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INTACT INFILTRATION MODEL DESIGN CHECK FOR E-AREA LLWF

Ref:

1. SRNL-STI-2018-00141, J. A. Dyer to B. T. Butcher, *Impact of Different Vegetative Cover Scenarios on Infiltration Rates for the E-Area PA Intact Case*, 04/18/2018
2. SRNL-STI-2017-00678, J. A. Dyer to B. T. Butcher, *Conceptual Modeling Framework for E-Area PA HELP Infiltration Model Simulations*, 11/30/2017
3. SRNL-STI-2017-00506, Rev. 0, J. C. Shipmon and J. A. Dyer, *Analysis of Factors that Influence Infiltration Rates using the HELP Model*, 09/2017
4. SRNL-STI-2017-00104, K. L. Dixon to B. T. Butcher, *HELP 4.0 Documentation Updates for Software and Data*, 02/22/2017
5. WSRC-STI-2007-00184, Rev. 2, M. A. Phifer et al., *FTF Closure Cap Concept and Infiltration Estimates*, 10/2007

Scope

A design check will be performed on the infiltration-rate time profile for the intact case for the proposed E-Area Low-Level Waste Facility (LLWF) final closure cap design.

Background

Previous HELP-model-based infiltration studies (ref. 1 and 3) showed that the F-Area Tank Farm (FTF) Bahia grass case (ref. 5) with 2% slope and 585-foot slope length represents a reasonable upper bound on intact infiltration rates for the proposed E-Area LLWF final closure cap design (ref. 2). The use of a single intact infiltration case will reduce the number of computationally intensive PORFLOW simulations for both the intact- and subsided-cap scenarios. Version 4.0 of the HELP model (ref. 4) was used to generate the desired intact infiltration-rate time profile (degradation curve) based on the same (or slight modifications thereof) cap design and degradation parameters employed for the FTF infiltration calculations. The simulation period of interest in this design check runs from 100 to 10,100 years, where Year 100 is the installation date of the final closure cap for the E-Area LLWF.

Design Check Objective

Table 1 below summarizes the calculated infiltration rates as a function of relative time for the 2%-slope, 585-foot-slope-length intact case of interest.

Table 1. Infiltration Rates for E-Area LLWF Intact Case (2% slope, 585-foot slope length)

Relative Year	Intact Infiltration Rate (in/yr)
100	0.00088
180	0.0079
290	0.19
300	0.20
340	0.32
380	0.41
480	1.46
660	3.23
1100	7.01
1900	10.65
2723	11.47
3300	11.53
5700	11.63
10100	11.67

The objective of the design check is to confirm the reported intact infiltration rate in inches per year at each time step.

Design Check Steps and Associated Files

All files identified below can be found at \\godzilla-01\hpc_project\projwork50\E-Area\PA_2019\CoverSystem\Intact_Infiltration_Design_Check_2018

The HELP 4.0 model files are stored in the folder \Help4.0 in three subfolders:

- \Hweather contains the weather input files,
- \PNGRASS contains the input and output files for each infiltration case time step (stored in separate subfolders labeled \ST00 for Year 100 through \ST13 for Year 10,100), and
- \Source contains the executable Fortran files for the HELP model.

The 14 infiltration time-step cases are executed at one time by double-clicking the HELP.bat Windows batch file stored in folder \PNGRASS. Overall summary output files labeled ST.OUT, ST_DRAINAGE.OUT, ST_PERC.OUT, and ST_RUNOFF.OUT are also stored in the folder \PNGRASS. Output files for each individual case are stored in \STxx\Output.

The design check comprises the following steps:

- Copy the Help4.0 folder to your Windows C:\ drive "as is." The files must be executed from the C:\ drive.
- Open each STxx.D10 input file in Notepad++. Each line of the input file contains the design and physical property parameters required in the HELP model simulation for each layer of the closure cap. Figure 1 below shows the cap design and associated layers in a nondegraded state (Year 100, ST00.D10). In subsequent years (ST01.D10 through ST13.D10), the number of cap layers as well as the layer physical and hydraulic properties change or degrade with time. Each of the input parameters in each of the 14 input files needs to be checked. Worksheet D10_File_Description in Help4.0_QA_R1.xlsx provides additional description of the HELP model input file structure.

