	34.86	1.19E-08
	1070	4.1	19.3	155.8	17.63	73.2	3.4E-08	2.88E-08	3475.1	1210.0	35.38	1.25E-08
	2512	8.9	13.6	145.4	38.27	51.7	3.0E-08	3.11E-08	3499.1	1230.6	35.98	1.17E-08
5/9/14	4140	14.1	7.8	134.4	60.63	29.6	2.8E-08	3.08E-08	3526.3	1253.0	36.64	1.17E-08
	0	0.0	24.0	164.7	0.00	91.2	3.0E-08	2.95E-08	3526.3	1253.0	36.64	1.19E-08
5/13/14	1446	5.7	17.4	152.4	24.51	66.1	3.5E-08	3.12E-08	3550.4	1277.5	37.35	1.30E-08
5/14/14	6952	10.7	11.6	141.6	45.80	44.1	8.1E-09	2.46E-08	3642.1	1298.8	37.98	3.23E-09
				140.7	0.00	0.0	2.5E-10	1.45E-08	3642.1	1298.8	37.98	-2.35E-10
							2.46E-08					**9.39E-09**

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Flux and Hydraulic Conductivity Measurement of GCL
Using a Flexible Wall Permeameter

Project Name:	Delta
Sample I.D.	Resistex 12GCL013-3
Start Date:	10/21/2013

Test Parameters

Method:	ASTM D6766		Cell Pressure =	80.0	psi
Permeation Liquid:	XCEL Comanche (lab made customer's formula)		Inflow Pressure =	77.0	psi
Hydration Liquid:	XCEL Comanche (lab made customer's formula)		Outflow Pressure =	75.0	psi
Panel No.	368		Pressure Difference =	2.0	psi
Type of Liquid Reservoir:	annulus		Max. Effective Stress =	5.0	psi
Volume Correction Factor R (if pipet only, R=1):			Hydraulic Gradient, i =	203.0	
R_{in} =	4.1		Area of influent reservoir, a_{in} =	3.5652	cm^2
R_{out} =	4.0		Area of effluent reservoir, a_{out} =	3.4483	cm^2
Diameter of Sample, D =	10.2	cm	Specific Gravity:	2.7	
Length of Sample, L =	0.7	cm	Total Volume:	56.2	cm^3
Area of Sample, A =	81.07	cm^2	Volume of Solids:	18.7	cm^3
Sample Volume, V =	56.2	cm^3	Void Ratio:	2.0	
Dry Weight:	51.17	grams	Porosity:	66.8	%
Wet Weight:	82.415	grams	Pore Volume:	37.5	cm^3
Initial Height of Sample:	0.6	cm			
Final Height of Sample:	0.7	cm			

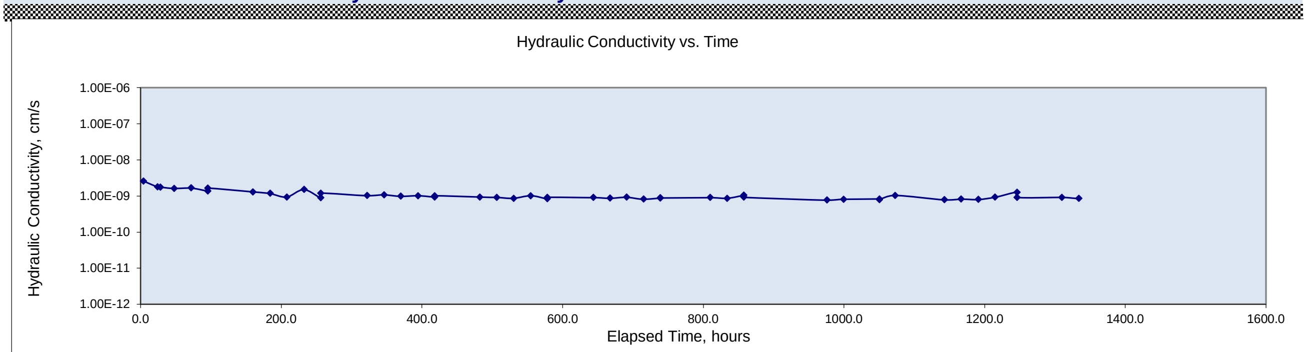
Leachate Characteristics

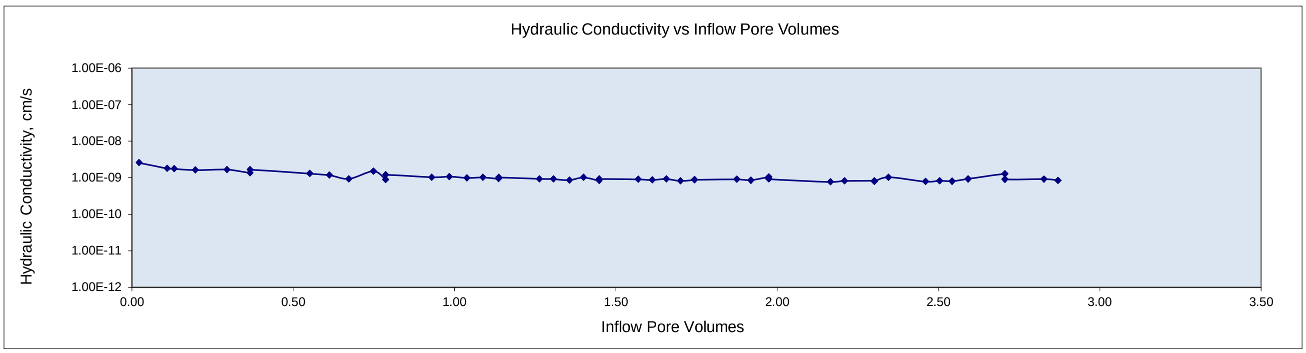
Target Ionic Strength, I		M	Initial Electrical Conductivity	4500.00	µS/cm
Target RMD			Final Electrical Conductivity	10.40	µS/cm
			Initial pH	9.50	
			Final pH		

Note: Length of Sample, L, is equal of Initial Height of Sample, while the test is in progress and to Final Height of Sample after completion of the test.

$$Flux = \frac{(Inflow + Outflow)/2}{A * \Delta t} \qquad K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Final Flux	**2.48E-09**	$m^3/m^2/sec$
Final Hydraulic Conductivity	**9.17E-10**	cm/sec





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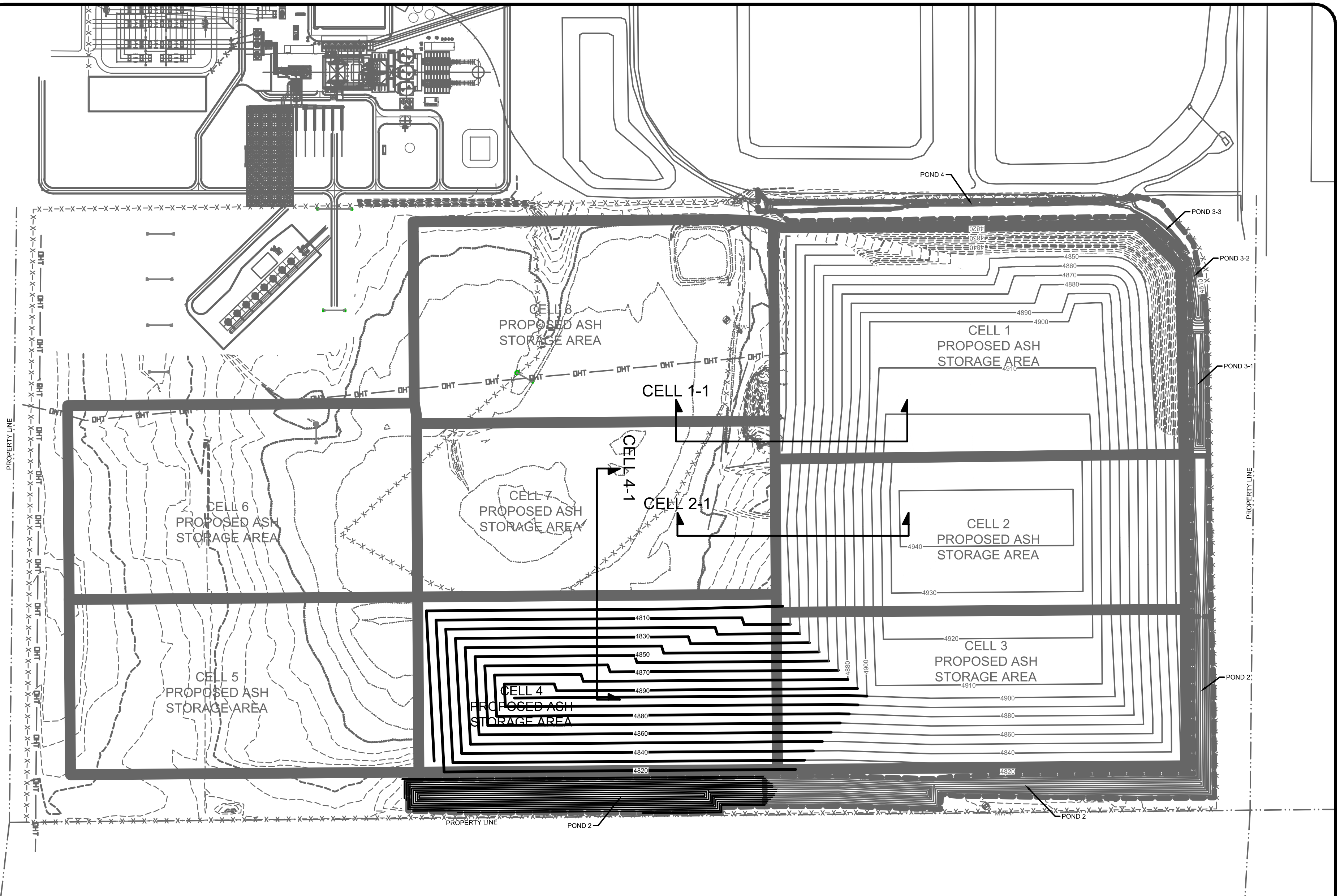
Date	Time (min)	Inflow Reading	Outflow Reading	H (cm)	Inflow Volume (cm^3)	Outflow Volume (cm^3)	Flux ($m^3/m^2/sec$)	Avg Flux ($m^3/m^2/sec$)	Elapsed Time (hrs)	Total Cumulative Inflow (cm^3)	Inflow Pore Volumes	K (cm/sec)
10/21/13	0	0.0	24.0	164.7	0.00	96.0			0.0	0.0	0.0	
	236	0.2	23.8	164.3	0.82	95.2	7.1E-09	7.06E-09	3.9	0.8	0.02	2.57E-09
10/22/13	1428	1.0	23.2	162.9	4.10	92.8	4.9E-09	5.98E-09	23.8	4.1	0.11	1.79E-09
	1691	1.2	23.1	162.6	4.92	92.4	4.8E-09	5.57E-09	28.2	4.9	0.13	1.75E-09
10/23/13	2840	1.8	22.5	161.4	7.38	90.0	4.3E-09	4.67E-09	47.3	7.4	0.20	1.61E-09
10/24/13	4293	2.7	21.9	159.8	11.07	87.4	4.4E-09	4.52E-09	71.6	11.1	0.30	1.66E-09
10/25/13	5728	3.4	21.3	158.6	13.74	85.0	3.6E-09	4.14E-09	95.5	13.7	0.37	1.37E-09
	0	0.0	24.0	164.7	0.00	96.0	4.4E-09	4.17E-09	95.5	13.7	0.37	1.65E-09
10/28/13	3848	1.7	22.5	161.4	6.97	89.8	3.5E-09	3.86E-09	159.6	20.7	0.55	1.29E-09
10/29/13	5303	2.3	21.9	160.3	9.23	87.6	3.1E-09	3.70E-09	183.9	23.0	0.61	1.17E-09
10/30/13	6729	2.8	21.6	159.5	11.48	86.4	2.5E-09	3.05E-09	207.6	25.2	0.67	9.31E-10
10/31/13	8195	3.5	20.9	158.1	14.35	83.6	4.0E-09	3.20E-09	232.1	28.1	0.75	1.50E-09
11/1/13	9619	3.9	20.5	157.3	15.79	81.8	2.3E-09	2.93E-09	255.8	29.5	0.79	8.90E-10
	0	0.0	24.0	164.7	0.00	96.0	3.2E-09	3.17E-09	255.8	29.5	0.79	1.19E-09
11/4/13	3955	1.3	22.7	162.0	5.33	90.6	2.8E-09	2.78E-09	321.7	34.9	0.93	1.02E-09
11/5/13	5400	1.8	22.2	161.0	7.38	88.6	2.9E-09	2.96E-09	345.8	36.9	0.98	1.07E-09
11/6/13	6827	2.3	21.8	160.1	9.43	87.0	2.6E-09	2.77E-09	369.6	39.0	1.04	9.81E-10
11/7/13	8292	2.8	21.3	159.2	11.28	85.0	2.7E-09	2.74E-09	394.0	40.8	1.09	1.01E-09
11/8/13	9725	3.2	20.9	158.3	13.12	83.4	2.5E-09	2.60E-09	417.9	42.6	1.14	9.33E-10
	0	0.0	24.0	164.7	0.00	96.0	2.7E-09	2.63E-09	417.9	42.6	1.14	1.01E-09
11/11/13	3860	1.2	22.8	162.3	4.72	91.2	2.5E-09	2.57E-09	482.2	47.4	1.26	9.30E-10
11/12/13	5292	1.6	22.4	161.5	6.36	89.4	2.5E-09	2.57E-09	506.1	49.0	1.31	9.16E-10
11/13/13	6740	2.0	22.0	160.7	8.20	88.0	2.3E-09	2.44E-09	530.2	50.8	1.36	8.57E-10
11/14/13	8201	2.4	21.5	159.7	9.84	85.8	2.7E-09	2.49E-09	554.6	52.5	1.40	1.01E-09
11/15/13	9618	2.9	21.2	159.0	11.69	84.6	2.2E-09	2.40E-09	578.2	54.3	1.45	8.30E-10
	0	0.0	24.0	164.7	0.00	96.0	2.5E-09	2.46E-09	578.2	54.3	1.45	9.15E-10
11/18/13	3907	1.1	22.8	162.4	4.51	91.2	2.4E-09	2.38E-09	643.3	58.8	1.57	8.99E-10
11/19/13	5330	1.5	22.4	161.6	6.15	89.6	2.3E-09	2.42E-09	667.0	60.5	1.61	8.67E-10
11/20/13	6763	1.9	22.0	160.7	7.79	87.8	2.5E-09	2.42E-09	690.9	62.1	1.66	9.19E-10
11/21/13	8203	2.3	21.6	160.0	9.43	86.4	2.2E-09	2.33E-09	714.9	63.8	1.70	8.11E-10
11/22/13	9637	2.7	21.2	159.2	11.07	84.8	2.3E-09	2.32E-09	738.8	65.4	1.74	8.73E-10
	0	0.0	24.0	164.7	0.00	96.0	2.4E-09	2.29E-09	738.8	65.4	1.74	8.80E-10
11/25/13	4241	1.2	22.7	162.2	4.92	90.8	2.5E-09	2.38E-09	809.5	70.3	1.87	9.01E-10
11/26/13	5683	1.6	22.3	161.4	6.56	89.2	2.3E-09	2.38E-09	833.5	72.0	1.92	8.56E-10
11/27/13	7104	2.1	21.9	160.4	8.61	87.4	2.8E-09	2.52E-09	857.2	74.0	1.97	1.04E-09
	0	0.0	24.0	164.7	0.00	96.0	2.5E-09	2.53E-09	857.2	74.0	1.97	9.19E-10
12/2/13	7092	1.8	22.2	161.1	7.18	88.8	2.1E-09	2.45E-09	975.4	81.2	2.16	7.67E-10
12/3/13	8531	2.2	21.9	160.4	8.82	87.4	2.2E-09	2.25E-09	999.4	82.8	2.21	8.10E-10
12/5/13	11580	3.0	21.1	158.8	12.30	84.4	2.2E-09	2.15E-09	1050.2	86.3	2.30	8.21E-10
	0	0.0	24.0	164.7	0.00	96.0	2.1E-09	2.16E-09	1050.2	86.3	2.30	7.87E-10
12/6/13	1332	0.4	23.5	163.8	1.64	94.0	2.8E-09	2.37E-09	1072.4	87.9	2.34	1.03E-09
12/9/13	5547	1.5	22.4	161.6	5.95	89.6	2.1E-09	2.35E-09	1142.6	92.3	2.46	7.83E-10
12/10/13	6968	1.9	22.1	160.9	7.59	88.2	2.2E-09	2.38E-09	1166.3	93.9	2.50	8.17E-10
12/11/13	8425	2.2	21.7	160.1	9.02	86.6	2.1E-09	2.15E-09	1190.6	95.3	2.54	8.01E-10
12/12/13	9864	2.7	21.3	159.3	10.87	85.0	2.5E-09	2.27E-09	1214.6	97.2	2.59	9.24E-10
12/13/13	11727	3.7	20.8	157.8	15.17	83.2	3.4E-09	2.66E-09	1245.6	101.5	2.71	1.27E-09
	0	0.0	24.0	164.7	0.00	96.0	2.5E-09	2.76E-09	1245.6	101.5	2.71	9.12E-10
12/16/13	3839	1.1	22.8	162.4	4.51	91.2	2.5E-09	2.77E-09	1309.6	106.0	2.83	9.15E-10
12/17/13	5287	1.5	22.4	161.6	6.15	89.6	2.3E-09	2.41E-09	1333.8	107.6	2.87	8.52E-10
12/18/13	6703	2.0	22.0	160.7	8.20	88.0	2.6E-09	2.48E-09	1357.4	109.7	2.92	9.85E-10
				140.7	0.00	0.0	-1.2E-08	-2.43E-09	1357.4	109.7	2.92	-4.95E-09
							2.48E-09					**9.17E-10**

