Contract No:

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SRNL-STI-2017-00678

Date: November 30, 2017

TO: B. T. Butcher, 773-42A

FROM: J. A. Dyer, 773-42A

REVIEWER: T. L. Danielson, 703-41A

Topic 3.5.1: Vadose Zone Models

Recommendation 150: Decide how to represent intact and subsided conditions for the proposed new conceptual closure cap design for the purpose of calculating infiltration. Produce new intact and subsided infiltration cases based on new conceptual design.

Conceptual Modeling Framework for E-Area PA HELP Infiltration Model Simulations

Scope

A conceptual modeling framework based on the proposed E-Area Low-Level Waste Facility (LLWF) closure cap design is presented for conducting Hydrologic Evaluation of Landfill Performance (HELP) model simulations of intact and subsided cap infiltration scenarios for the next E-Area Performance Assessment (PA).

Conclusions

Four infiltration scenarios representing the proposed E-Area closure cap design comprise ten intact infiltration model cases spanning 2% to 4% slope and 150-foot to 600-foot slope length. If necessary for computational efficiency, the number of intact infiltration model cases can be reduced to a few. The F-Area Tank Farm (FTF) closure cap infiltration model is based on a single upper bounding case of 2% slope and 585-foot slope length, which can also serve as a bounding case for the proposed E-Area LLWF closure cap (Phifer et al., 2007).

A generalized conceptual model is also presented for cap subsidence that applies regardless of the direction of the cap cross-section. The conceptual model assumes that 100% of the lateral drainage (i.e., infiltrating water shed through the closure cap drainage layer) and surface run-off from the upslope intact portion of the cap enters the subsided region as run-on. The total run-on (flux) to the subsided region is directly proportional to the ratio of the upslope intact area to the downslope subsided area, and can be estimated using both stochastic and bounding models. Maximum bounding values for this upslope area ratio vary significantly with percent subsidence, increasing from 9.0 at 10% subsidence to 99.0 at 1% subsidence.

A review of historical data for non-crushable waste container content in E-Area slit trenches that are at least 90% full, while also invoking practical considerations for the number and size of subsided compartments, limits the parameter space to be explored by the vadose-zone model to 1.6% to 10% subsidence. The conceptual model for subsidence also demonstrates that for scenarios where one of the one or more subsided areas is located at the toe of the cap, the spatially averaged infiltration rate is independent of percent subsidence for all subsidence scenarios up to and including 100%. Subsequent reports will provide greater detail on the water mass balance for intact and subsided areas (Dyer, 2017) and the stochastic subsidence model (Dyer and Flach, 2017).

Discussion

The proposed new E-Area LLWF closure cap design drawings (SRP Drawing Nos. C-CT-E-00083 and C-CT-E-00084) were used to develop a limited number of intact and subsided infiltration scenarios that reasonably capture the variations in percent slope, slope length, and subsidence across the complex 100-acre cap. The conceptual model scenarios will help facilitate the development of the HELP infiltration model and PORFLOW vadose zone flow model for the next E-Area PA.

Intact Infiltration Scenarios

Scenario No. 1 – SLIT #11 → SLIT #5

Figure 1 displays the approximately 25-acre central slit trench (SLIT or ST) region of the proposed E-Area closure cap identified as Scenario No. 1.

Figure 1. Intact Infiltration Scenario No. 1 (from SRP Drawing Nos. C-CT-E-00083 and C-CT-E-00084)

A simplified conceptual model of this region, which can be represented as two cases (3% slope by 585-foot slope length and 2% slope by 150-foot slope length) for the HELP model simulations, is shown in Figure 2.

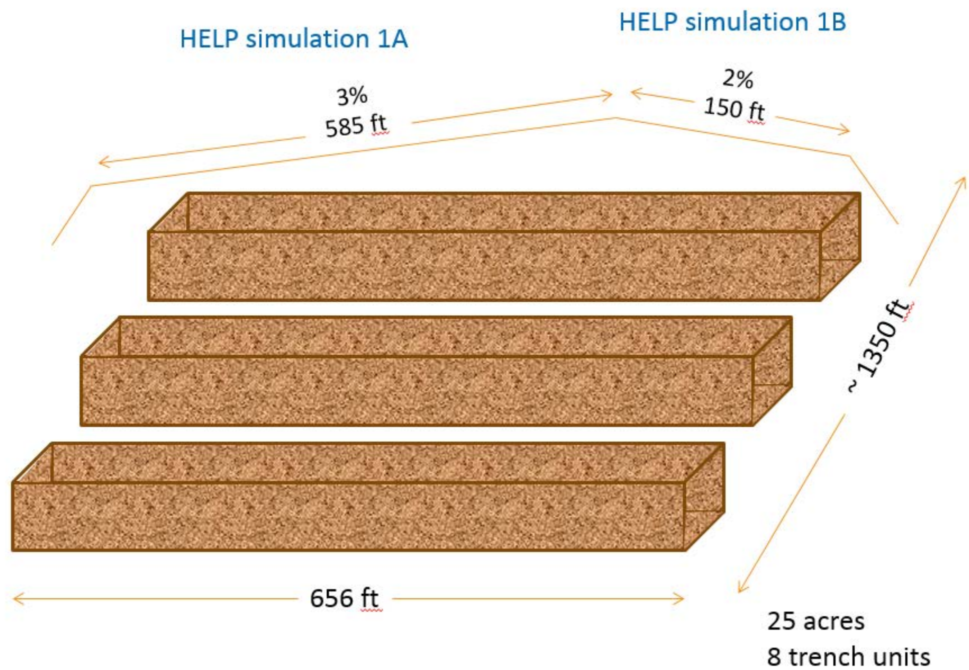


Figure 2. HELP Model Simulation Cases for Intact Infiltration Scenario No. 1

<u>Scenario No. 2 – LAWV #1 → SLIT #21</u>

Scenario No. 2 encompasses the approximately 17.5-acre eastern region of the proposed E-Area closure cap as shown in Figure 3, and includes SLIT #16 through #21 and half of Low Activity Waste Vault (LAWV) #1. Figure 4 presents a simplified conceptual model of this region, which can also be represented as two cases (4% slope by 400-foot slope length and 2% slope by 400-foot slope length) for the HELP model simulations.

<u>Scenario No. 3 – SLIT #7 → LAWV #1</u>

Figure 5 shows the approximately 17-acre east-central trench region of the proposed E-Area closure cap covered by Scenario No. 3, which includes SLIT #7, #14, and #15, Engineered Trenches (ET) #1 and #2, and half of LAWV #1. Figure 6 presents a simplified conceptual model of this region, which can also be represented as two cases (4% slope by 450-foot slope length and 2.5% slope by 450-foot slope length) for the HELP model simulations.