- Layer 1 - Topsoil
- Layer 2 - Upper Backfill
- Layer 3 - Erosion Barrier
- Layer 4 - Middle Backfill
- Layer 5 - Lateral Drainage Layer
- Layer 6 - Combined Geomembrane
- Layer 7 - Geotextile Clay Liner
- Layer 8 - Upper Foundation Layer
- Layer 9 - Lower Foundation Layer

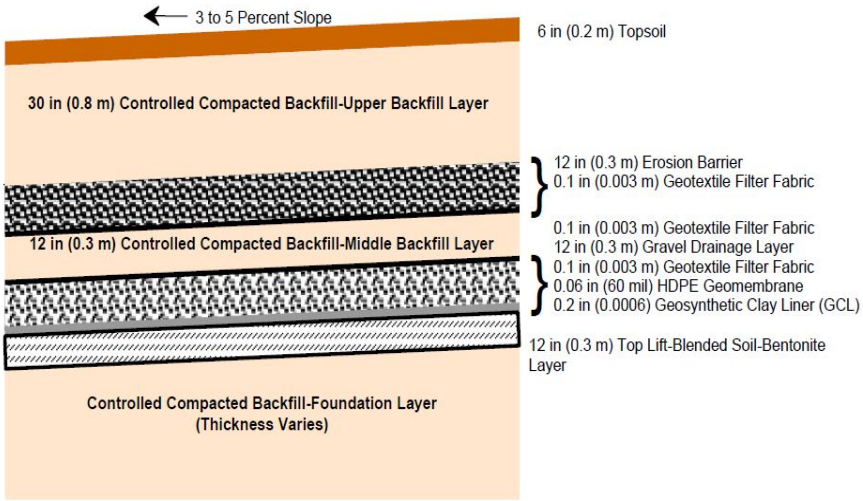

Figure 1. Planned Final Closure Cap Design for E-Area LLWF

- Appendix J in WSRC-STI-2007-00184, Rev. 2 (ref. 5) contains the HELP Model input data tables for each of the FTF design cases that most closely align with the E-Area Bahia grass design case (see FTF Year 0 example below in Figure 2 which corresponds to \ST00 or Year 100 for the E-Area timeline). Because the E-Area LLWF timeline for the final closure cap commences 100 years later than the FTF case, total porosity, field capacity, wilting point, saturated hydraulic conductivity, and geomembrane defects were modified (interpolated) for some (but not all) time steps from the values reported with the FTF design case. Tables of HELP model input data for the E-Area LLWF Bahia Grass intact infiltration case are attached.

Figure 2. HELP Model Input Data Sheet for F-Area Tank Farm Design Case

HELP Model Input Data for Configuration #1a (Year 0):

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.0134 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane	6	4 (geomembrane liner)
GCL	7	3 (barrier soil liner)
Foundation Layer (1E-06)	8	1 (vertical percolation layer)
Foundation Layer (1E-03)	9	1 (vertical percolation layer)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	6		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.10	0.07	0.10
4	1	12		0.35	0.252	0.181	0.252
5	2	12		0.417	0.045	0.018	0.045
6	4	0.06					
7	3	0.2		0.750	0.747	0.400	0.750
8	1	12		0.35	0.252	0.181	0.252
9	1	72		0.457	0.131	0.058	0.131

	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	4.1E-05					
5	2	5.0E-02	585	2			
6	4	2.0E-13					
7	3	5.0E-09					
8	1	1.0E-06					
9	1	1.0E-03					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	4	1	4	2	
7	3				
8	1				
9	1				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

- The revised geomembrane defect assumptions for the E-Area Bahia grass design case are from Table 1 in SRNL-STI-2018-00141 (ref. 1) as shown below in Table 2 under the column label "E-Area Phifer/Nelson Grass Only."