APPENDIX B

STABILITY ANALYSIS



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XCEL ENERGY

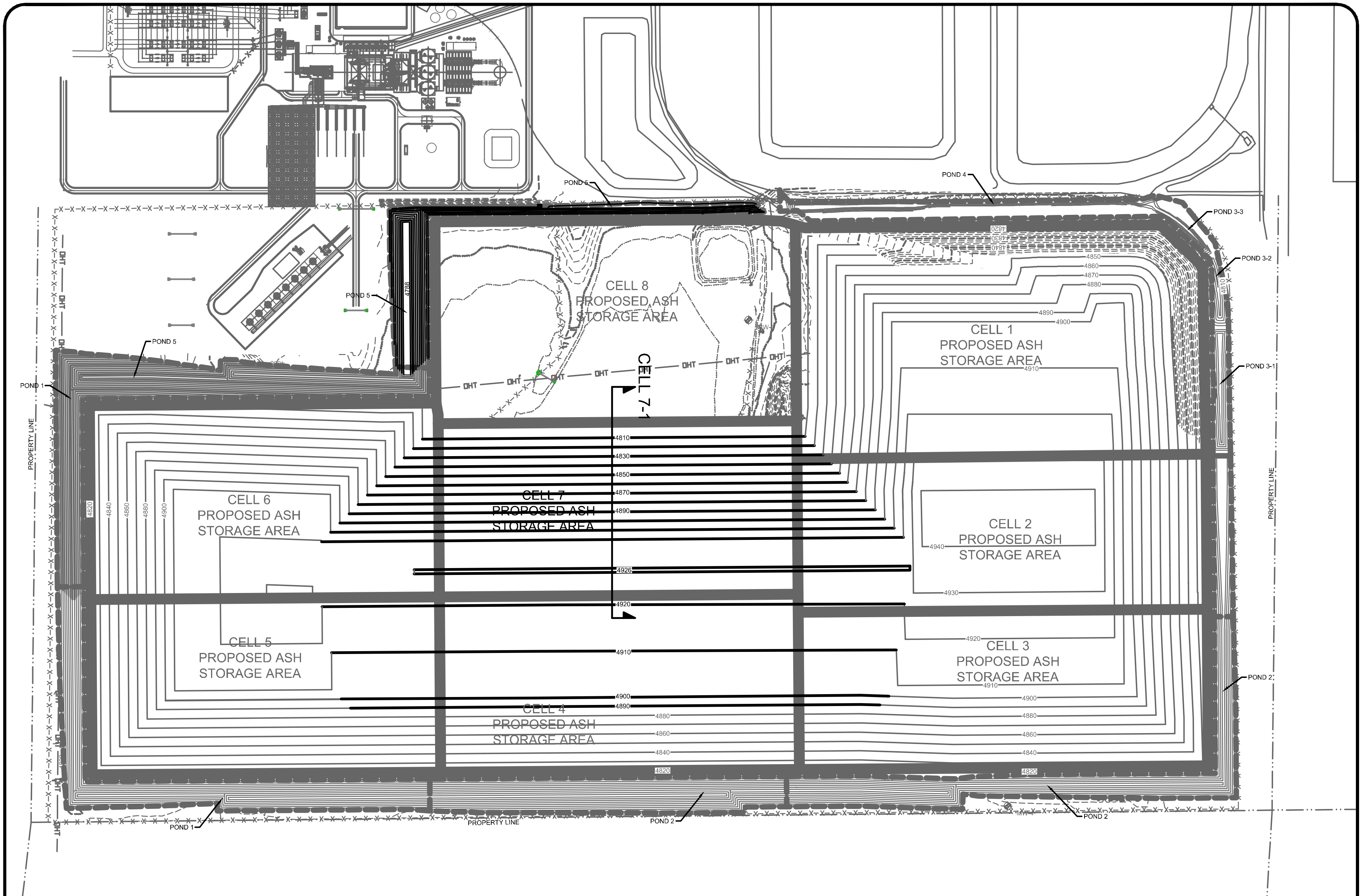
COMANCHE
ASH LANDFILL

SLOPE STABILITY SECTIONS

Project No.:	117-2827028
Date:	07-2015
Designed By:	JMS

Figure
H.1

Bar Measures 1 inch



XCEL ENERGY	Project No.: 117-2827028
COMANCHE ASH LANDFILL	Date: 07-2015
	Designed By: JMS
SLOPE STABILITY SECTIONS	Figure H.2

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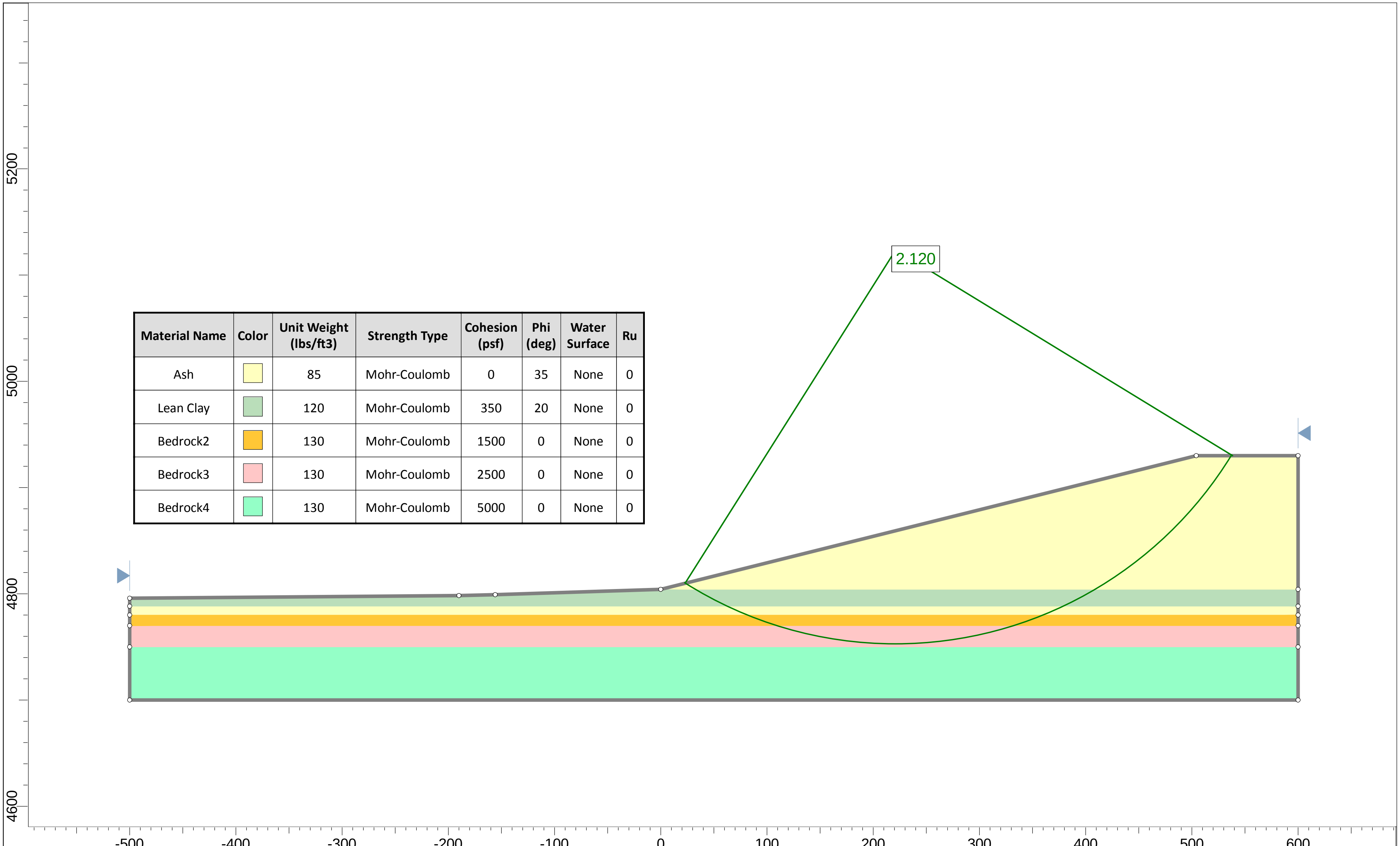
Bar Measures 1 inch

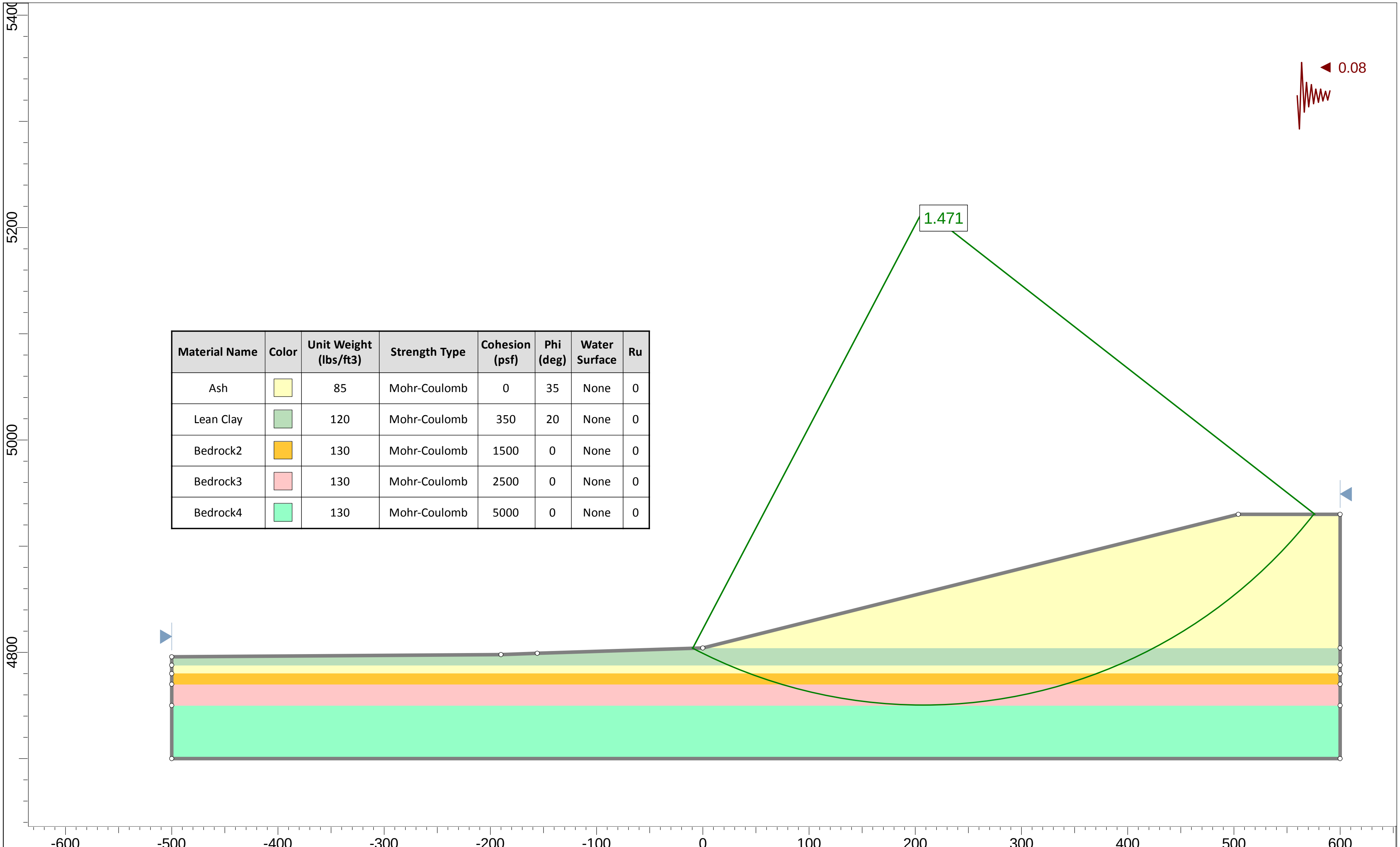
9/30/2015 3:43:45 PM - N:\PROJECTS\TTCASPER\114-560461 117-XCEL-COMANCHE LANDFILL DES\CAD\D17803-EPDO COMANCHE STATION\SHEETFILES\FIGURES\F-H2-SLOPE STABILITY SECTIONS.DWG



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0

Project	Commanche Ash Landfill
Analysis Description	Cell 1-1 Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	September, 2015
Figure Number	H.3