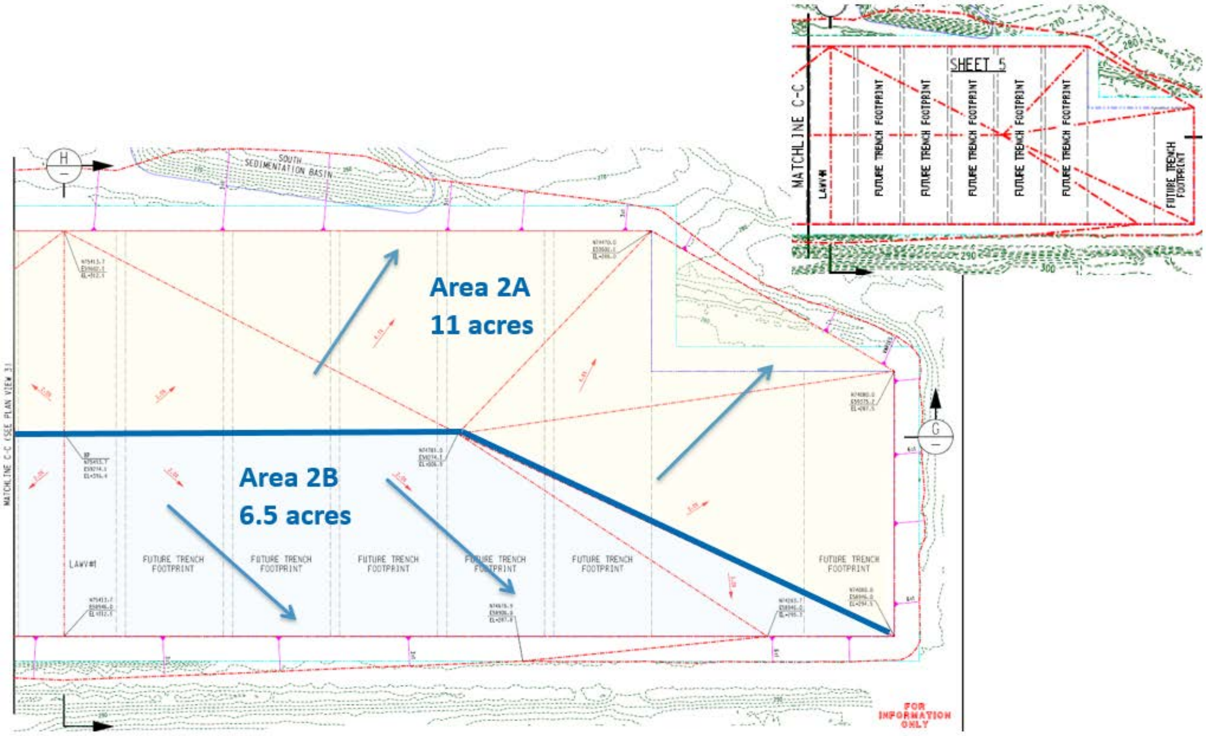


Figure 3. Intact Infiltration Scenario No. 2 (from SRP Drawing Nos. C-CT-E-00083 and C-CT-E-00084)

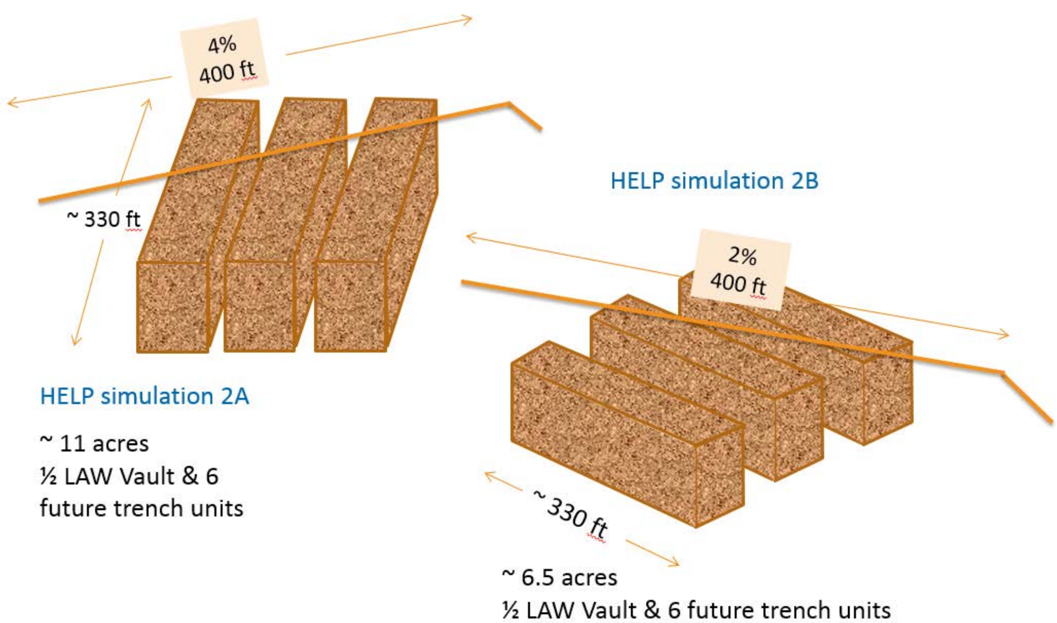


Figure 4. HELP Model Simulation Cases for Intact Infiltration Scenario No. 2

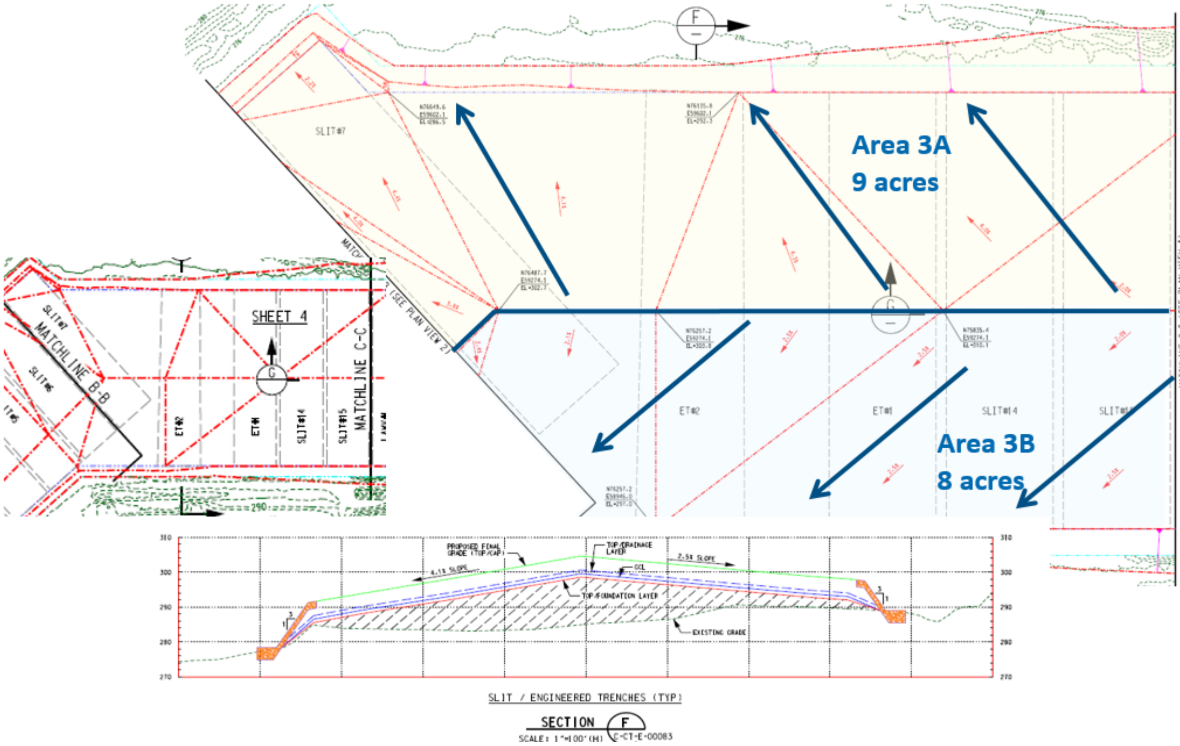


Figure 5. Intact Infiltration Scenario No. 3 (from SRP Drawing Nos. C-CT-E-00083 and C-CT-E-00084)