Table 2. Defect Assumptions for use in HELP Model Simulations for Slit and Engineered Trenches – Next Revision of the E-Area LLWF Performance Assessment

	Number of 1 cm^2 holes in geomembrane layer									
Facility Event	Relative Year (yr)	F-Area Tank Farm (# defects)	Relative Year (yr)	E-Area Phifer/Nelson Grass Only (# defects)	Relative Year (yr)	E-Area Skibo Grass Only (# defects)	Relative Year (yr)	E-Area Skibo Bamboo Unmanaged (#defects)	Relative Year (yr)	E-Area Skibo Bamboo Managed (# defects)
Start of Institutional Control	0	4	0		0		0		0	
Interim Cap Installed	NA		0		0		0		0	
Establish 600-foot Bahiagrass Buffer	0		0		0		0		0	
Final Cap Installed	0		100	4	100	4	100	4	100	4
Bamboo Planted as Final Vegetative Cover	NA		NA		NA		100		100	
End of Active Cap Maintenance	100	50	100		100		100		135	17
	180	90	180	40						
Initial Pine Tree Encroachment	260	131	260	80	110	6	120	9	185	42
Tap Roots Reach Geomembrane	290	146	290	96	160		180		270	85
Pine Trees Cover 1/3 Cap	300	170	300	101	130	14	140	19	220	60
Pine Trees Cover 2/3 Cap	340	334	340	121	160	29	180	40	300	101
Pine Trees Cover 100% Cap	380	479	380	141	175	37	225	63	360	131
Mature Pine Tree Stand with 100-year Turnover	380		380		187	43	275	88	450	373
			480	479	400	170	400	170		
	560	1115	660	1115	660	1115	660	1115	660	1115
	1000	2669	1100	2669	1100	2669	1100	2669	1100	2669
	1800	5496	1900	5496	1900	5496	1900	5496	1900	5496
Silting In of Lateral Drainage Layer Complete	2623	8403	2723	8403	2723	8403	2723	8403	2723	8403
	3200	10442	3300	10442	3300	10442	3300	10442	3300	10442
	5600	18921	5700	18921	5700	18921	5700	18921	5700	18921
	10000	34466	10100	34466	10100	34466	10100	34466	10100	34466

Pine tree roots reach geomembrane or pine trees cover 1/3 cap, whichever comes later.

The number of defects for the F-Area Tank Farm case are given by Phifer et al. (2007) in WSRC-STI-2007-00184, Rev. 2, Appendix I, pg. 329, lower table.

The number of defects for the four E-Area cases are also derived from the F-Area Tank Farm case, but are adjusted to account for the four different E-Area grass and bamboo timelines shown in the table above. The time-adjusted defect numbers are calculated via linear interpolation of values reported by Phifer et al. (2007) in WSRC-STI-2007-00184, Rev. 2, Appendix I, tables on pp. 325 and 329.

- To adjust for differences in the timelines, an Excel spreadsheet HELPModel_Interpolation_Tool.xlsx was developed for estimating input values for topsoil thickness, total porosity, field capacity, wilting point, and saturated hydraulic conductivity for the E-Area Bahia grass design case using linear interpolation of values reported in Appendix J, WSRC-STI-2007-00184, Rev. 2 (ref. 5) for the FTF design case.
- Execute the model by double-clicking the HELP.bat Windows batch file stored in folder \PNGRASS.
- Double-click the Python model cat_FC.py in \PNGRASS to update/generate the summary files ST.OUT, ST_DRAINAGE.OUT, ST_PERC.OUT, and ST_RUNOFF.OUT.
- Open ST_PERC.OUT to compare the reported percolation (infiltration) rates through the geomembrane/GCL barrier layer to the intact infiltration values in the table above under

Design Check Objective. Two percolation rates are reported for each time step in ST_PERC.OUT. For the first four time steps, the lower barrier layer is Layer 7. For the next six time steps, the lower barrier layer is Layer 6, and for the remaining four time steps, the lower barrier layer is Layer 5.

Results of Design Check

I have compared the input files to the reference materials and no errors were found. The values checked included:

Layer type and thickness, total porosity, field capacity, wilting point, initial moisture, saturated hydraulic conductivity, drainage length, drain slope, geomembrane pinhole density, geomembrane installation defects, and geomembrane placement quality.

Using the input files I ran HELP 4.0 and checked the output percolation data to match the table provided. No transcription errors were found.

Thank you for the opportunity to learn something new.

Att.