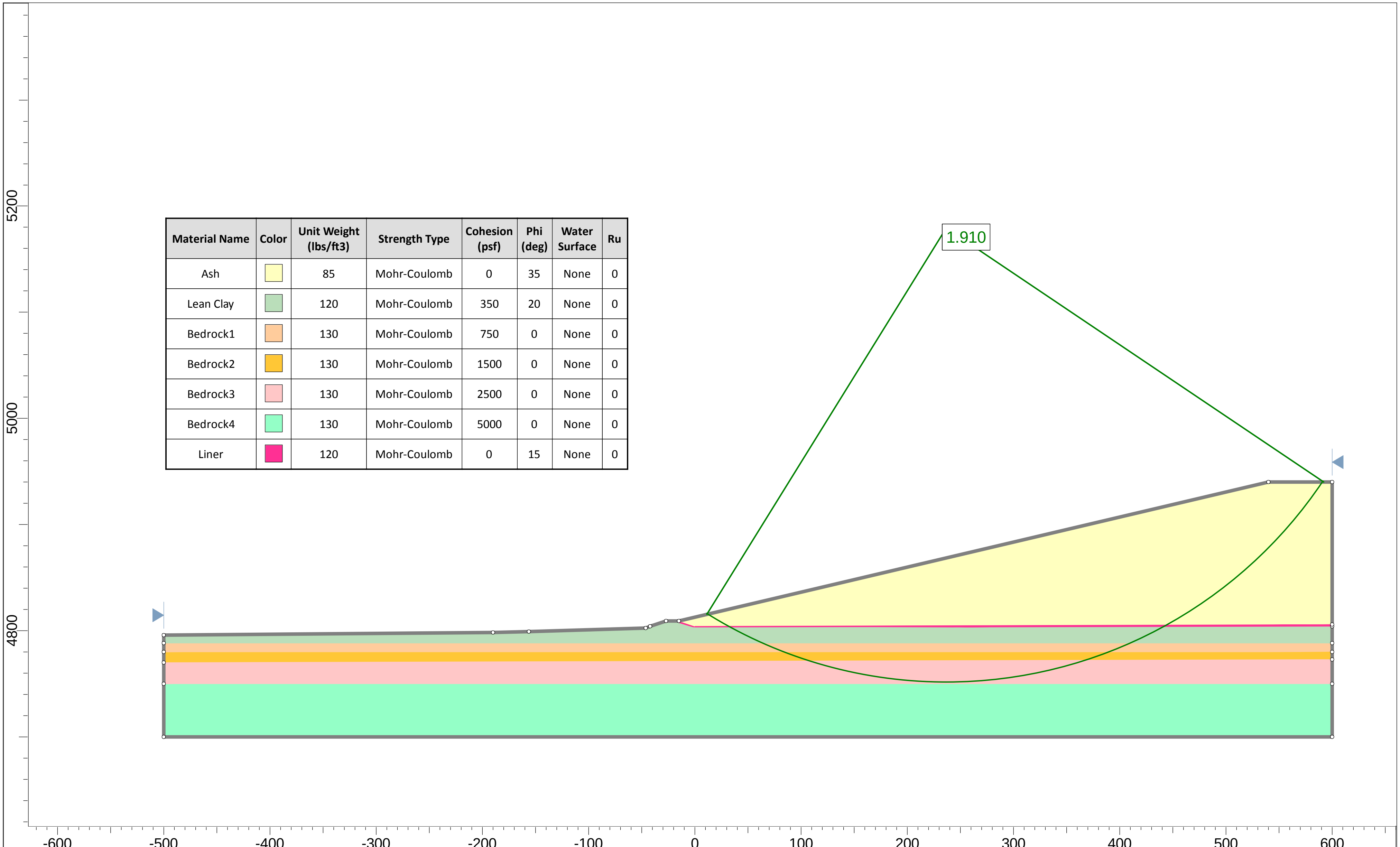
SLIDEINTERPRET 6.031



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0

Project	Commanche Ash Landfill		
Analysis Description	Cell 1-1 Pseudo-Static		
Drawn By		*Scale* 1:1500	*Company* Tetra Tech
Date	September, 2015		*Figure Number* H.4

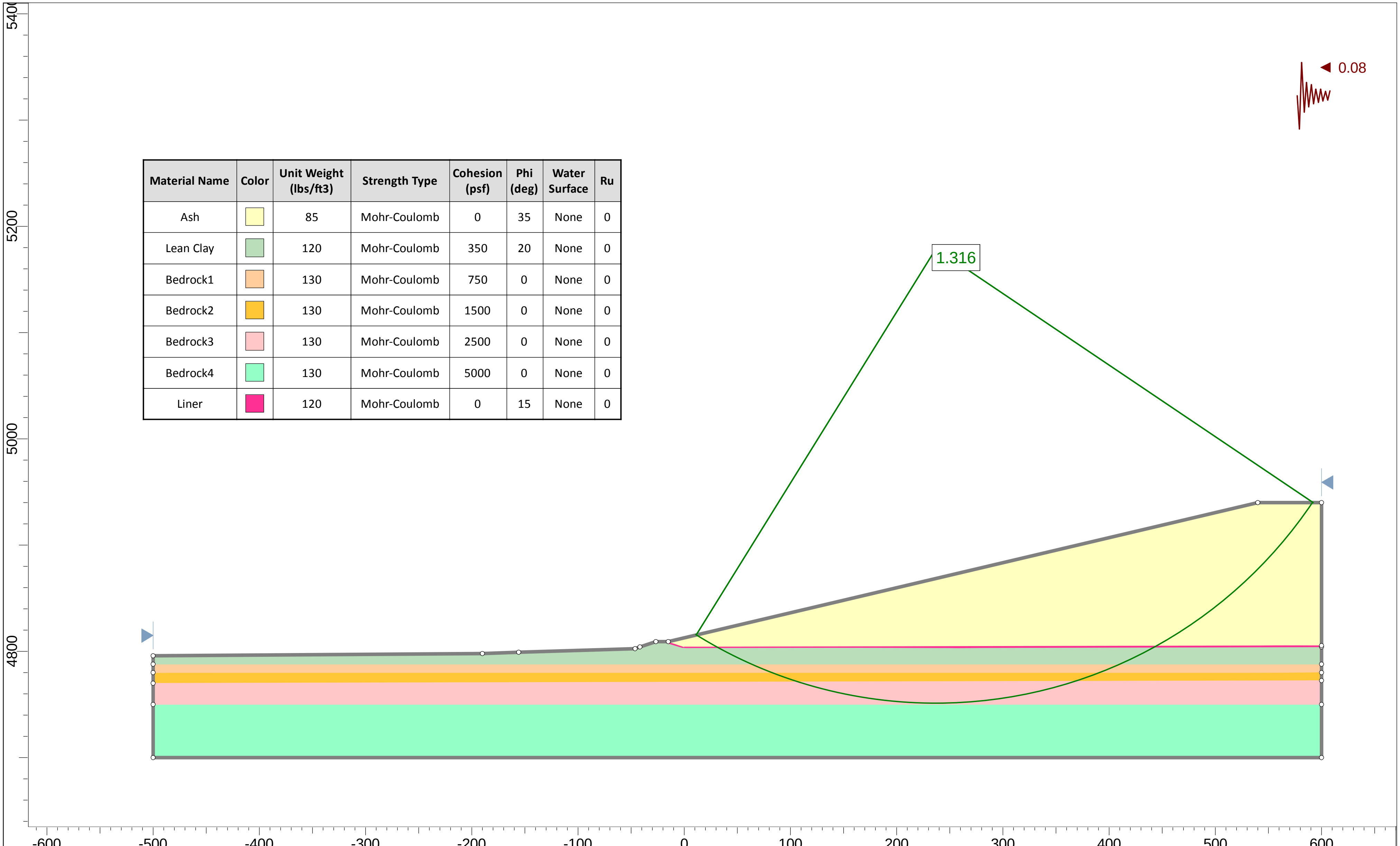
SLIDEINTERPRET 6.031



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

SLIDEINTERPRET 6.031

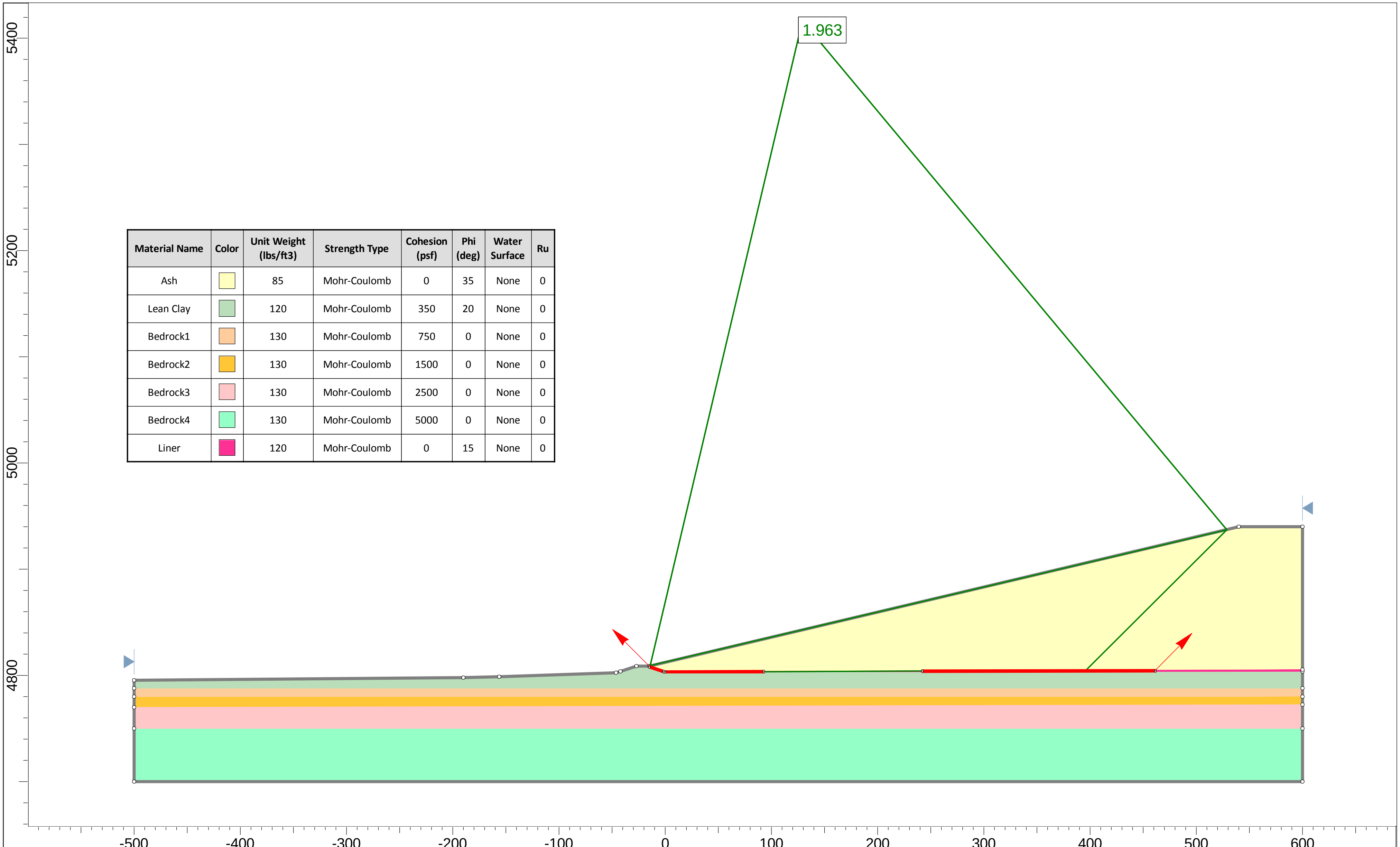
Project	Commanche Ash Landfill
Analysis Description	Cell 2-1 Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	September, 2015
Figure Number	H.5



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

Project	Commanche Ash Landfill		
Analysis Description	Cell 2-1 Pseudo-Static		
Drawn By		*Scale* 1:1500	*Company* Tetra Tech
Date	September, 2015		*Figure Number* H.6

SLIDEINTERPRET 6.031

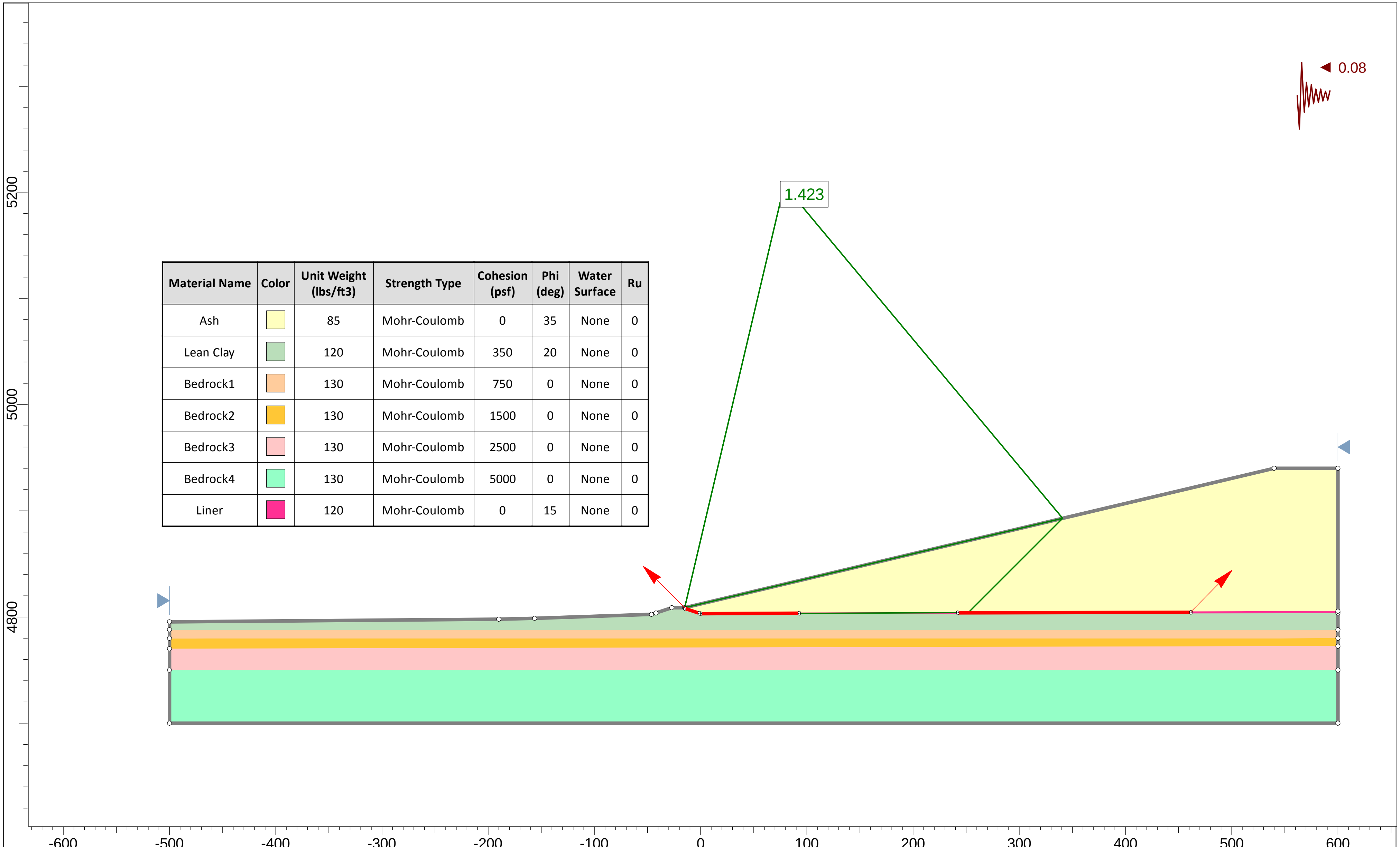


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

rocscience

SLIDEINTERPRET 6.031

Project	Commanche Ash Landfill
Analysis Description	Cell 2-1 Sliding Block, Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	September, 2015
Figure Number	H.7