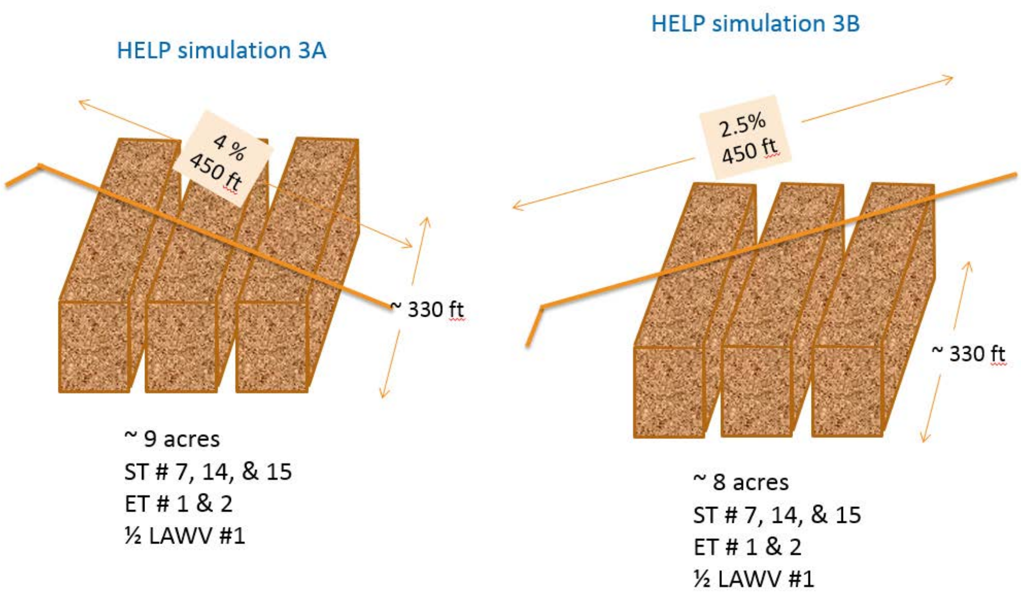


Figure 6. HELP Model Simulation Cases for Intact Infiltration Scenario No. 3

Scenario No. 4 – SLIT #10 → ET #3 and #4

Scenario No. 4 comprises the approximately 20-acre western region of the proposed E-Area closure cap as shown in Figure 7, and includes SLIT #8, #9, and #10, ET #3 and #4, the Intermediate-Level Vault (ILV), and the 643-26E NRCDA. Figure 8 presents a simplified conceptual model of this region, which can be represented as four cases (3% slope by 300-foot slope length, 3% slope by 200-foot slope length, 2% slope by 325-foot slope length, and 4% slope by 600-foot slope length) for the HELP model simulations.

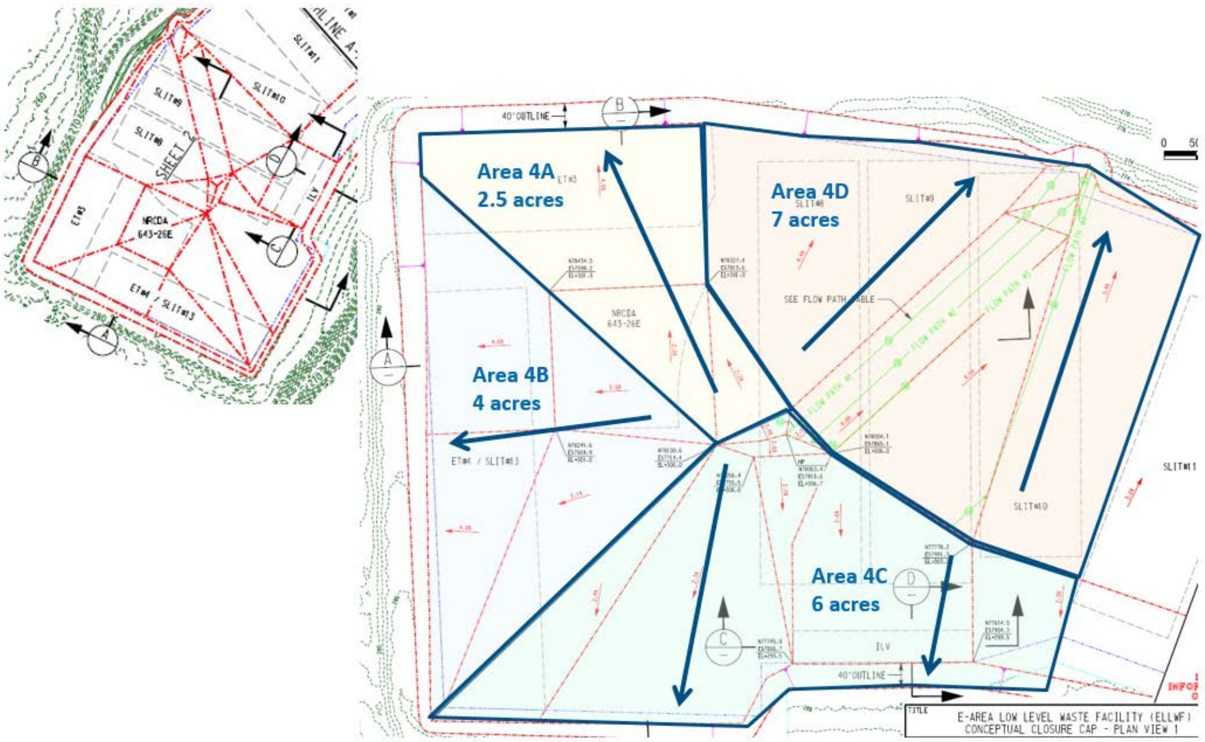


Figure 7. Intact Infiltration Scenario No. 4 (from SRP Drawing Nos. C-CT-E-00083 and C-CT-E-00084)

Summary of Intact Infiltration Scenarios

Four infiltration scenarios representing the proposed E-Area closure cap design comprise ten intact infiltration model cases spanning 2% to 4% slope and 150-foot to 600-foot slope length. For illustration purposes, the ten intact cases were modeled in HELP v4.0 (Dixon, 2017) using the same design (number, type, and material properties of layers) as the FTF closure cap (Phifer et al., 2007 and Phifer et al., 2009). Figure 9 shows the proposed E-Area closure cap profile, while Figure 10 presents the HELP-generated infiltration curves for the ten intact E-Area cases using the design basis for the FTF closure cap. The infiltration rates are preliminary and should not be used for final design and vadose zone modeling purposes.