Attachment

HELP v4.0 Model Input Parameters for Intact Infiltration Case (2% slope, 585-foot slope length)

Table 3. HELP Model Input Data for Year 100 (ST00.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	**CN Input Parameter Value**
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane	6	4 (geomembrane liner)
GCL	7	3 (barrier soil liner)
Foundation Layer (1E-06)	8	1 (vertical percolation layer)
Foundation Layer (1E-03)	9	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	6		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.35	0.252	0.181	0.252
5	2	12		0.417	0.045	0.018	0.045
6	4	0.06					
7	3	0.2		0.75	0.747	0.4	0.75
8	1	12		0.35	0.252	0.181	0.252
9	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	4.1E-05					
5	2	5.0E-02	585	2			
6	4	2.0E-13					
7	3	5.0E-09					
8	1	1.0E-06					
9	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	4	2	

Table 4. HELP Model Input Data for Year 180 (ST01.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane	6	4 (geomembrane liner)
GCL	7	3 (barrier soil liner)
Foundation Layer (1E-06)	8	1 (vertical percolation layer)
Foundation Layer (1E-03)	9	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.96		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.351	0.249	0.179	0.249
5	2	12		0.416	0.048	0.021	0.048
6	4	0.06					
7	3	0.2		0.75	0.747	0.4	0.75
8	1	12		0.35	0.252	0.181	0.252
9	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	4.57E-05					
5	2	4.48E-02	585	2			
6	4	2.0E-13					
7	3	5.0E-08					
8	1	1.0E-06					
9	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	40	2	

Table 5. HELP Model Input Data for Year 290 (ST02.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane	6	4 (geomembrane liner)
GCL	7	3 (barrier soil liner)
Foundation Layer (1E-06)	8	1 (vertical percolation layer)
Foundation Layer (1E-03)	9	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.90		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.352	0.244	0.175	0.244
5	2	12		0.414	0.052	0.024	0.052
6	4	0.06					
7	3	0.2		0.75	0.747	0.4	0.75
8	1	12		0.35	0.252	0.181	0.252
9	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	5.29E-05					
5	2	3.86E-02	585	2			
6	4	2.0E-13					
7	3	5.0E-08					
8	1	1.0E-06					
9	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	96	2	

Table 6. HELP Model Input Data for Year 300 (ST03.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane	6	4 (geomembrane liner)
GCL	7	3 (barrier soil liner)
Foundation Layer (1E-06)	8	1 (vertical percolation layer)
Foundation Layer (1E-03)	9	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.90		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.352	0.244	0.175	0.244
5	2	12		0.414	0.053	0.024	0.053
6	4	0.06					
7	3	0.2		0.75	0.747	0.4	0.75
8	1	12		0.35	0.252	0.181	0.252
9	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	5.37E-05					
5	2	3.81E-02	585	2			
6	4	2.0E-13					
7	3	5.0E-08					
8	1	1.0E-06					
9	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	101	2	

Table 7. HELP Model Input Data for Year 340 (ST04.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.88		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.353	0.242	0.174	0.242
5	2	12		0.414	0.054	0.026	0.054
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	5.66E-05					
5	2	3.60E-02	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	121	2	

Table 8. HELP Model Input Data for Year 380 (ST05.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.85		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.353	0.241	0.172	0.241
5	2	12		0.413	0.056	0.027	0.056
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	5.98E-05					
5	2	3.41E-02	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	141	2	

Table 9. HELP Model Input Data for Year 480 (ST06.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.84		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.354	0.237	0.169	0.237
5	2	12		0.412	0.06	0.03	0.06
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	6.84E-05					
5	2	2.98E-02	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	479	2	

Table 10. HELP Model Input Data for Year 660 (ST07.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.82		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.356	0.23	0.164	0.23
5	2	12		0.409	0.067	0.036	0.067
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	8.71E-05					
5	2	2.33E-02	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	1115	2	

Table 11. HELP Model Input Data for Year 1,100 (ST08.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.76		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.361	0.212	0.15	0.212
5	2	12		0.403	0.084	0.049	0.084
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	1.58E-04					
5	2	1.28E-02	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	2669	2	