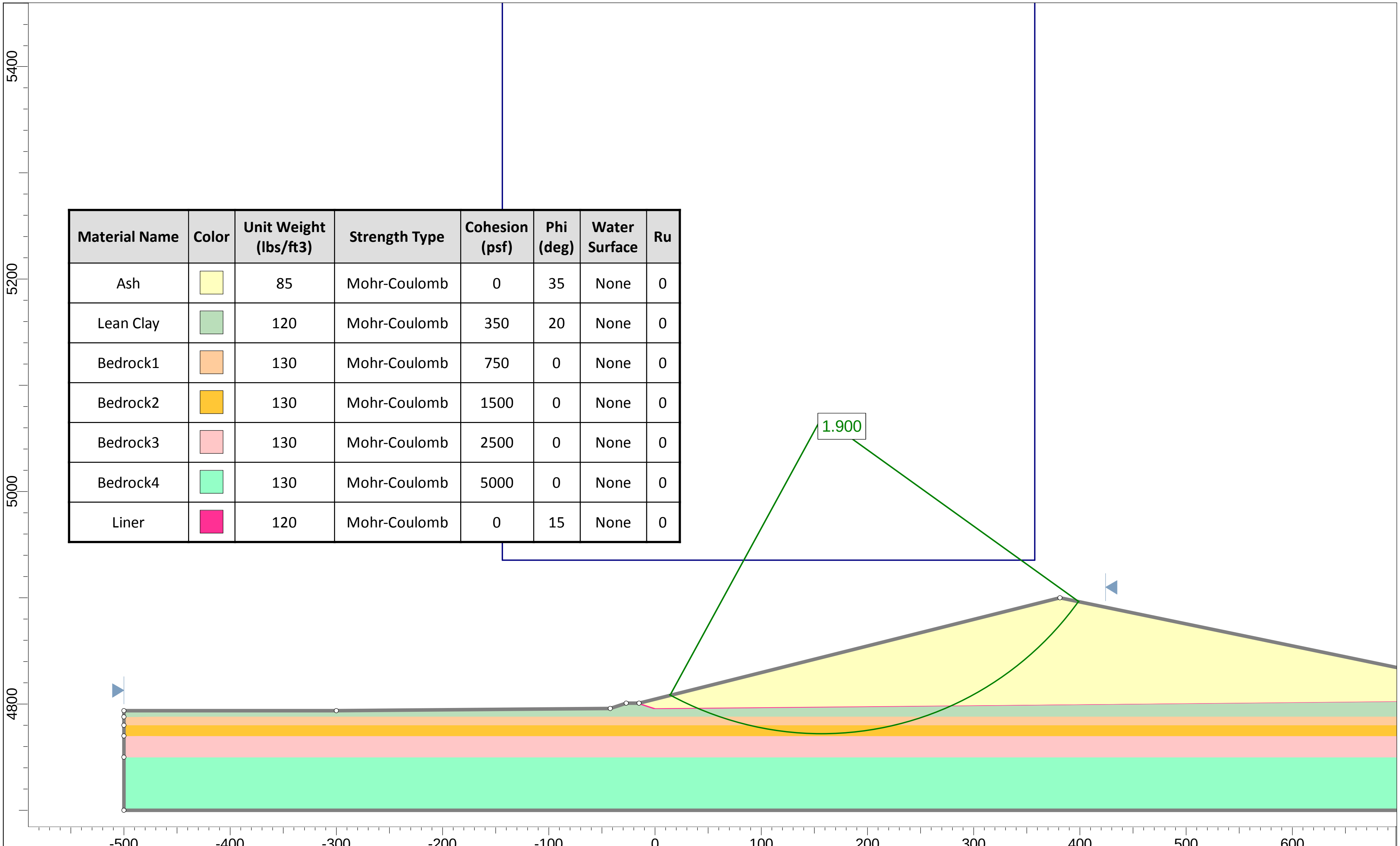


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

Project	Commanche Ash Landfill		
Analysis Description	Cell 2-1 Sliding Block, Pseudo-Static		
Drawn By		*Scale* 1:1500	*Company* Tetra Tech
Date	September, 2015	*Figure Number*	H.8

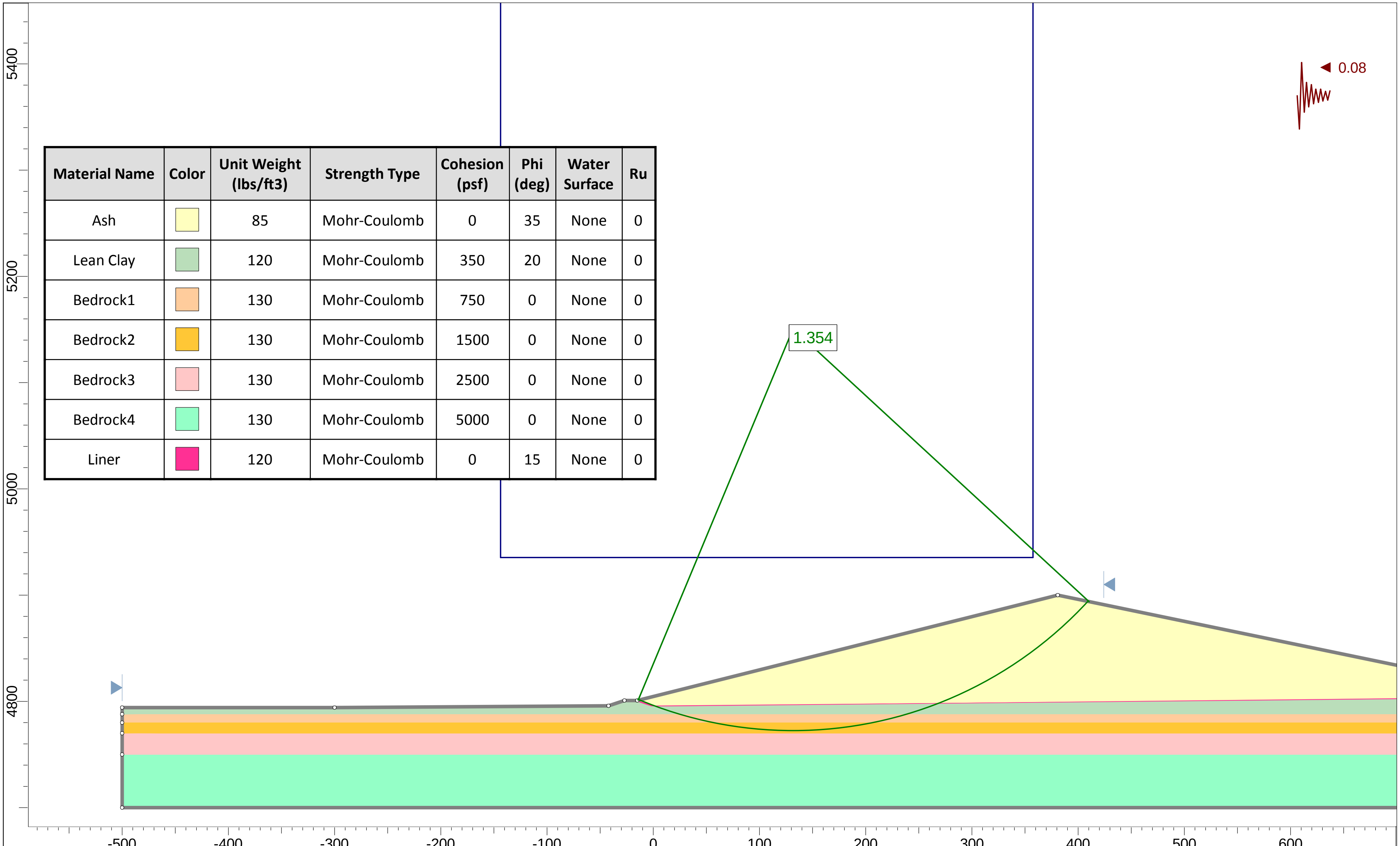
SLIDEINTERPRET 6.031

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0



Project	Commanche Ash Landfill
Analysis Description	Cell 4-1 Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.9

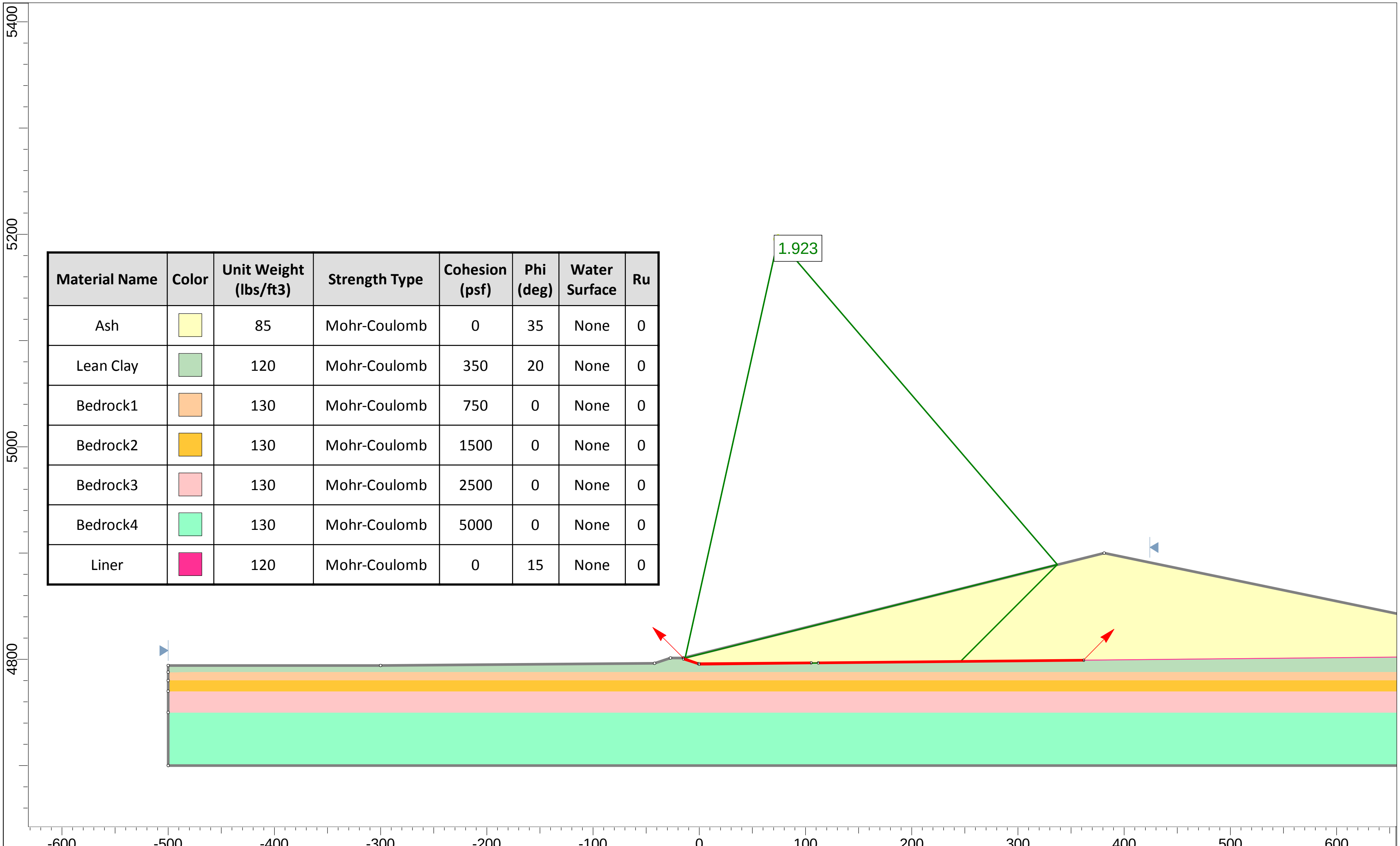
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

Project	Commanche Ash Landfill		
Analysis Description	Cell 4-1 Pseudo-Static		
Drawn By	*Scale* 1:1500	*Company*	Tetra Tech
Date	July, 2015	*Figure Number*	H.10

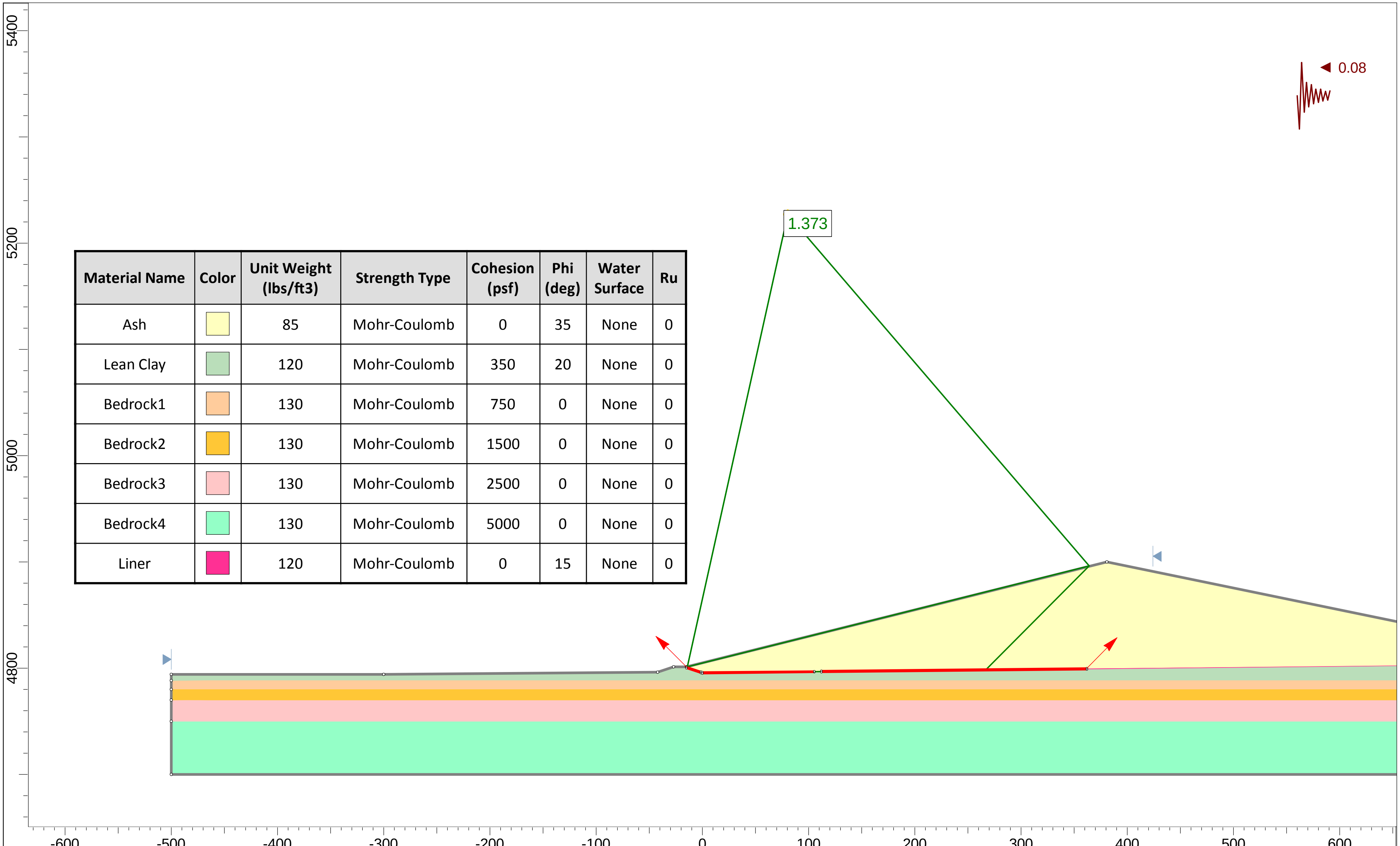
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

Project	Commanche Ash Landfill
Analysis Description	Cell 4-1, Sliding-Block, Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.11