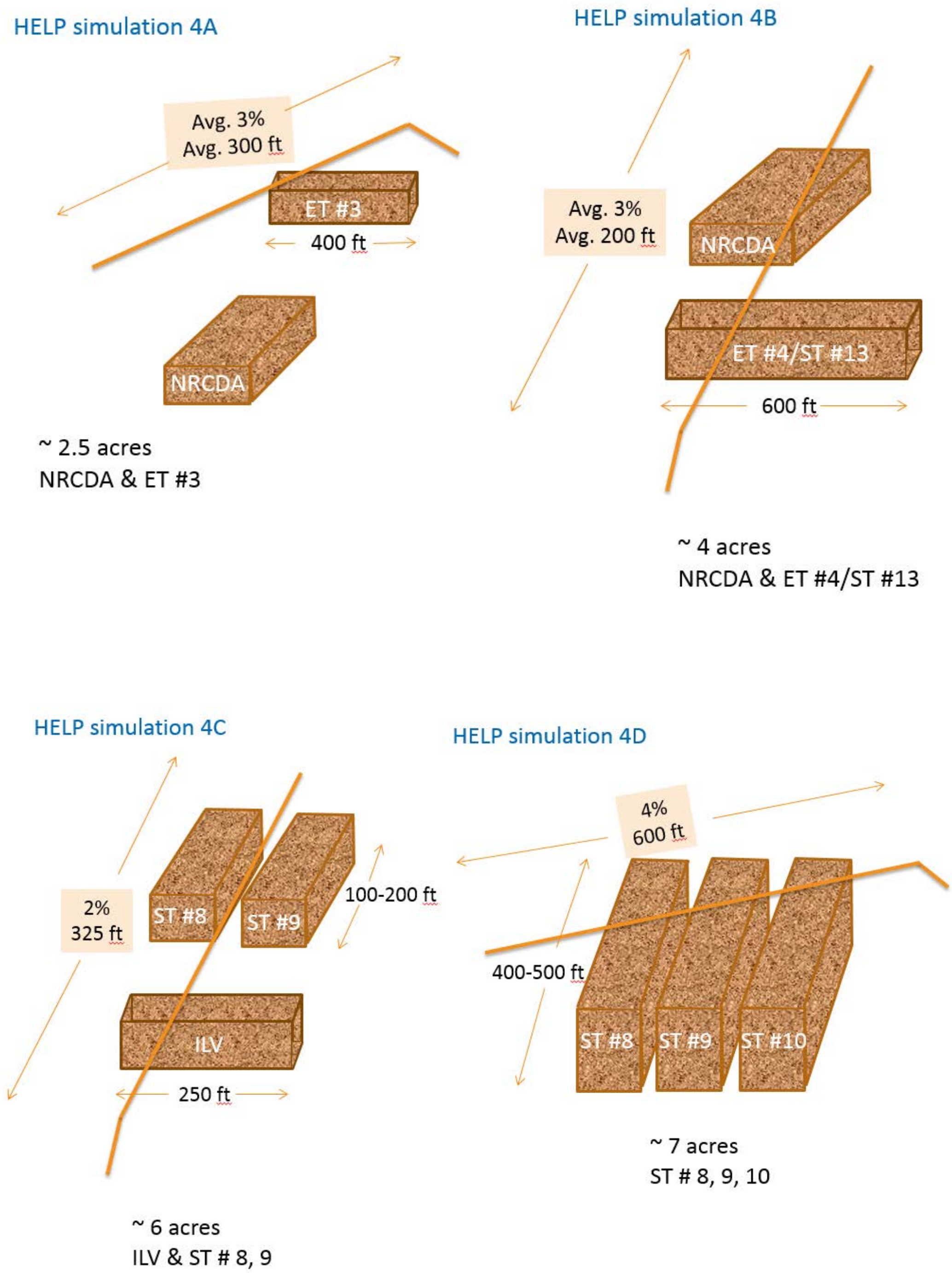


Figure 8. HELP Model Simulation Cases for Intact Infiltration Scenario No. 4

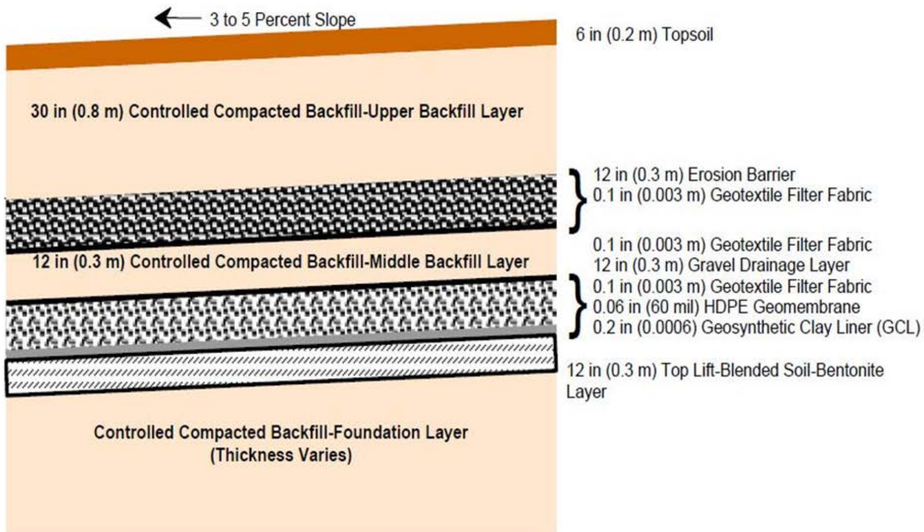


Figure 9. Proposed E-Area Waste Cover System Profile (Phifer et al., 2009)

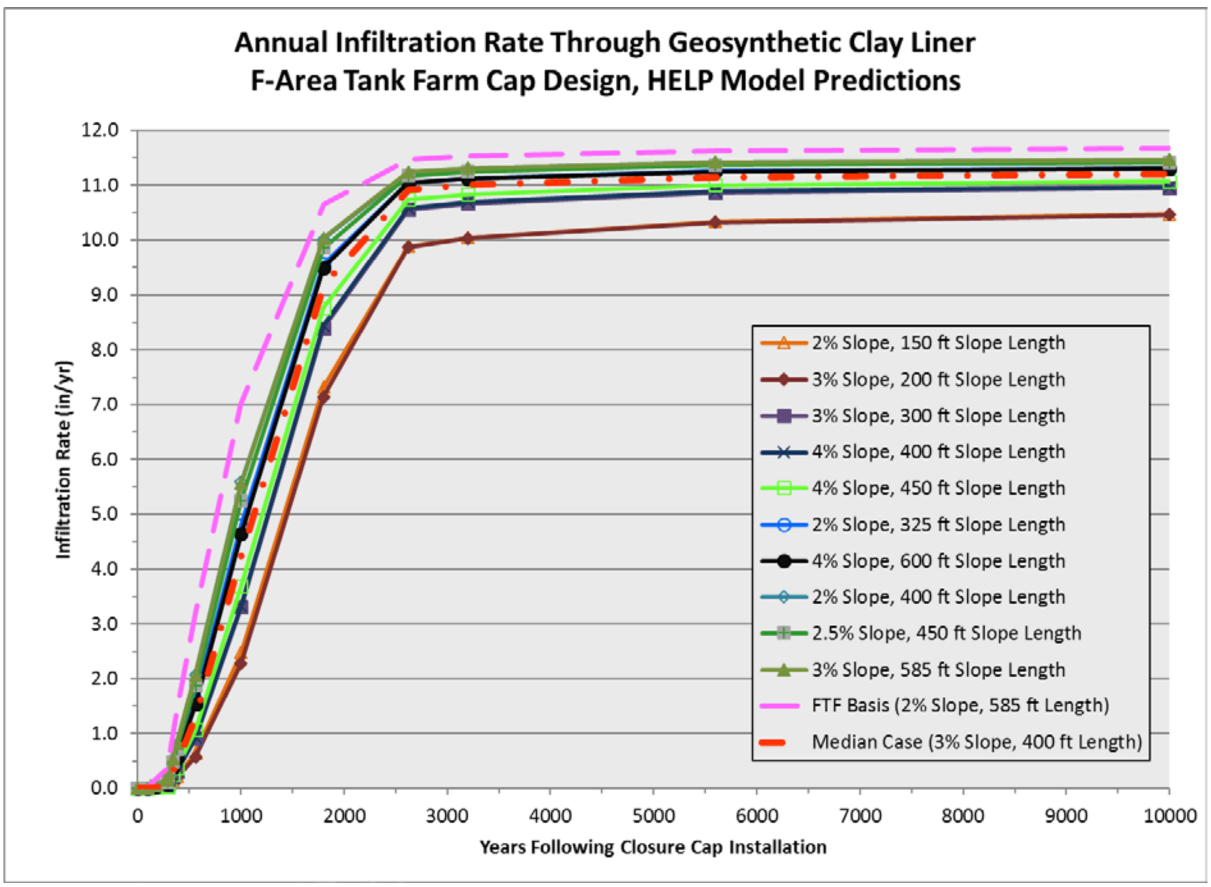


Figure 10. Annual Infiltration Rates as a Function of Percent Slope and Slope Length

If it becomes necessary to limit the number of unique PORFLOW vadose-zone model cases, the number of intact infiltration model cases can be reduced to fewer than ten. For example, the FTF closure cap infiltration model is based on a single upper bounding case represented by 2% slope and 585-foot slope length. As shown in Figure 10, the FTF design basis can serve as an upper bounding case for the proposed E-Area closure cap as well. The infiltration curves for the ten E-Area intact infiltration model cases all fall below the infiltration curve for the FTF design basis. A median case for the ten E-Area infiltration model cases is represented by 3% slope and 400-foot slope length.