Table 12. HELP Model Input Data for Year 1,900 (ST09.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Lateral Drainage Layer	5	2 (lateral drainage layer)
HDPE Geomembrane & GCL	6	4 (geomembrane liner)
Foundation Layer (1E-06)	7	1 (vertical percolation layer)
Foundation Layer (1E-03)	8	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.66		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	1	12		0.371	0.181	0.125	0.181
5	2	12		0.392	0.116	0.074	0.116
6	4	0.26					
7	1	12		0.35	0.252	0.181	0.252
8	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	1	4.62E-04					
5	2	4.3E-03	585	2			
6	4	8.7E-13					
7	1	1.0E-06					
8	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	5496	2	

Table 13. HELP Model Input Data for Year 2,723 (ST10.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Lateral Drainage Layer (including Middle Backfill)	4	2 (lateral drainage layer)
HDPE Geomembrane & GCL	5	4 (geomembrane liner)
Foundation Layer (1E-06)	6	1 (vertical percolation layer)
Foundation Layer (1E-03)	7	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.55		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	2	24		0.38	0.148	0.1	0.148
5	4	0.26					
6	1	12		0.35	0.252	0.181	0.252
7	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	2	1.4E-03	585	2			
5	4	8.7E-13					
6	1	1.0E-06					
7	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	8403	2	

Table 14. HELP Model Input Data for Year 3,300 (ST11.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Lateral Drainage Layer (including Middle Backfill)	4	2 (lateral drainage layer)
HDPE Geomembrane & GCL	5	4 (geomembrane liner)
Foundation Layer (1E-06)	6	1 (vertical percolation layer)
Foundation Layer (1E-03)	7	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.47		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	2	24		0.38	0.148	0.1	0.148
5	4	0.26					
6	1	12		0.35	0.252	0.181	0.252
7	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	2	1.4E-03	585	2			
5	4	8.7E-13					
6	1	1.0E-06					
7	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	10442	2	

Table 15. HELP Model Input Data for Year 5,700 (ST12.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Lateral Drainage Layer (including Middle Backfill)	4	2 (lateral drainage layer)
HDPE Geomembrane & GCL	5	4 (geomembrane liner)
Foundation Layer (1E-06)	6	1 (vertical percolation layer)
Foundation Layer (1E-03)	7	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	5.16		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	2	24		0.38	0.148	0.1	0.148
5	4	0.26					
6	1	12		0.35	0.252	0.181	0.252
7	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	2	1.4E-03	585	2			
5	4	8.7E-13					
6	1	1.0E-06					
7	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	18921	2	

Table 16. HELP Model Input Data for Year 10,100 (ST13.D10)

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	0.2686 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	2 %
Slope length =	585 ft
Soil Texture =	4 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.2	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Lateral Drainage Layer (including Middle Backfill)	4	2 (lateral drainage layer)
HDPE Geomembrane & GCL	5	4 (geomembrane liner)
Foundation Layer (1E-06)	6	1 (vertical percolation layer)
Foundation Layer (1E-03)	7	1 (vertical percolation layer)

Layer #	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture [2] (Vol/Vol)
1	1	4.59		0.396	0.109	0.047	0.109
2	1	30		0.35	0.252	0.181	0.252
3	1	12		0.15	0.1	0.07	0.1
4	2	24		0.38	0.148	0.1	0.148
5	4	0.26					
6	1	12		0.35	0.252	0.181	0.252
7	1	72		0.457	0.131	0.058	0.131

Layer #	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.1E-03					
2	1	4.1E-05					
3	1	1.3E-04					
4	2	1.4E-03	585	2			
5	4	8.7E-13					
6	1	1.0E-06					
7	1	1.0E-03					

Layer #	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
6	4	1	34466	2	

c:

S. E. Aleman, 735-A
B. T. Butcher, 773-42A
D. A. Crowley, 773-42A
T. L. Danielson, 703-41A
K. L. Dixon, 773-42A
J. A. Dyer, 773-42A
G. P. Flach, 773-42A
L. L. Hamm, 735-A
T. Hang, 773-42A
L. T. Reid, 773-A
T. Whiteside, 773-42A
J. L. Wohlwend, 703-41A
EM File, 773-42A – Rm. 243