SLIDEINTERPRET 6.035

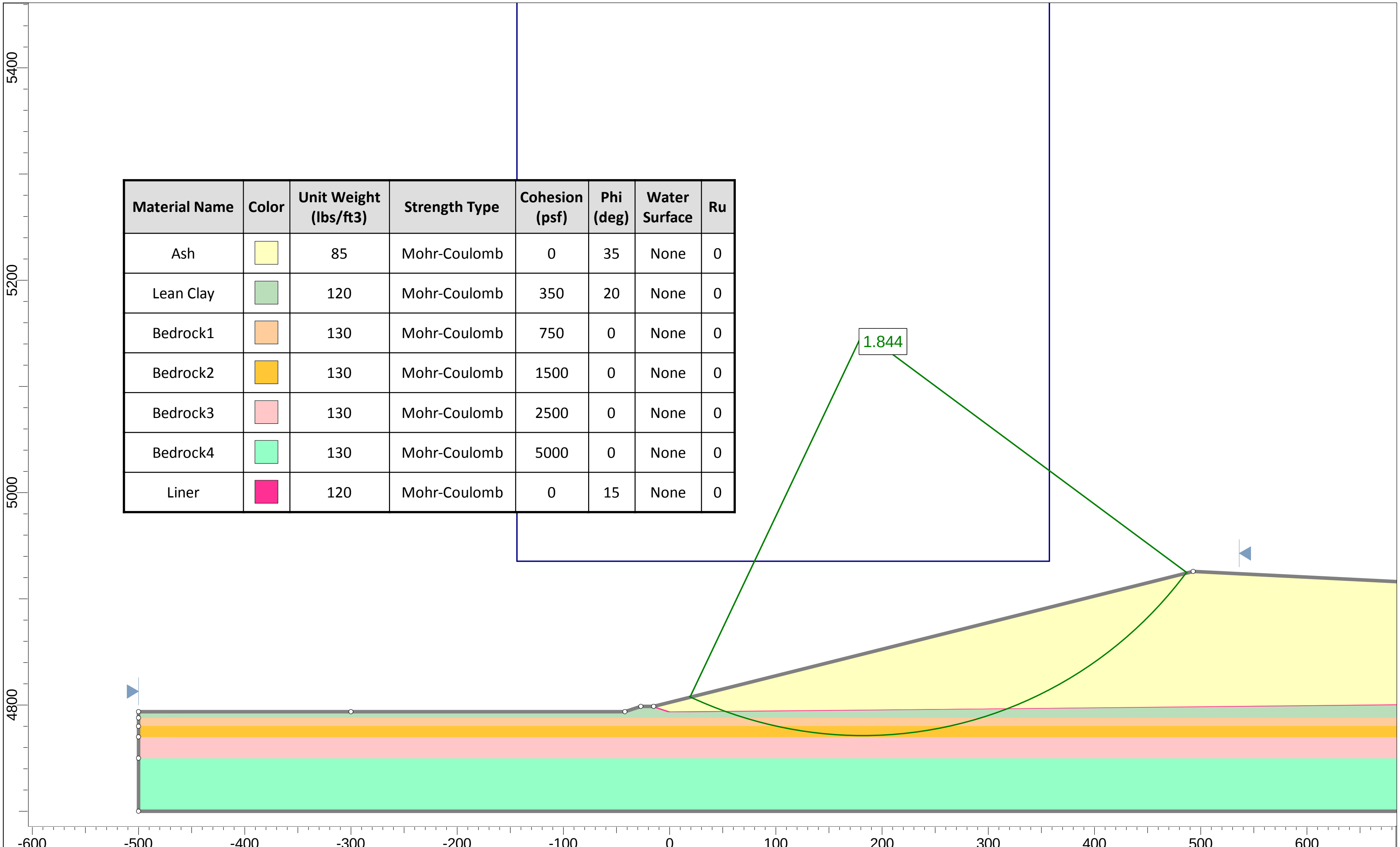


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

SLIDEINTERPRET 6.035

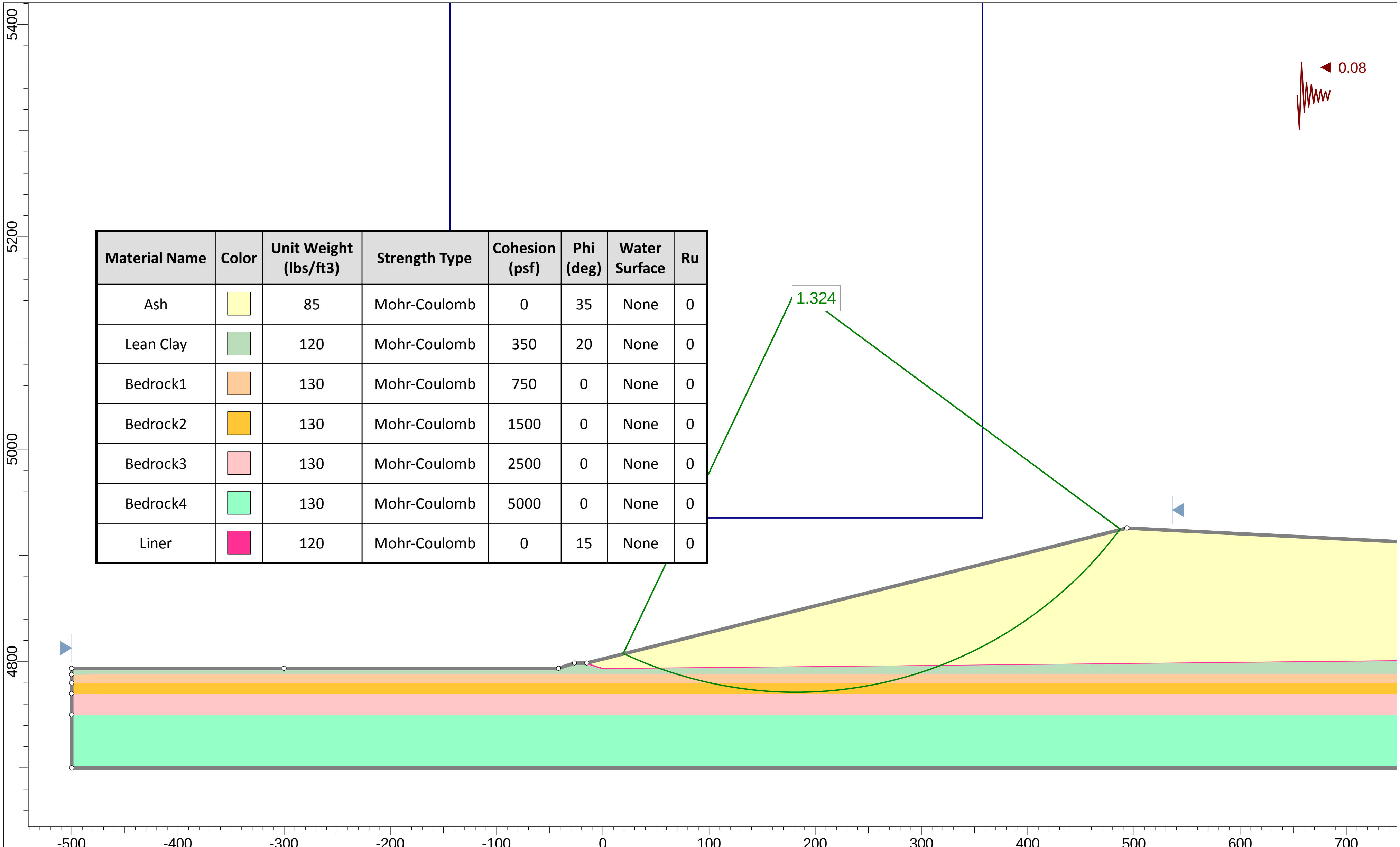
Project	Commanche Ash Landfill
Analysis Description	Cell 4-1, Sliding-Block, Pseudo-Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.12

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0



Project	Commanche Ash Landfill
Analysis Description	Cell 7-1, Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.13

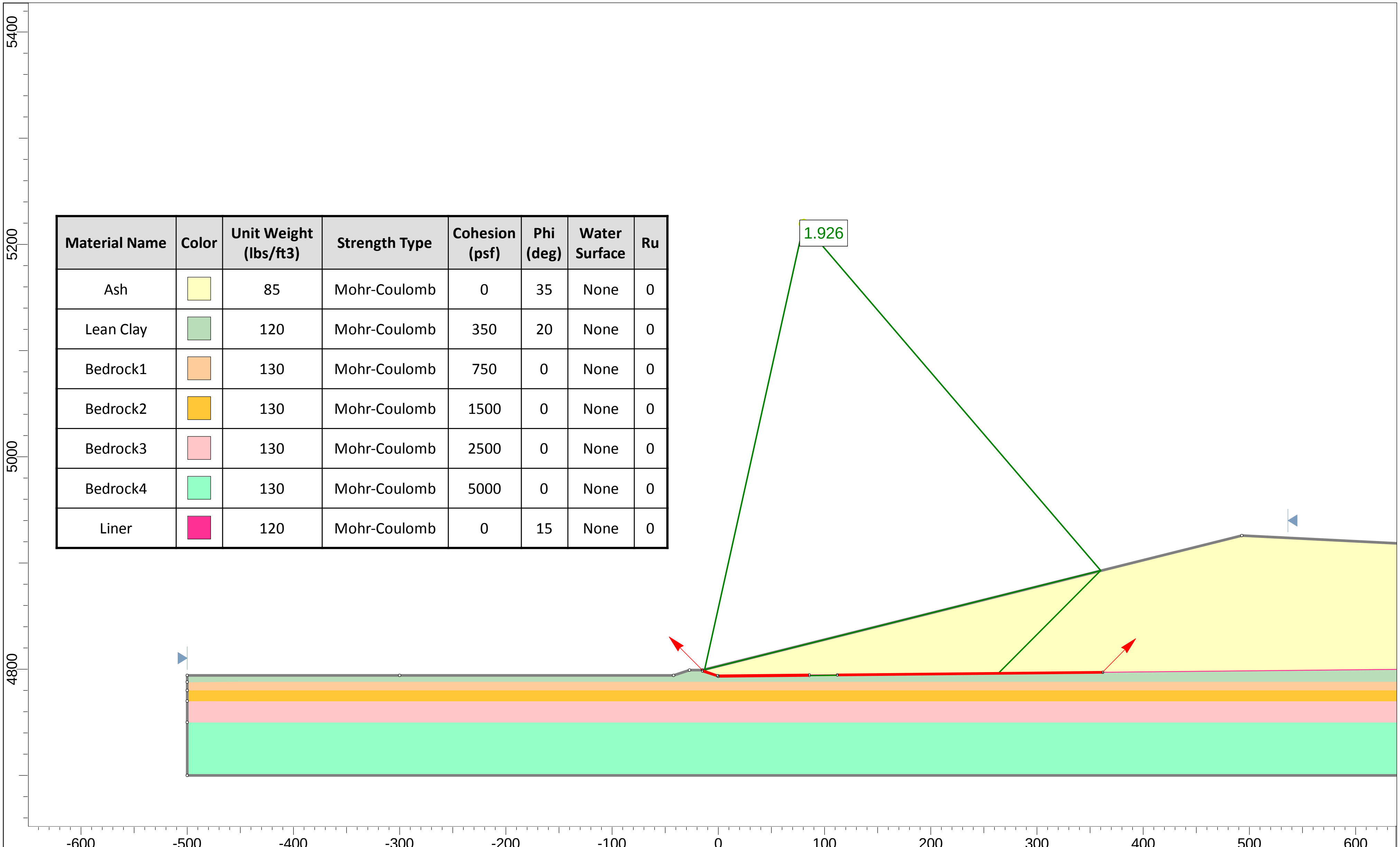
SLIDEINTERPRET 6.035



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

SLIDEINTERPRET 6.035

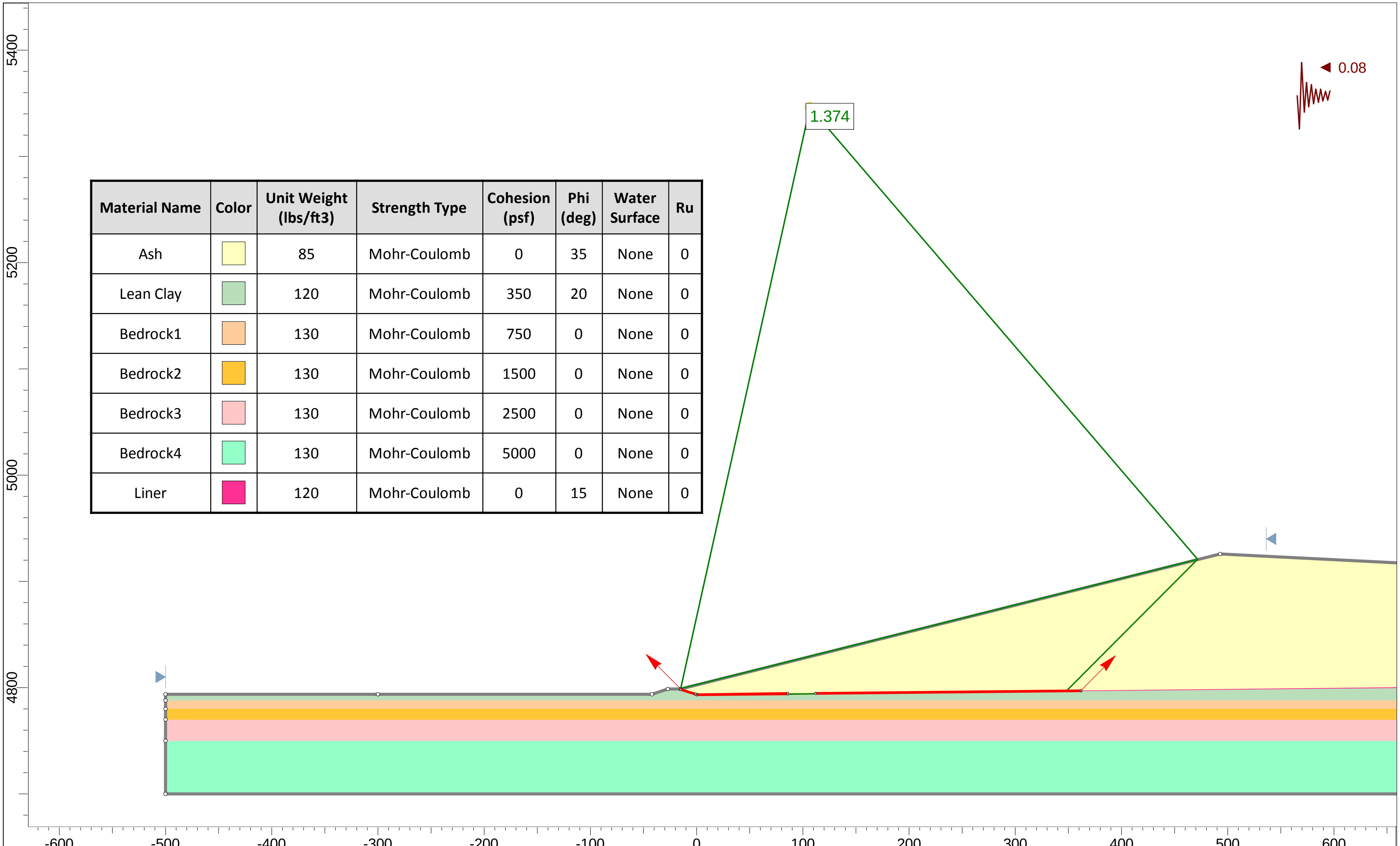
Project	Commanche Ash Landfill
Analysis Description	Cell 7-1, Psuedo-Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.14



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

SLIDEINTERPRET 6.035

Project	Commanche Ash Landfill
Analysis Description	Cell 7-1, Sliding-Block, Static
Drawn By	
Scale	1:1500
Company	Tetra Tech
Date	July, 2015
Figure Number	H.15



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Ash		85	Mohr-Coulomb	0	35	None	0
Lean Clay		120	Mohr-Coulomb	350	20	None	0
Bedrock1		130	Mohr-Coulomb	750	0	None	0
Bedrock2		130	Mohr-Coulomb	1500	0	None	0
Bedrock3		130	Mohr-Coulomb	2500	0	None	0
Bedrock4		130	Mohr-Coulomb	5000	0	None	0
Liner		120	Mohr-Coulomb	0	15	None	0

Project	Commanche Ash Landfill	
Analysis Description	Cell 7-1, Sliding-Block, Psuedo-Static	
Drawn By	Scale 1:1500	Company Tetra Tech
Date July, 2015		Figure Number H.16

SLIDEINTERPRET 6.035

APPENDIX C

HELP MODEL RESULTS

Comanche ADF HELP Model Simulations

The Hydrologic Evaluation of Landfill Performance (HELP) model, version 3, was used to estimate leachate generation from Cell 2 East. The HELP model was developed by the U.S. Environmental Protection Agency to analyze water balance in landfill lining and capping systems.

The HELP program contains parameters for stochastically generated weather data for select U.S. cities. The parameters include precipitation, daily temperatures, solar radiation, and evapotranspiration. Weather data was synthetically generated for a 30 year period based on the parameters for Pueblo, Colorado contained in the HELP program.

The model for Cell 2 East was developed with a liner system consisting of 2 feet of compacted clay (HELP soil texture #16) with a hydraulic conductivity of 1×10^{-7} cm/sec under a 60-mil HDPE liner (HELP soil texture #35). The liner was assumed to have a manufacturing quality rating of excellent, which results in a manufactured defect density of one per acre. Similarly, the installation quality was assumed to be excellent. A 12-inch thick layer of sand (HELP soil texture #4) with a hydraulic conductivity of 1.7×10^{-3} cm/sec was utilized above the HDPE liner. This layer was designated as a lateral drainage layer to collect leachate generated from the ash. The drainage layer was input with a 1% slope and a length 270 feet prior to reaching the leachate collection pipe. The waste fill material was modeled as a vertical percolation layer. Based on information provided by PSCo, the estimated annual quantities of materials placed in the landfill are provided in Table 1-1.

Table 1-1. Estimated Annual Quantities of Materials.