Further Refinement of Conceptual Model for Intact Infiltration

Preliminary PORFLOW vadose-zone modeling results for Section E in Figure 1 indicate that radionuclide flux is impacted by how infiltration water is distributed across the cap slope length. The indication is that increasing water mass flux downslope increases the peak mass flux for certain radionuclides (e.g., strontium). The vadose-zone model cases originally assumed a constant, annual-averaged infiltration rate along the entire slope length; however, L. L. Hamm and T. L. Danielson recognized that the infiltration rate will increase with distance down the cap slope as shown in Figure 11 for the FTF HELP model case at 2% slope. Conceptually, this increase in average infiltration rate as a function of percent slope and slope length is a result of increasing head within the lateral drainage layer and, to a lesser extent, along the surface (runoff).

Intact Infiltration as f (Slope length)
2% Slope

	in/yr				
Time (yr)	150 ft	250 ft	350 ft	450 ft	550 ft
0	0.00008	0.0002	0.0003	0.0005	0.0008
100	0.0005	0.001	0.003	0.005	0.009
180	0.01	0.02	0.04	0.09	0.1
290	0.01	0.04	0.10	0.20	0.3
300	0.07	0.13	0.21	0.32	0.5
340	0.1	0.3	0.4	0.7	0.9
380	0.2	0.4	0.7	1.0	1.3
560	0.6	1.2	1.8	2.4	3.0
1000	2.5	3.9	5.1	6.0	6.8
1800	7.3	8.9	9.7	10.2	10.6
2623	9.9	10.7	11.1	11.3	11.4
3200	10.0	10.8	11.2	11.4	11.5
5600	10.3	11.0	11.3	11.5	11.6
10000	10.5	11.1	11.4	11.5	11.6

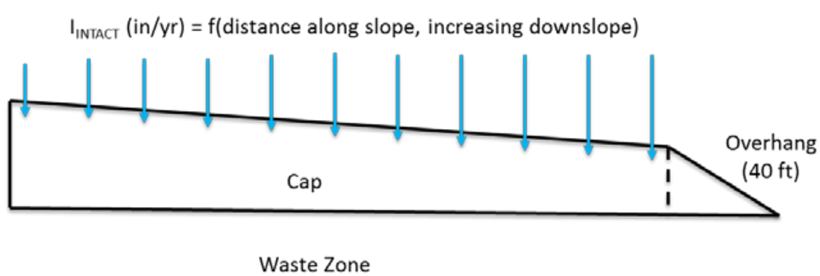


Figure 11. Intact Infiltration Case with Variable Infiltration Rate along Slope Length

Subsided Infiltration Scenarios

Figure 12 presents a generalized approach for managing cap subsidence in the infiltration model regardless of cap crest orientation with respect to the long axis of the disposal units (i.e., longitudinal or latitudinal). The conceptual model for subsidence assumes that 100% of the lateral drainage and surface run-off from the intact portion of the cap directly upslope of the subsided region (light-blue-shaded areas in Figure 12) enters the subsided region (orange-shaded areas) as run-on. The total run-on (flux) to the subsided region in inches/year is directly proportional to the ratio of the upslope intact area (UA1 or UA2) to the downslope subsided area (SA1 or SA2) as given by:

$$\text{Run-on} = (\text{Area}_{UAi}/\text{Area}_{SAi})(\text{Lateral Drainage} + \text{Surface Run-off})_{\text{HELP Intact Case}} \quad (1)$$

For intact and subsided sections of uniform and equal trench width, Equation (1) becomes:

$$\text{Run-on} = (\text{Length}_{UAi}/\text{Length}_{SAi})(\text{Lateral Drainage} + \text{Surface Run-off})_{\text{HELP Intact Case}} \quad (2)$$

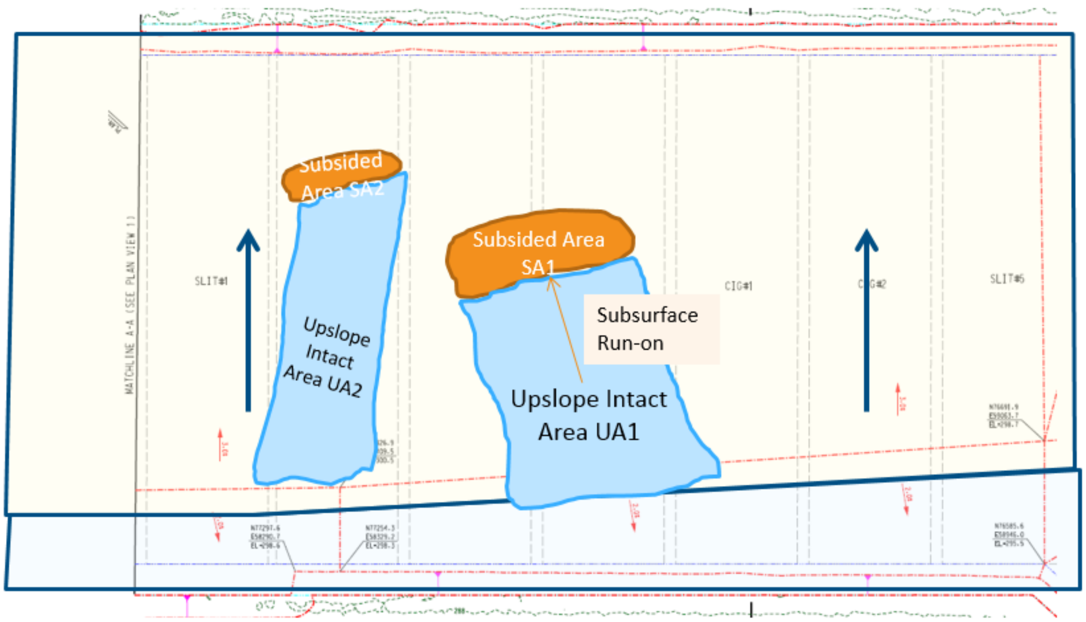


Figure 12. Conceptual Approach to Cap Subsidence

Figure 13 displays the HELP-model-predicted sum of lateral drainage and surface run-off for the median and lower- and upper-bound FTF intact cases shown in Figure 10 above. The sums range from 16+ inches/year at time zero (cap installation) to 4+ inches/year at 10,000 years. Sums for the E-Area closure cap will be comparable. Total run-on to the subsided area, therefore, will be ($\text{Area}_{UAi}/\text{Area}_{SAi}$) or ($\text{Length}_{UAi}/\text{Length}_{SAi}$) times greater than the drainage/run-off fluxes shown in Figure 13 based on Equations (1) and (2). Figure 14 illustrates this dramatic increase in infiltration rate through the subsided region as a function of ($\text{Area}_{UAi}/\text{Area}_{SAi}$) for the 2008 intact slit-trench HELP model cases. Subsidence is assumed to occur immediately upon cap installation at time zero. Because of the revised E-Area closure cap orientation, a 30:1 (or greater) upslope-intact-area to subsided-area ratio is possible (e.g., 600-foot slope length / 20-foot long subsided region = 30:1).

For the cap orientation shown in Figure 12 (cap crestline running perpendicular to the long axis of the trench units), there is an unlimited number of possible values for ($\text{Area}_{UAi}/\text{Area}_{Sai}$) that are a function of the total subsided area relative to the total area of the cap (i.e., percent subsidence), the number of subsided regions that comprise the total subsided area, and the location of the subsided regions along the cap slope length (i.e., crestline to bottom edge of cap).

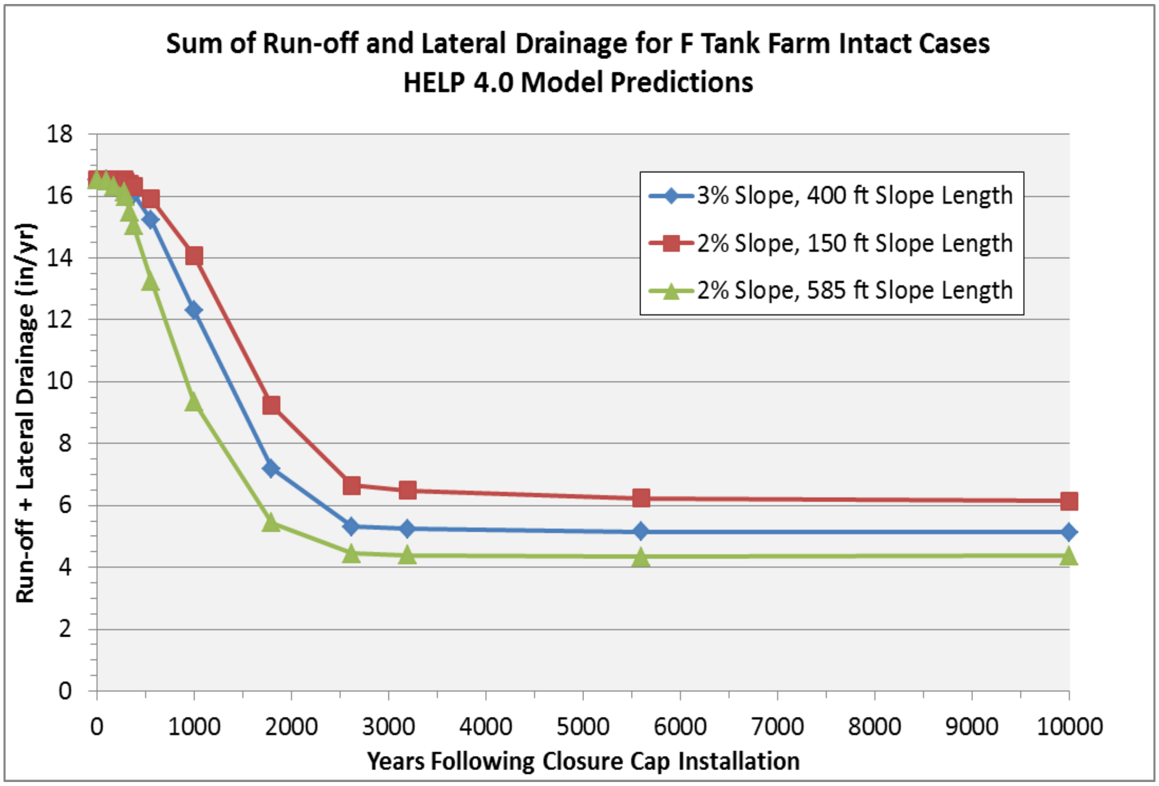


Figure 13. Sum of Surface Run-off and Lateral Drainage for FTF Intact Cases

Two numerical modeling approaches are available to arrive at a reasonable estimate of the subsided area run-on rate:

1. A stochastic approach (e.g., Monte Carlo simulation) that randomly samples distributions of the controlling input parameters (e.g., percent subsidence, number of subsided areas, and distance of the subsided areas from the cap crestline). Realistic lower and upper bounds can be placed on each of the input parameter distributions (e.g., 0% to 10% subsidence, one to ten subsided regions, and zero to "slope length" feet below the cap crestline).

2. A bounding approach where a small number of most-probable and end-member cases are identified.

Water Mass Balance

For the conceptual subsidence model adopted for the E-Area PA (where a subsided area is located at the toe of the slope on each side), the total mass of water infiltrating the surface of the closure cap (i.e., the sum of intact plus subsided area infiltration) is essentially equal regardless of the assumed number and percentage of subsided areas. This approximate equality holds because the area-averaged infiltration rate of water at the cap surface (i.e., mass rainfall minus mass evapotranspiration) for subsided cases ($M_{TOT\ X\%\ SUBSIDENCE}$) is approximately equal to the

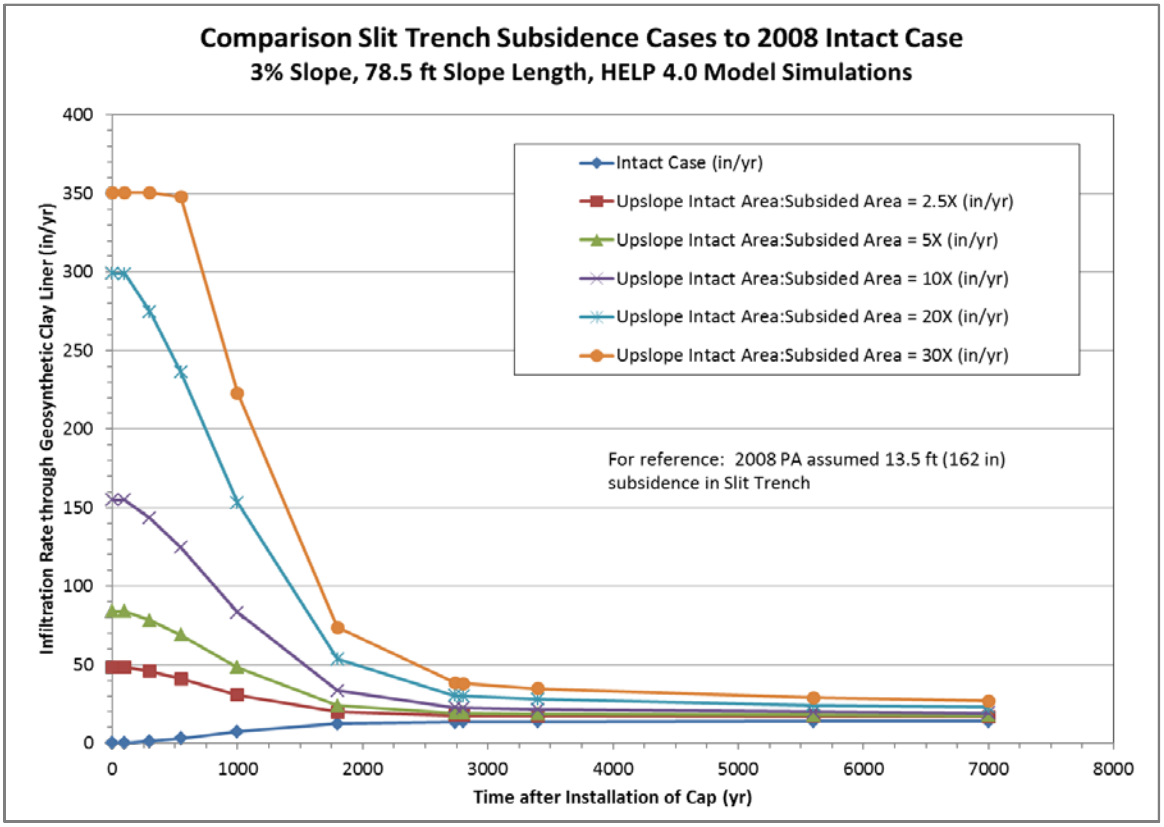


Figure 14. Subsided-Region Infiltration Rates Based on 2008 Slit-Trench HELP Model Cases

quantity "rainfall minus evapotranspiration" for the 100% intact case ($M_{\text{TOT INTACT}}$) where the drainage and barrier layers have been removed from the HELP model.

$$M_{\text{TOT INTACT}} = M_{\text{TOT 3\% SUBSIDENCE}} = M_{\text{TOT 5\% SUBSIDENCE}} = M_{\text{TOT 10\% SUBSIDENCE}} \quad (3)$$

$$M_{\text{TOT INTACT}} = \text{Mass Rainfall}_{intact} - \text{Mass Evapotranspiration}_{intact} \quad (4)$$

$$M_{\text{TOT X\% SUBSIDENCE}} = \sum_{i}^{n_{intact}} I_{i\ intact} A_{i\ intact} + \sum_{j}^{n_{subsided}} I_{j\ subsided}\, A_{j\ subsided} \quad (5)$$

where I_i and I_j are the infiltration rates and A_i and A_j are the areas for each intact and subsided segment, respectively.