Material	**Tons/Year**	**CY/Year**	**Percentage of Mix**	**Comments**
Dry Fly Ash	300,000	240,000	85.7	Assumed density of 1.25 tons/CY
Bottom Ash	5,000	4,000	1.4	Assumed density of 1.25 tons/CY
Lime Sludge	N/A	36,000	12.9	
TOTAL	N/A	280,000	100	

Separate material properties (porosity, field capacity, wilting point, and hydraulic conductivity) were selected for each waste stream that comprises the fill. The material properties for the dry fly ash were assumed to be that of HELP soil texture #30 (high-density electric plant coal fly ash), and the material properties of the bottom ash were assumed to be that of HELP soil texture #31 (high-density electric coal bottom ash). The material properties for the lime sludge were assumed to be that of HELP soil texture #23 (silty loam) based on a literature review. Since the individual fill materials will not be placed in uniform layers and will be mixed during the placement/grading process, the individual material properties were combined to develop one set of bulk material properties to use in modeling the fill. The bulk hydraulic conductivity of the fill was calculated using the geometric mean of the individual material properties. The remaining material properties were calculated using a weighted average of the individual material properties based on the expected volumes of each waste stream.

During the operational phase, a separate layer of fill was added to the model for each planned year of operation. The thickness of each fill layer was estimated to be 199 inches (16.6 feet) based on the capacity of Cell 2 East and the current ash fill rate. The anticipated life of Cell 2 East is 3.2 years. The model was run separately for the first 3 years of the operational phase using the 30-year average of the precipitation data. Each layer was added under the initial, steady state conditions for moisture content. Each year's model output was then utilized as the input for the subsequent year. During the operational phase, it was assumed that there would be no runoff from the landfill, and all precipitation would be contained in the landfill.

In the 4^{th} year of the model, a final 39 inch (3.3 feet) layer of waste fill was added and covered with a 24-inch compacted soil cover. The soil cover will be constructed using site soils; therefore, the results of geotechnical analysis for soil samples collected at a depth of 0 to 7 feet at the site were used as the basis for developing material properties for the model. Porosity, initial moisture content, and hydraulic conductivity values were obtained directly from the geotechnical results. Field capacity and wilting point were obtained from HELP soil texture #24 (United States Department of Agriculture classification of moderate sandy clay loam), the model soil texture which most closely approximated the known material properties of the on-site soil. The soil cover is intended to be a barrier to infiltration; however, the HELP model requires the uppermost layer in the model to consist of a vertical percolation layer which allows for a vegetative cover. Water either flows downward or is extracted by evapotranspiration in vertical percolation layers, whereas barrier soil layers are intended to restrict vertical flow. Default evaporative zone depths in the HELP program are based on the "Climates of the States" (Ruffner, 1985) and "Climatic Atlas of the United States" (National Oceanic and Atmospheric Administration, 1974). The default evaporative depths for Pueblo, Colorado are 14 inches for bare ground, 28 inches for a fair stand of vegetation, and 42 inches for an excellent stand of vegetation. However, the evaporative depth in the model is limited to the depth of the uppermost vertical percolation layer. For modeling purposes, the 24-inch thick soil cover was treated as two layers: an upper vertical percolation layer underlain by a barrier soil layer. The sensitivity of the Comanche landfill model to the thickness of the uppermost vertical percolation layer (and subsequent evapotranspiration depth) was analyzed by performing 30-year model runs with three different layer designations for the soil cover. The first model run assumed the 24-inch soil cover consisted of a 14-inch vertical percolation layer underlain by a 10-inch barrier soil layer to represent evaporative conditions for bare ground. The second model run assumed a 21-inch vertical percolation layer underlain by a 3-inch barrier soil layer to represent vegetative conditions between bare ground and a fair stand of vegetation. The third model run assumed the entire 24-inch soil cover was a vertical percolation layer. The results of the sensitivity analysis demonstrated that varying the designating of the vertical percolation layer between 14 inches and 24-inches did not have significant impact on the quantity of leachate recovered in the leachate collection system. The quantity of water removed from the cover by evapotranspiration varied by a maximum of 0.8% in any given year, and the total quantity of water removed by evapotranspiration over the 30 year model varied by only 0.02%. These results indicate the majority of evapotranspiration of surface precipitation is occurring within the upper 14-inches of the soil cover, and infiltration through the cover is not significantly influenced by the thickness of the vertical percolation layer designated in the model.

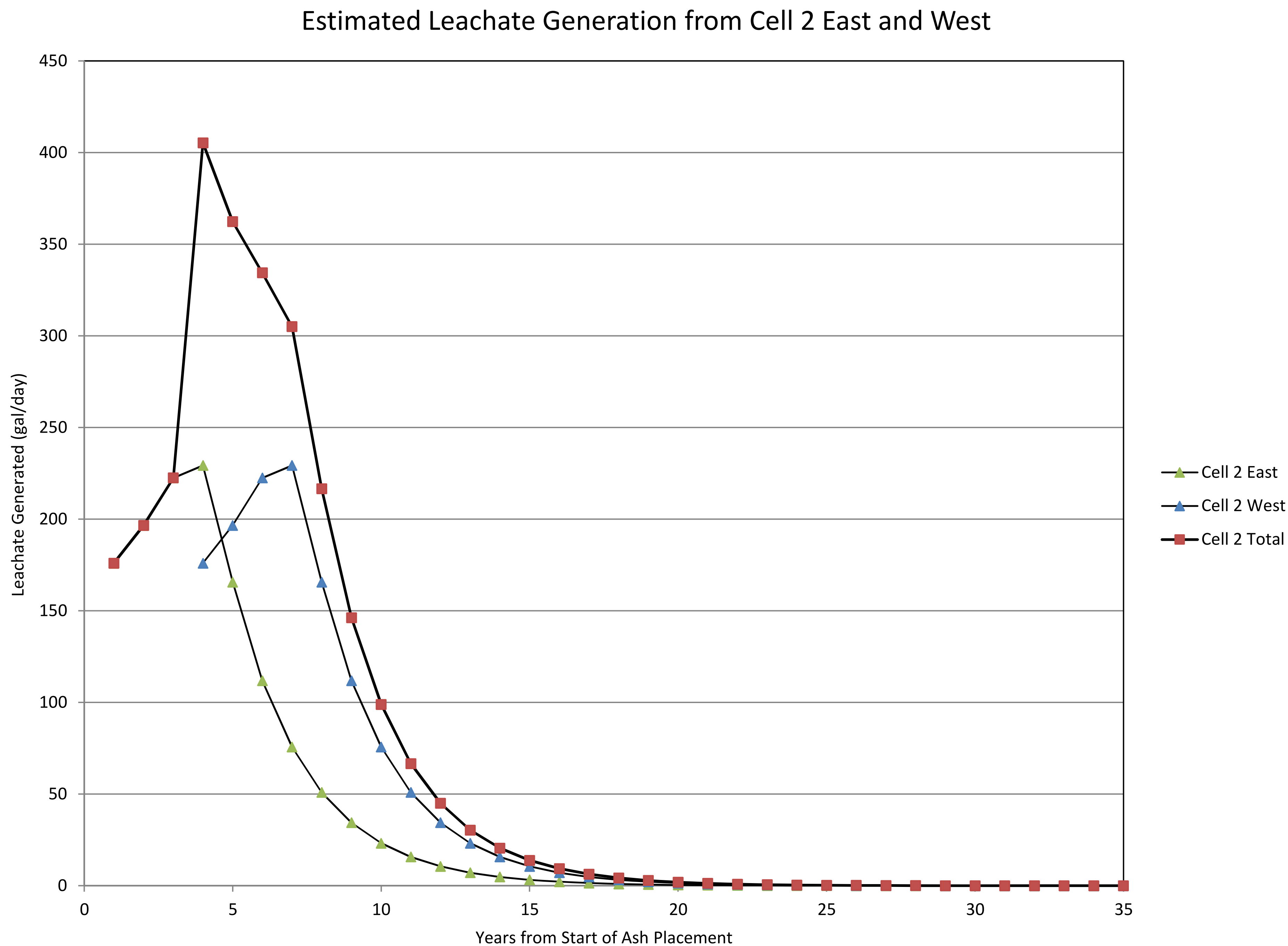
The final 24-inch soil cover was modeled to represent vegetative conditions between bare ground and a fair stand of vegetation, with the upper 21 inches of the cover input as a vertical percolation layer and the bottom 3 inches input as a barrier soil layer. The model was converted to allow runoff from 100% of the footprint with the cover in place. The model was then run for 30 years using 30 years of synthetically generated weather data for Pueblo, Colorado.

The maximum head on top of the HDPE liner for Cell 2 East was 3.14 inches, located a distance of 48.9 feet from the leachate collection pipe. The estimated maximum leachate generation from Cell 2 East is 229 gallons per day. The results were offset 4 years to coincide with the estimated start of ash placement in Cell 2 West when the cover is placed on Cell 2 East. This assumes Cell 2 West will have the same volume and contain the same materials modeled for Cell 2 East. The resulting maximum leachate generation is 405 gallons per day, which occurs in Year 4 when Cell 2 East is capped and ash placement begins in Cell 2 West. A summary of the HELP model results are provided in Appendix B.

Comanche Ash Landfill Cell 2
HELP Model Output Summary

Year from Beginning of Ash Placement	Fill Depth (ft)	Leachate Collected (ft^3)	Leachate Collected (gal)	Collection Rate East Half of Cell 2 (gpd)	Collection Rate East Half of Cell 2 (gpd)	Combined Collection Rate For All of Cell 2
1	16.6	8586.943	64234.80	176.0		176.0
2	33.2	9594.286	71770.25	196.6		196.6
3	49.8	10857.807	81222.04	222.5		222.5
4*	53.1	11190.687	83712.16	229.3	176.0	405.3
5	53.1	8084.458	60475.95	165.7	196.6	362.3
6	53.1	5458.819	40834.80	111.9	222.5	334.4
7**	53.1	3694.166	27634.28	75.7	229.3	305.1
8	53.1	2486.149	18597.69	51.0	165.7	216.6
9	53.1	1678.708	12557.61	34.4	111.9	146.3
10	53.1	1133.504	8479.20	23.2	75.7	98.9
11	53.1	767.081	5738.16	15.7	51.0	66.7
12	53.1	516.240	3861.74	10.6	34.4	45.0
13	53.1	348.577	2607.54	7.1	23.2	30.4
14	53.1	235.375	1760.73	4.8	15.7	20.5
15	53.1	159.254	1191.30	3.3	10.6	13.8
16	53.1	107.150	801.54	2.2	7.1	9.3
17	53.1	72.320	540.99	1.5	4.8	6.3
18	53.1	48.798	365.03	1.0	3.3	4.3
19	53.1	32.988	246.77	0.7	2.2	2.9
20	53.1	22.163	165.79	0.5	1.5	1.9
21	53.1	14.927	111.66	0.3	1.0	1.3
22	53.1	10.041	75.11	0.2	0.7	0.9
23	53.1	6.756	50.54	0.1	0.5	0.6
24	53.1	4.507	33.71	0.1	0.3	0.4
25	53.1	3.004	22.47	0.1	0.2	0.3
26	53.1	1.989	14.88	0.0	0.1	0.2
27	53.1	1.306	9.77	0.0	0.1	0.1
28	53.1	0.839	6.28	0.0	0.1	0.1
29	53.1	0.527	3.94	0.0	0.0	0.1
30	53.1	0.316	2.36	0.0	0.0	0.0
31	53.1	0.174	1.30	0.0	0.0	0.0
32	53.1	0.077	0.58	0.0	0.0	0.0
33	53.1	0.014	0.10	0.0	0.0	0.0
34	53.1	0.000	0.00	0.0	0.0	0.0
35	53.1	0.000	0.00	0.0	0.0	0.0
36	53.1	0.000	0.00	0.0	0.0	0.0

Notes:
* - Cover placement on Cell 2 East, begin filling Cell 2 West.
** - Cover placement on Cell 2 West.



Estimated Leachate Generation from Cell 2 East and West
Leachate Generated (gal/day)
Years from Start of Ash Placement
0
50
100
150
200
250
300
350
400
450
0
5
10
15
20
25
30
35
Cell 2 East
Cell 2 West
Cell 2 Total

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


PRECIPITATION DATA FILE:    C:\HELP3\c\p-ave-op.D4
TEMPERATURE DATA FILE:      C:\HELP3\c\t-ave-op.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\c\s-ave-op.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\c\e-ave-op.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\c\LCS1.D10
OUTPUT DATA FILE:           C:\HELP3\c\Year1.OUT