When considering radionuclide transport and waste disposal limits, however, percent subsidence as well as the number and distribution of subsided areas will matter. For example, lower percent subsidence and fewer subsided areas mean that less waste will be contacted by the infiltrating water. The water mass balance provides a convenient reality check for any proposed subsidence scenario implemented in PORFLOW. The water mass balance check will be demonstrated in a subsequent technical report (Dyer, 2017).

Stochastic Approach

A probabilistic model using a Monte Carlo sampling technique was developed in Python by G. P. Flach to generate statistical distributions of the upslope-intact-area to subsided-area ratio ($Area_{UAi}/Area_{SAi}$) for different cap subsidence scenarios (i.e., number of subsided compartments, and total number of intact and subsided compartments). The Python-based model generates a mean or best-estimate value for ($Area_{UAi}/Area_{SAi}$) that can be used in Equation (1) to calculate a mean run-on rate to an assumed subsided region of the proposed E-Area closure cap. The probabilistic model will be presented in a subsequent technical report (Dyer and Flach, 2017).

Bounding Approach

Two endmembers for the subsidence scenarios are an intact case as shown in Figure 11 (0% subsidence) and a 100% subsidence case as displayed in Figure 15. The HELP-model-predicted infiltration rates included in Figure 15 are based on an FTF closure cap design with a 3% slope and 585-foot slope length for illustration purposes only. If the E-Area cap is instead represented as a single upper bounding case (2% slope, 585-foot slope length), then Figure 15 would be based on 2% slope and 585-foot slope length. Note the positive check of the average infiltration rate for the 100% subsidence case (16.2 to 16.5 inches/year) against the “rainfall minus evapotranspiration” rate for the equivalent intact case (i.e., geomembrane and geosynthetic clay liners have been removed).

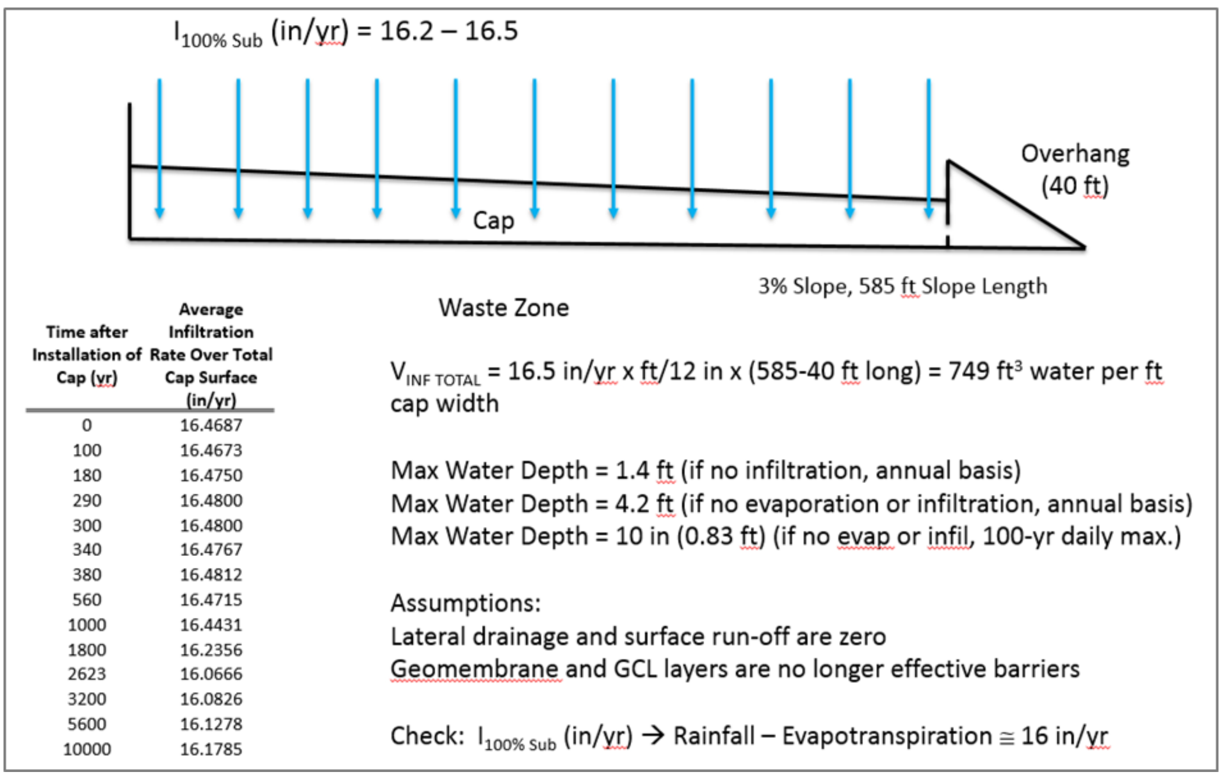


Figure 15. Conceptual Model of Infiltration for 100% Subsidence Case

A practical upper limit for subsidence is 10 percent based on the maximum non-crushable container content established for the E-Area disposal trenches. Inventory data provided in 2017 by E-Area Solid Waste Operations for eight trenches that are at least 90% full indicate a non-crushable container content of mean 2.3%, median 1.9%, minimum 0.0%, and maximum 7.7%. The mean increases to 4.0% if only the five non-zero trenches are included. Figure 16 depicts the conceptual model for a 10% subsidence case where a single subsided region is located at the bottom edge (toe) of the 585-foot long cap. There will exist any number of possible 10% subsidence cases in terms of the number, location, and spacing along the cap slope length.

While unlikely to occur, the scenario shown in Figure 16 serves as a possible conservative upper bound for certain radionuclides. The value of ($Area_{UAi}$/$Area_{SAi}$) for this scenario is 9.0 (i.e., 90 intact square feet / 10 subsided square feet), which represents an upper bound for 10% subsidence when one of the subsided areas is located at the toe of the cap. The use of the upper bound value for ($Area_{UAi}$/$Area_{SAi}$) maximizes the calculated run-on rate from the upslope intact area. The Python-based probabilistic model (Dyer and Flach, 2017) reveals how the mean value of ($Area_{UAi}$/$Area_{SAi}$) changes with the assumed number of subsided compartments. For a practical number of subsided compartments (e.g., two to six), the mean of ($Area_{UAi}$/$Area_{SAi}$) will be less than 9.0.

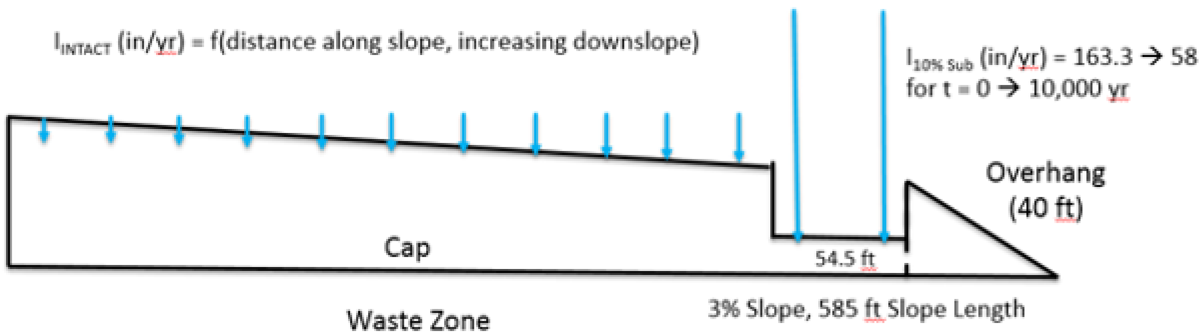
The tables embedded in Figure 16 compare the intact- and subsided-area infiltration rates predicted by HELP v4.0 for the FTF closure cap design with a 3% slope. The peak infiltration rate within the subsided area is predicted to be approximately 163 inches/year, the majority of which (~16.5 inches/year from Figure 13 times 9.0 equals ~145 inches/year) is run-on from the upslope intact area calculated via Equation (1) or (2).