TIME:  13:32     DATE:  11/ 1/2013


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

     TITLE:  Comanche Landfill Cell#2

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


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


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    199.00   INCHES
           POROSITY                   =      0.5312 VOL/VOL
           FIELD CAPACITY             =      0.2077 VOL/VOL
           WILTING POINT              =      0.0667 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2093 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.123000005000E-03 CM/SEC
```

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

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   4
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4370 VOL/VOL
FIELD CAPACITY              =      0.1050 VOL/VOL
WILTING POINT               =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.170000002000E-02 CM/SEC
SLOPE                       =      1.00   PERCENT
DRAINAGE LENGTH             =    270.0    FEET


                          LAYER  3
                          --------

                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    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  2 - EXCELLENT


                          LAYER  4
                          --------

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

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 255. FEET.

SCS RUNOFF CURVE NUMBER	=	96.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	13.600	ACRES
EVAPORATIVE ZONE DEPTH	=	14.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.930	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.437	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.934	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	53.471	INCHES
TOTAL INITIAL WATER	=	53.471	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM PUEBLO COLORADO

STATION LATITUDE	=	38.17	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	111	
END OF GROWING SEASON (JULIAN DATE)	=	291	
EVAPORATIVE ZONE DEPTH	=	14.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	46.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.25	0.27	0.68	1.00	1.47	1.16
1.81	1.83	0.81	0.78	0.49	0.31

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO
AND STATION LATITUDE = 38.17 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72	529226.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.451	219732.219	41.52
DRAINAGE COLLECTED FROM LAYER 2	0.1739	8586.943	1.62
PERC./LEAKAGE THROUGH LAYER 4	0.000119	5.869	0.00
AVG. HEAD ON TOP OF LAYER 3	1.3333		
CHANGE IN WATER STORAGE	6.095	300899.437	56.86
SOIL WATER AT START OF YEAR	53.471	2639739.500	
SOIL WATER AT END OF YEAR	53.297	2631146.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	6.269	309492.281	58.48
ANNUAL WATER BUDGET BALANCE	0.0000	1.493	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.22	0.26	0.57	0.98	1.54	1.07
	1.75	1.81	0.77	0.76	0.64	0.35
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.220	0.260	0.570	0.420	0.256	0.326
	0.621	0.510	0.382	0.314	0.255	0.317
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0108	0.0099	0.0118	0.0129	0.0163	0.0173
	0.0173	0.0168	0.0157	0.0157	0.0147	0.0147
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.9754	0.9935	1.0688	1.2048	1.4714	1.6134
	1.5672	1.5157	1.4668	1.4195	1.3736	1.3293
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 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72 (0.000)	529226.0	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	4.451 (0.0000)	219732.23	41.520
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.17394 (0.00000)	8586.943	1.62255
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00012 (0.00000)	5.869	0.00111
AVERAGE HEAD ON TOP OF LAYER 3	1.333 (0.000)		
CHANGE IN WATER STORAGE	6.095 (0.0000)	300899.44	56.857

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	0.18	8886.240
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.00058	28.76446
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.01967
AVERAGE HEAD ON TOP OF LAYER 3	1.632	
MAXIMUM HEAD ON TOP OF LAYER 3	2.723	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	44.8 FEET	
SNOW WATER	6.31	311329.0940
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2093	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2093	

*** 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 1

LAYER	(INCHES)	(VOL/VOL)
1	41.3547	0.2078
2	1.6939	0.1412
3	0.0000	0.0000
4	10.2480	0.4270
SNOW WATER	6.269	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\HELP3\c\p-ave-op.D4
TEMPERATURE DATA FILE:      C:\HELP3\c\t-ave-op.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\c\s-ave-op.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\c\e-ave-op.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\c\LCS2.D10
OUTPUT DATA FILE:           C:\HELP3\c\Year2.OUT


TIME:  13:46     DATE:  11/ 1/2013


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     TITLE:  Comanche Landfill Cell#2

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


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                 =    199.00   INCHES
           POROSITY                  =      0.5312 VOL/VOL
           FIELD CAPACITY            =      0.2079 VOL/VOL
           WILTING POINT             =      0.0667 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.2093 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.123000005000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	199.00	INCHES
POROSITY	=	0.5312	VOL/VOL
FIELD CAPACITY	=	0.2077	VOL/VOL
WILTING POINT	=	0.0667	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2078	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.123000005000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 4

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.1050	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1412	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000002000E-02	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	270.0	FEET

LAYER 4

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	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

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

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 255. FEET.

SCS RUNOFF CURVE NUMBER	=	96.80	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	13.600	ACRES
EVAPORATIVE ZONE DEPTH	=	14.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.930	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.437	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.934	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	94.945	INCHES
TOTAL INITIAL WATER	=	94.945	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PUEBLO COLORADO

STATION LATITUDE	=	38.17 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	111
END OF GROWING SEASON (JULIAN DATE)	=	291
EVAPORATIVE ZONE DEPTH	=	14.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	46.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	50.00 %

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 54.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.25	0.27	0.68	1.00	1.47	1.16
1.81	1.83	0.81	0.78	0.49	0.31

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO
AND STATION LATITUDE = 38.17 DEGREES

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72	529226.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.451	219732.219	41.52
DRAINAGE COLLECTED FROM LAYER 3	0.1943	9594.286	1.81
PERC./LEAKAGE THROUGH LAYER 5	0.000133	6.559	0.00

AVG. HEAD ON TOP OF LAYER 4	1.4915		
CHANGE IN WATER STORAGE	6.075	299891.531	56.67
SOIL WATER AT START OF YEAR	94.945	4687257.500	
SOIL WATER AT END OF YEAR	94.751	4677657.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	6.269	309492.281	58.48
ANNUAL WATER BUDGET BALANCE	0.0000	1.370	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 2 THROUGH 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.22	0.26	0.57	0.98	1.54	1.07
	1.75	1.81	0.77	0.76	0.64	0.35
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.220	0.260	0.570	0.420	0.256	0.326
	0.621	0.510	0.382	0.314	0.255	0.317
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0148	0.0140	0.0161	0.0157	0.0162	0.0154
	0.0155	0.0157	0.0170	0.0188	0.0176	0.0176
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 5

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	1.3361	1.4021	1.4542	1.4675	1.4680	1.4415
	1.4023	1.4152	1.5846	1.6951	1.6423	1.5893
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 2 THROUGH 2

	INCHES		CU. FEET	PERCENT
PRECIPITATION	10.72	(0.000)	529226.0	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	4.451	(0.0000)	219732.23	41.520
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.19434	(0.00000)	9594.286	1.81289
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00013	(0.00000)	6.559	0.00124
AVERAGE HEAD ON TOP OF LAYER 4	1.492	(0.000)		
CHANGE IN WATER STORAGE	6.075	(0.0000)	299891.53	56.666

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PEAK DAILY VALUES FOR YEARS 2 THROUGH 2

	(INCHES)	(CU. FT.)
PRECIPITATION	0.18	8886.240
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00061	30.25775
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.02070
AVERAGE HEAD ON TOP OF LAYER 4	1.717	
MAXIMUM HEAD ON TOP OF LAYER 4	2.848	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	46.1 FEET	
SNOW WATER	6.31	311329.0940

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2093
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2093

*** 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 2

LAYER	(INCHES)	(VOL/VOL)
1	41.3917	0.2080
2	41.3323	0.2077
3	1.7788	0.1482
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	6.269	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\HELP3\c\p-ave-op.D4
TEMPERATURE DATA FILE:      C:\HELP3\c\t-ave-op.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\c\s-ave-op.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\c\e-ave-op.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\c\LCS3.D10
OUTPUT DATA FILE:           C:\HELP3\c\Year3.OUT


TIME:  13:48     DATE:  11/ 1/2013


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     TITLE:  Comanche Landfill Cell#2

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


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    199.00   INCHES
           POROSITY                   =      0.5312 VOL/VOL
           FIELD CAPACITY             =      0.2077 VOL/VOL
           WILTING POINT              =      0.0667 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2093 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.123000005000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =    199.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2080 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC
```

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =    199.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2077 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC
```

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 4

```
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4370 VOL/VOL
FIELD CAPACITY               =      0.1050 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1482 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC
SLOPE                        =      1.00   PERCENT
DRAINAGE LENGTH              =    270.0    FEET
```

LAYER 5

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              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
   THICKNESS                  =      0.06   INCHES
   POROSITY                   =      0.0000 VOL/VOL
   FIELD CAPACITY             =      0.0000 VOL/VOL
   WILTING POINT              =      0.0000 VOL/VOL
   INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY        =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
   FML PLACEMENT QUALITY      =  2 - EXCELLENT


                          LAYER  6
                          --------

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


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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF  1.% AND
          A SLOPE LENGTH OF  255. FEET.

SCS RUNOFF CURVE NUMBER            =     96.80
FRACTION OF AREA ALLOWING RUNOFF   =      0.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     13.600  ACRES
EVAPORATIVE ZONE DEPTH             =     14.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.930  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      7.437  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.934  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =    136.401  INCHES
TOTAL INITIAL WATER                =    136.401  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
PUEBLO COLORADO

STATION LATITUDE	=	38.17 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	111
END OF GROWING SEASON (JULIAN DATE)	=	291
EVAPORATIVE ZONE DEPTH	=	14.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	46.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	50.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.25	0.27	0.68	1.00	1.47	1.16
1.81	1.83	0.81	0.78	0.49	0.31

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO
AND STATION LATITUDE = 38.17 DEGREES

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72	529226.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	4.451	219732.219	41.52
DRAINAGE COLLECTED FROM LAYER 4	0.2199	10857.807	2.05
PERC./LEAKAGE THROUGH LAYER 6	0.000150	7.426	0.00
AVG. HEAD ON TOP OF LAYER 5	1.6877		
CHANGE IN WATER STORAGE	6.049	298626.750	56.43
SOIL WATER AT START OF YEAR	136.401	6733863.000	
SOIL WATER AT END OF YEAR	136.181	6722997.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	6.269	309492.281	58.48
ANNUAL WATER BUDGET BALANCE	0.0000	1.767	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 3 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.22	0.26	0.57	0.98	1.54	1.07
	1.75	1.81	0.77	0.76	0.64	0.35
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	0.220	0.260	0.570	0.420	0.256	0.326
	0.621	0.510	0.382	0.314	0.255	0.317
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0171	0.0157	0.0182	0.0181	0.0186	0.0185
	0.0196	0.0191	0.0188	0.0193	0.0184	0.0185
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 6

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	1.5448	1.5665	1.6476	1.6932	1.6854	1.7322
	1.7691	1.7296	1.7512	1.7410	1.7212	1.6702
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 3 THROUGH 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72 (0.000)	529226.0	100.00

RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	4.451	(0.0000)	219732.23	41.520
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.21994	(0.00000)	10857.807	2.05164
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00015	(0.00000)	7.426	0.00140
AVERAGE HEAD ON TOP OF LAYER 5	1.688	(0.000)		
CHANGE IN WATER STORAGE	6.049	(0.0000)	298626.75	56.427

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PEAK DAILY VALUES FOR YEARS 3 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	0.18	8886.240
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.00064	31.69993
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.02169
AVERAGE HEAD ON TOP OF LAYER 5	1.799	
MAXIMUM HEAD ON TOP OF LAYER 5	2.968	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	47.3 FEET	
SNOW WATER	6.31	311329.0940
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2093	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2093	

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

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering

Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	41.3547	0.2078
2	41.3323	0.2077
3	41.4368	0.2082
4	1.8095	0.1508
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	6.269	

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


PRECIPITATION DATA FILE:    C:\HELP3\c\precip30.D4
TEMPERATURE DATA FILE:      C:\HELP3\c\temp30.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\c\solrad30.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\c\et30_v2.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\c\cap_v4.D10
OUTPUT DATA FILE:           C:\HELP3\c\Year4-33.OUT


TIME:  14:57     DATE:   2/10/2014


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     TITLE:  Comanche Landfill Cell#2

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


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                 =     21.00   INCHES
           POROSITY                  =      0.3582 VOL/VOL
           FIELD CAPACITY            =      0.3050 VOL/VOL
           WILTING POINT             =      0.2020 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1970 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.799999998000E-05 CM/SEC
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                        LAYER  2
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              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      3.00   INCHES
POROSITY                     =      0.3582 VOL/VOL
FIELD CAPACITY               =      0.3050 VOL/VOL
WILTING POINT                =      0.2020 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3582 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.799999998000E-05 CM/SEC

                        LAYER  3
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     39.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2093 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC

                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    199.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2078 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC

                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    199.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2077 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC
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                    LAYER  6
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              TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    199.00   INCHES
POROSITY                     =      0.5312 VOL/VOL
FIELD CAPACITY               =      0.2077 VOL/VOL
WILTING POINT                =      0.0667 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2082 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.123000005000E-03 CM/SEC


                    LAYER  7
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               TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   4
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4370 VOL/VOL
FIELD CAPACITY               =      0.1050 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1508 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.170000002000E-02 CM/SEC
SLOPE                        =      1.00   PERCENT
DRAINAGE LENGTH              =    270.0    FEET


                    LAYER  8
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               TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  2 - EXCELLENT

                    LAYER  9
                    --------

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

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #24 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 255. FEET.

SCS RUNOFF CURVE NUMBER	=	90.50	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	13.600	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.137	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.522	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.242	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	149.548	INCHES
TOTAL INITIAL WATER	=	149.548	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM PUEBLO COLORADO

STATION LATITUDE	=	38.17	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	111	
END OF GROWING SEASON (JULIAN DATE)	=	291	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	52.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	46.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.25	0.27	0.68	1.00	1.47	1.16
1.81	1.83	0.81	0.78	0.49	0.31

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR PUEBLO COLORADO
AND STATION LATITUDE = 38.17 DEGREES

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.48	369272.687	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	5.163	254905.828	69.03
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.2267	11190.687	3.03
PERC./LEAKAGE THROUGH LAYER 9	0.000155	7.655	0.00
AVG. HEAD ON TOP OF LAYER 8	1.7401		
CHANGE IN WATER STORAGE	2.090	103169.477	27.94
SOIL WATER AT START OF YEAR	149.548	7382892.000	
SOIL WATER AT END OF YEAR	149.426	7376878.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	2.212	109183.039	29.57
ANNUAL WATER BUDGET BALANCE	0.0000	-0.950	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.44	712873.875	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.877	388863.687	54.55
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.1638	8084.458	1.13
PERC./LEAKAGE THROUGH LAYER 9	0.000112	5.524	0.00
AVG. HEAD ON TOP OF LAYER 8	1.2581		
CHANGE IN WATER STORAGE	6.399	315919.969	44.32
SOIL WATER AT START OF YEAR	149.426	7376878.500	
SOIL WATER AT END OF YEAR	149.262	7368788.000	
SNOW WATER AT START OF YEAR	2.212	109183.039	15.32
SNOW WATER AT END OF YEAR	8.775	433193.406	60.77
ANNUAL WATER BUDGET BALANCE	0.0000	0.228	0.00

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ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.86	634872.500	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.616	375977.500	59.22
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.1106	5458.819	0.86

PERC./LEAKAGE THROUGH LAYER 9	0.000075	3.726	0.00
AVG. HEAD ON TOP OF LAYER 8	0.8495		
CHANGE IN WATER STORAGE	5.134	253432.703	39.92
SOIL WATER AT START OF YEAR	149.262	7368788.000	
SOIL WATER AT END OF YEAR	149.152	7363326.000	
SNOW WATER AT START OF YEAR	8.775	433193.406	68.23
SNOW WATER AT END OF YEAR	14.019	692088.250	109.01
ANNUAL WATER BUDGET BALANCE	0.0000	-0.280	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.12	598340.437	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.744	382310.156	63.90
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0748	3694.166	0.62
PERC./LEAKAGE THROUGH LAYER 9	0.000051	2.520	0.00
AVG. HEAD ON TOP OF LAYER 8	0.5731		
CHANGE IN WATER STORAGE	4.301	212332.547	35.49
SOIL WATER AT START OF YEAR	149.152	7363326.000	
SOIL WATER AT END OF YEAR	149.077	7359629.000	
SNOW WATER AT START OF YEAR	14.019	692088.250	115.67
SNOW WATER AT END OF YEAR	18.395	908118.000	151.77
ANNUAL WATER BUDGET BALANCE	0.0000	1.055	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.72	529225.062	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.611	375737.969	71.00
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0504	2486.149	0.47
PERC./LEAKAGE THROUGH LAYER 9	0.000034	1.695	0.00
AVG. HEAD ON TOP OF LAYER 8	0.3869		
CHANGE IN WATER STORAGE	3.059	150999.859	28.53
SOIL WATER AT START OF YEAR	149.077	7359629.000	
SOIL WATER AT END OF YEAR	149.027	7357141.500	
SNOW WATER AT START OF YEAR	18.395	908118.000	171.59
SNOW WATER AT END OF YEAR	21.504	1061605.250	200.60
ANNUAL WATER BUDGET BALANCE	0.0000	-0.649	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.07	595871.812	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.744	382316.687	64.16
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0340	1678.708	0.28

PERC./LEAKAGE THROUGH LAYER 9	0.000023	1.144	0.00
AVG. HEAD ON TOP OF LAYER 8	0.2612		
CHANGE IN WATER STORAGE	4.292	211876.531	35.56
SOIL WATER AT START OF YEAR	149.027	7357141.500	
SOIL WATER AT END OF YEAR	148.992	7355461.500	
SNOW WATER AT START OF YEAR	21.504	1061605.250	178.16
SNOW WATER AT END OF YEAR	25.830	1275161.620	214.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.273	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.57	472451.812	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.908	390399.375	82.63
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0230	1133.504	0.24
PERC./LEAKAGE THROUGH LAYER 9	0.000016	0.772	0.00
AVG. HEAD ON TOP OF LAYER 8	0.1764		
CHANGE IN WATER STORAGE	1.639	80918.766	17.13
SOIL WATER AT START OF YEAR	148.992	7355461.500	
SOIL WATER AT END OF YEAR	148.970	7354327.000	
SNOW WATER AT START OF YEAR	25.830	1275161.620	269.90
SNOW WATER AT END OF YEAR	27.492	1357214.870	287.27
ANNUAL WATER BUDGET BALANCE	0.0000	-0.613	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.34	609201.187	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.978	393835.437	64.65
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0155	767.081	0.13
PERC./LEAKAGE THROUGH LAYER 9	0.000011	0.523	0.00
AVG. HEAD ON TOP OF LAYER 8	0.1190		
CHANGE IN WATER STORAGE	4.347	214599.125	35.23
SOIL WATER AT START OF YEAR	148.970	7354327.000	
SOIL WATER AT END OF YEAR	148.954	7353559.500	
SNOW WATER AT START OF YEAR	27.492	1357214.870	222.79
SNOW WATER AT END OF YEAR	31.854	1572581.500	258.14
ANNUAL WATER BUDGET BALANCE	0.0000	-0.983	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.24	406792.406	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.130	401374.594	98.67
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00

AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0105	516.240	0.13
PERC./LEAKAGE THROUGH LAYER 9	0.000007	0.352	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0803		
CHANGE IN WATER STORAGE	0.099	4900.190	1.20
SOIL WATER AT START OF YEAR	148.954	7353559.500	
SOIL WATER AT END OF YEAR	148.943	7353043.000	
SNOW WATER AT START OF YEAR	31.854	1572581.500	386.58
SNOW WATER AT END OF YEAR	31.964	1577998.500	387.91
ANNUAL WATER BUDGET BALANCE	0.0000	1.017	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.35	560326.812	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.015	395698.094	70.62
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0071	348.577	0.06
PERC./LEAKAGE THROUGH LAYER 9	0.000005	0.251	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0542		
CHANGE IN WATER STORAGE	3.328	164280.937	29.32
SOIL WATER AT START OF YEAR	148.943	7353043.000	
SOIL WATER AT END OF YEAR	148.936	7352694.000	
SNOW WATER AT START OF YEAR	31.964	1577998.500	281.62
SNOW WATER AT END OF YEAR	35.299	1742628.250	311.00

ANNUAL WATER BUDGET BALANCE	0.0000	-1.040	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.02	593403.437	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.914	390699.344	65.84
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0048	235.357	0.04
PERC./LEAKAGE THROUGH LAYER 9	0.000004	0.208	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0366		
CHANGE IN WATER STORAGE	4.101	202468.984	34.12
SOIL WATER AT START OF YEAR	148.936	7352694.000	
SOIL WATER AT END OF YEAR	148.932	7352458.000	
SNOW WATER AT START OF YEAR	35.299	1742628.250	293.67
SNOW WATER AT END OF YEAR	39.405	1945333.000	327.83
ANNUAL WATER BUDGET BALANCE	0.0000	-0.466	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.02	445299.344	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.784	384275.781	86.30

PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0032	159.254	0.04
PERC./LEAKAGE THROUGH LAYER 9	0.000004	0.181	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0247		
CHANGE IN WATER STORAGE	1.233	60864.613	13.67
SOIL WATER AT START OF YEAR	148.932	7352458.000	
SOIL WATER AT END OF YEAR	148.928	7352299.000	
SNOW WATER AT START OF YEAR	39.405	1945333.000	436.86
SNOW WATER AT END OF YEAR	40.641	2006356.500	450.56
ANNUAL WATER BUDGET BALANCE	0.0000	-0.489	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	570694.187	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.023	396103.094	69.41
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0022	107.150	0.02
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.162	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0167		
CHANGE IN WATER STORAGE	3.534	174486.125	30.57
SOIL WATER AT START OF YEAR	148.928	7352299.000	
SOIL WATER AT END OF YEAR	148.926	7352191.500	

SNOW WATER AT START OF YEAR	40.641	2006356.500	351.56
SNOW WATER AT END OF YEAR	44.177	2180950.500	382.16
ANNUAL WATER BUDGET BALANCE	0.0000	-2.321	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.61	474426.719	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.481	369332.437	77.85
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0015	72.320	0.02
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.149	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0113		
CHANGE IN WATER STORAGE	2.127	105022.062	22.14
SOIL WATER AT START OF YEAR	148.926	7352191.500	
SOIL WATER AT END OF YEAR	148.925	7352119.000	
SNOW WATER AT START OF YEAR	44.177	2180950.500	459.70
SNOW WATER AT END OF YEAR	46.306	2286044.750	481.85
ANNUAL WATER BUDGET BALANCE	0.0000	-0.270	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.04	396918.719	100.00

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.155	402574.656	101.42
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0010	48.798	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.140	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0076		
CHANGE IN WATER STORAGE	-0.116	-5702.827	-1.44
SOIL WATER AT START OF YEAR	148.925	7352119.000	
SOIL WATER AT END OF YEAR	148.924	7352070.000	
SNOW WATER AT START OF YEAR	46.306	2286044.750	575.95
SNOW WATER AT END OF YEAR	46.192	2280391.000	574.52
ANNUAL WATER BUDGET BALANCE	0.0000	-2.046	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.50	468996.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.924	391168.031	83.41
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0007	32.988	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.135	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0051		
CHANGE IN WATER STORAGE	1.576	77795.312	16.59
SOIL WATER AT START OF YEAR	148.924	7352070.000	

SOIL WATER AT END OF YEAR	148.923	7352037.000	
SNOW WATER AT START OF YEAR	46.192	2280391.000	486.23
SNOW WATER AT END OF YEAR	47.768	2358219.250	502.82
ANNUAL WATER BUDGET BALANCE	0.0000	-0.472	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.59	374703.125	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.166	403156.562	107.59
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0004	22.163	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.131	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0034		
CHANGE IN WATER STORAGE	-0.577	-28475.150	-7.60
SOIL WATER AT START OF YEAR	148.923	7352037.000	
SOIL WATER AT END OF YEAR	148.923	7352014.500	
SNOW WATER AT START OF YEAR	47.768	2358219.250	629.36
SNOW WATER AT END OF YEAR	47.192	2329766.750	621.76
ANNUAL WATER BUDGET BALANCE	0.0000	-0.613	0.00

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.35	510958.937	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.709	380580.062	74.48
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0003	14.927	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.128	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0023		
CHANGE IN WATER STORAGE	2.641	130362.937	25.51
SOIL WATER AT START OF YEAR	148.923	7352014.500	
SOIL WATER AT END OF YEAR	148.922	7352000.000	
SNOW WATER AT START OF YEAR	47.192	2329766.750	455.96
SNOW WATER AT END OF YEAR	49.833	2460144.000	481.48
ANNUAL WATER BUDGET BALANCE	0.0000	0.858	0.00

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.92	539098.562	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.835	386787.469	71.75
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0002	10.041	0.00

PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.126	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0016		
CHANGE IN WATER STORAGE	3.085	152302.312	28.25
SOIL WATER AT START OF YEAR	148.922	7352000.000	
SOIL WATER AT END OF YEAR	148.922	7351989.500	
SNOW WATER AT START OF YEAR	49.833	2460144.000	456.34
SNOW WATER AT END OF YEAR	52.918	2612457.000	484.60
ANNUAL WATER BUDGET BALANCE	0.0000	-1.386	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.17	452704.656	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.389	414166.031	91.49
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0001	6.756	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.125	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0010		
CHANGE IN WATER STORAGE	0.781	38532.027	8.51
SOIL WATER AT START OF YEAR	148.922	7351989.500	
SOIL WATER AT END OF YEAR	148.922	7351983.000	
SNOW WATER AT START OF YEAR	52.918	2612457.000	577.08
SNOW WATER AT END OF YEAR	53.699	2650995.750	585.59
ANNUAL WATER BUDGET BALANCE	0.0000	-0.290	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.92	390994.562	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.122	400991.187	102.56
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0001	4.507	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.124	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0007		
CHANGE IN WATER STORAGE	-0.203	-10001.321	-2.56
SOIL WATER AT START OF YEAR	148.922	7351983.000	
SOIL WATER AT END OF YEAR	148.922	7351978.500	
SNOW WATER AT START OF YEAR	53.699	2650995.750	678.01
SNOW WATER AT END OF YEAR	53.496	2640999.000	675.46
ANNUAL WATER BUDGET BALANCE	0.0000	0.076	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.43	613644.437	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.774	383794.906	62.54
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00

AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0001	3.004	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000003	0.124	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0005		
CHANGE IN WATER STORAGE	4.656	229844.891	37.46
SOIL WATER AT START OF YEAR	148.922	7351978.500	
SOIL WATER AT END OF YEAR	148.922	7351975.500	
SNOW WATER AT START OF YEAR	53.496	2640999.000	430.38
SNOW WATER AT END OF YEAR	58.152	2870846.750	467.84
ANNUAL WATER BUDGET BALANCE	0.0000	1.486	0.00

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.34	559833.125	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.974	393673.281	70.32
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	1.989	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0003		
CHANGE IN WATER STORAGE	3.366	166157.859	29.68
SOIL WATER AT START OF YEAR	148.922	7351975.500	
SOIL WATER AT END OF YEAR	148.922	7351973.000	
SNOW WATER AT START OF YEAR	58.152	2870846.750	512.80
SNOW WATER AT END OF YEAR	61.518	3037007.000	542.48

ANNUAL WATER BUDGET BALANCE	0.0000	-0.135	0.00

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.03	445793.094	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.759	383037.125	85.92
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	1.306	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0002		
CHANGE IN WATER STORAGE	1.271	62755.387	14.08
SOIL WATER AT START OF YEAR	148.922	7351973.000	
SOIL WATER AT END OF YEAR	148.922	7351971.500	
SNOW WATER AT START OF YEAR	61.518	3037007.000	681.26
SNOW WATER AT END OF YEAR	62.789	3099763.750	695.34
ANNUAL WATER BUDGET BALANCE	0.0000	-0.865	0.00

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.38	561807.937	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.868	388420.969	69.14

PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.839	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0001		
CHANGE IN WATER STORAGE	3.512	173386.687	30.86
SOIL WATER AT START OF YEAR	148.922	7351971.500	
SOIL WATER AT END OF YEAR	148.922	7351971.000	
SNOW WATER AT START OF YEAR	62.789	3099763.750	551.75
SNOW WATER AT END OF YEAR	66.301	3273151.250	582.61
ANNUAL WATER BUDGET BALANCE	0.0000	-0.680	0.00

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.23	406298.719	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.335	411505.344	101.28
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.527	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0001		
CHANGE IN WATER STORAGE	-0.105	-5206.028	-1.28
SOIL WATER AT START OF YEAR	148.922	7351971.000	
SOIL WATER AT END OF YEAR	148.922	7351970.000	

SNOW WATER AT START OF YEAR	66.301	3273151.250	805.60
SNOW WATER AT END OF YEAR	66.196	3267946.000	804.32
ANNUAL WATER BUDGET BALANCE	0.0000	-1.262	0.00

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.44	663506.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.309	410221.937	61.83
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.316	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	5.131	253284.453	38.17
SOIL WATER AT START OF YEAR	148.922	7351970.000	
SOIL WATER AT END OF YEAR	148.922	7351969.500	
SNOW WATER AT START OF YEAR	66.196	3267946.000	492.53
SNOW WATER AT END OF YEAR	71.326	3521231.250	530.70
ANNUAL WATER BUDGET BALANCE	0.0000	-0.815	0.00

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ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.62	623024.187	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.041	347609.125	55.79
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.174	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	5.579	275415.156	44.21
SOIL WATER AT START OF YEAR	148.922	7351969.500	
SOIL WATER AT END OF YEAR	148.922	7351969.500	
SNOW WATER AT START OF YEAR	71.326	3521231.250	565.18
SNOW WATER AT END OF YEAR	76.905	3796646.250	609.39
ANNUAL WATER BUDGET BALANCE	0.0000	-0.415	0.00

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ANNUAL TOTALS FOR YEAR 32

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.90	587479.375	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.871	388591.094	66.15
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.077	0.00

PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.123	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	4.029	198891.969	33.86
SOIL WATER AT START OF YEAR	148.922	7351969.500	
SOIL WATER AT END OF YEAR	148.922	7351968.500	
SNOW WATER AT START OF YEAR	76.905	3796646.250	646.26
SNOW WATER AT END OF YEAR	80.934	3995539.000	680.12
ANNUAL WATER BUDGET BALANCE	-0.0001	-3.896	0.00

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ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.09	596859.250	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.449	367761.750	61.62
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
AVG. HEAD ON TOP OF LAYER 2	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.014	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.089	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	4.641	229100.266	38.38
SOIL WATER AT START OF YEAR	148.922	7351968.500	
SOIL WATER AT END OF YEAR	148.922	7351968.500	
SNOW WATER AT START OF YEAR	80.934	3995539.000	669.43
SNOW WATER AT END OF YEAR	85.574	4224639.500	707.81
ANNUAL WATER BUDGET BALANCE	-0.0001	-2.881	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 4 THROUGH 33

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.22	0.26	0.57	0.95	1.52	1.08
	1.78	1.76	0.75	0.78	0.63	0.34
STD. DEVIATIONS	0.18	0.21	0.43	0.77	0.92	0.78
	0.85	0.97	0.52	0.60	0.56	0.24
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	0.503	0.459	0.622	0.796	0.799	0.881
	0.849	0.756	0.640	0.503	0.499	0.483
STD. DEVIATIONS	0.123	0.085	0.109	0.113	0.167	0.144
	0.074	0.065	0.071	0.070	0.077	0.076
PERCOLATION/LEAKAGE THROUGH LAYER 2						
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 7						
TOTALS	0.0023	0.0021	0.0023	0.0022	0.0022	0.0021
	0.0021	0.0020	0.0019	0.0019	0.0018	0.0018
STD. DEVIATIONS	0.0048	0.0044	0.0049	0.0048	0.0048	0.0046
	0.0046	0.0045	0.0042	0.0042	0.0039	0.0039

PERCOLATION/LEAKAGE THROUGH LAYER 9

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

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

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

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.2087	0.2053	0.2039	0.2025	0.1966	0.1931
	0.1869	0.1808	0.1750	0.1693	0.1638	0.1586
STD. DEVIATIONS	0.4377	0.4351	0.4396	0.4456	0.4337	0.4310
	0.4174	0.4037	0.3907	0.3781	0.3659	0.3541

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 4 THROUGH 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.65 (1.907)	525522.4	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	7.789 (0.5698)	384529.00	73.171
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.00000 (0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 2	0.000 (0.000)		

LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.02436 (0.05346)	1202.697	0.22886
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00002 (0.00004)	0.895	0.00017
AVERAGE HEAD ON TOP OF LAYER 8	0.187 (0.410)		
CHANGE IN WATER STORAGE	2.832 (1.9260)	139790.53	26.600

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PEAK DAILY VALUES FOR YEARS 4 THROUGH 33

	(INCHES)	(CU. FT.)
PRECIPITATION	1.66	81950.883
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 2	0.000	
DRAINAGE COLLECTED FROM LAYER 7	0.00068	33.76498
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.02311
AVERAGE HEAD ON TOP OF LAYER 8	1.916	
MAXIMUM HEAD ON TOP OF LAYER 8	3.138	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	48.9 FEET	
SNOW WATER	85.96	4243769.5000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2020
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1970

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

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

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	4.2420	0.2020
2	1.0746	0.3582
3	8.1003	0.2077
4	41.3323	0.2077
5	41.3323	0.2077
6	41.3323	0.2077
7	1.2600	0.1050
8	0.0000	0.0000
9	10.2480	0.4270
SNOW WATER	85.574	

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APPENDIX D

CORRUGATED POLYETHYLENE PIPE STRENGTH CALCULATIONS

Corrugated Polyethylene Pipe Design

Typical properties for 6-inch pipe:

ID (inside diameter)=6in

OD (outside diameter)=7in

PS (minimum pipe stiffness at 5% deflection) = 35pii

A (section area) = 0.0568in

c (distance from inside diameter to Neutral Axis) = 0.192in

I (moment of inertia) = 0.0 in^4/in (54.1 mm^4/mm)

Site specific properties

Df (shape factor) = 5.6 (for compacted clean sand backfill around pipe)

No live load, WL = 0

Dead Load, WC = H γs OD/144

Where H = burial depth = 120 ft

γs = soil density = 90.2 pcf

OD = outside diameter of pipe = 7in

WC = 526 lb/linear inch of pipe

Check Deflection:

Deflection, Δy=K(DL Wc + WL)/(0.149PS+0.061E')

Where K=bending constant = 0.1 (common assumption)

DL = Deflection Lag Factor = 1.0 (for this dead load situation)

E' = soil modulus = 3,000 psi (for compacted clean sand backfill)

Δy=0.280 in = 4.7% of base inside diameter < 7.5% therefore acceptable.

Check Buckling:

Critical Buckling Pressure, $Pcr=(0.772/SF)(E'PS/(1-v^2))^{0.5}$

Where v = poisson's ratio = 0.4 for polyethylene

SF = safety factor = 2.0

Pcr=136.5 psi

Actual Buckling Pressure, Pv = (Rw*H*γs/144) + (γw*Hw/144) + WL/OD

Where Rw = water buoyancy factor = 1-0.33 (Hw/H) = 1

Hw = height of water above top of pipe = 0

γw = unit weight of water = 62.4 pcf

PV = 75.2 psi < Pcr (136.5 psi) therefore acceptable.

Bending Stress and Strain:

Stress, σb = 2*Df*E'*Δy*yo*SF/(DM^2)

Where yo=Distance from centroid of pipe wall to the furthest surface of the pipe

= greater of (OD-Dm)/2 or (Dm-ID)/2 = 0.308 in

Dm = mean pipe diameter = ID+2c = 6.384

SF = safety factor = 1.5

σb = 108.6 psi < 900 psi (tensile strength of polyethylene) therefore acceptable

Strain, εb = 2*Df* Δy*yo*SF/(DM^2)

εb = 0.0362 in/in <0.05 in/in therefore acceptable