Figure 17 displays the effect of percent subsidence on the upper bound for ($Area_{UAi}$/$Area_{SAi}$) and the HELP-model-predicted infiltration rate for the subsided region(s). Based upon data for non-crushable content in E-Area slit trenches filled to at least 90% by volume (0.0% SLIT1; 3.1% SLIT2; 7.7% SLIT3, 5.7% SLIT4, 0.9% SLIT5, 2.9% SLIT6, and 0.0% SLIT8), five trenches have a non-zero non-crushable content ranging from 0.9 to 7.7 percent, with a mean of 4.0 percent. The non-crushable contents alone point to a vadose-zone modeling window of 1% to 10% subsidence; however, practical considerations (i.e., a maximum of one to six holes over a 600-foot slope length with a hole size ranging from 10 to 60 feet) suggest increasing the minimum practical percent subsidence to 1.6% (i.e., one 10-foot hole / 600-foot slope length).

<u>Direction of PORFLOW Cross-Section</u>

The conceptual model development above assumes that the vadose-zone model cross-section in PORFLOW runs perpendicular to the crestline of the closure cap. This section will discuss the impact of a PORFLOW cross-section running parallel to the cap crestline.

Figure 18 presents the intact case, and compares the behavior of the infiltration rate along the cross-section for the two cases (perpendicular and parallel). In the parallel case, the infiltration rate will be constant in the x-direction, whereas the infiltration rate will increase in the y-direction (down the cap slope) for the perpendicular cross-section (see Figures 11 and 18). Regardless, the relevant infiltration rate(s) can be obtained from the same set of HELP-model simulation results.



$V_{INF\ TOTAL}$ = (163.3 in/yr x ft/12 in x 54.5 ft long) + (0.00037 in/yr x ft/12 in x (545-54.5 ft long)) = 742 ft^3 water per ft cap width

Assumptions:
Lateral drainage and surface run-off from upslope intact section drain into subsided area
Lateral drainage and surface run-off are zero in subsided section
Geomembrane and GCL layers are no longer effective barriers in subsided area

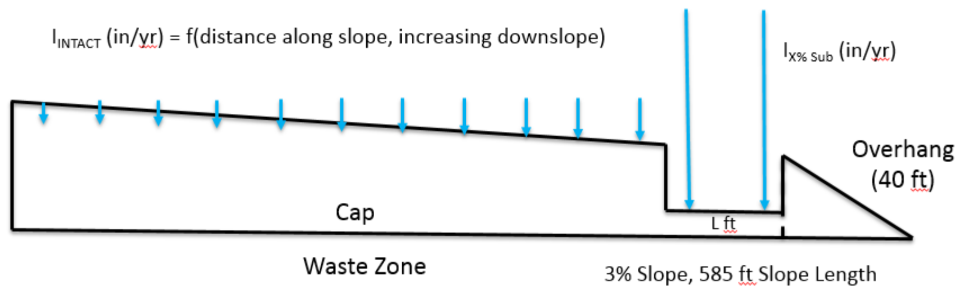
Intact Case
3% Slope, 585 ft Slope Length

Relative Time (yr)	InfiltrationRate (in/yr)
8.8	15.78
15	0.10
44.8	0.10
144.8	0.00037
244.8	0.0038
324.8	0.065
434.8	0.15
444.8	0.27
484.8	0.55
524.8	0.83
704.8	2.1
1144.8	5.6
1944.8	10.0
2767.8	11.2
3344.8	11.3
5744.8	11.4
10144.8	11.5

10% Subsided Case
3% Slope, 585 ft Slope Length

Relative Time (yr)	InfiltrationRate (in/yr)
8.8	15.78
15	0.10
44.8	0.10
144.8	163.3
244.8	163.3
324.8	162.8
434.8	162.1
444.8	161.0
484.8	158.5
524.8	156.1
704.8	144.8
1144.8	113.4
1944.8	71.5
2767.8	59.1
3344.8	58.6
5744.8	58.1
10144.8	58.2

Figure 16. Conceptual Infiltration Model for 10% Subsidence Case (9:1 Upslope-Intact-Area to Subsided-Area Ratio)



% Subsidence	Upslope: Subsided Area Ratio (Limit)	L (ft)	Subsided Area Infiltration @ t=0 (in/yr)
100	0	545	16.3
20	4	109	82
10	9	54.5	163.3
5	19	25.25	327
2.5	39	13.63	653
1	99	5.45	1630

Figure 17. Conceptual Model of the Impact of Percent Subsidence on Infiltration Rate

Intact Case

$I_i = f(y_i) \rightarrow$ increases down cap slope

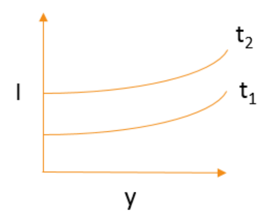
$I_i \neq f(x_i) \rightarrow$ constant across cap width

Intact infiltration rates for Figure 1, Section E cross-section still apply

Intact Case (Avg. Over Entire Surface)

3% Slope, 585 ft Slope Length

Relative Time (yr)	InfiltrationRate (in/yr)
8.8	15.78
15	0.10
44.8	0.10
144.8	0.00037
244.8	0.0038
324.8	0.065
434.8	0.15
444.8	0.27
484.8	0.55
524.8	0.83
704.8	2.1
1144.8	5.6
1944.8	10.0
2767.8	11.2
3344.8	11.3
5744.8	11.4
10144.8	11.5



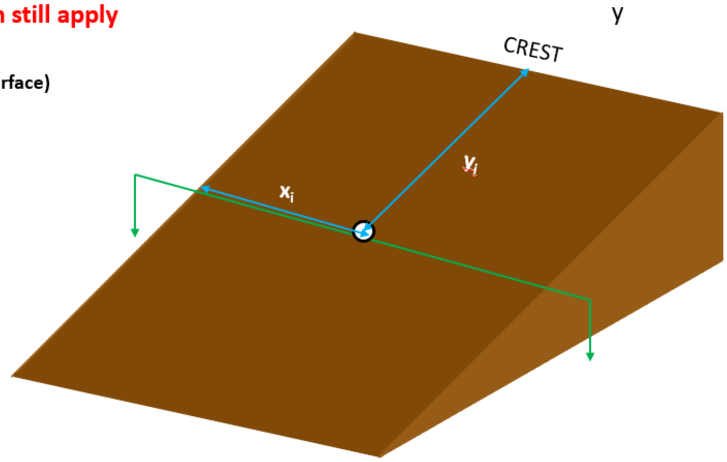


Figure 18. PORFLOW Cross-Section Running Parallel to Crest of Cap – Intact Case

Figures 19 and 20 present the one-hole-at-toe subsidence case for both the engineered and slit trenches. Figure 19 shows that the engineered-trench case will be more extreme than the slit-trench case because of the presence of 10-foot intact areas between the individual slit trenches. Figure 20 indicates that the subsided-area infiltration rates will be the same for both the parallel and perpendicular cross-sections.

Figure 21 depicts the parallel cross-section case where the single subsided region is located at the cap crestline. In this situation, run-on from upslope is zero and the subsided area can be treated as a 100% subsidence case.

Recommendations

For the next revision of the E-Area PA:

- Intact infiltration model cases can be limited to two, if desired. A recommended best-estimate case for uncertainty models of intact infiltration is 3% slope and 400-foot slope length, while a reasonably conservative or most probable and defensible (MPAD) case for deterministic models is 2% slope and 585-foot slope length.

- The cross-section for the vadose zone in PORFLOW should run perpendicular to the crestline of the closure cap because intact infiltration rates increase along the downward slope of the cap.

- An engineered-trench model representation is recommended because subsided-area infiltration rates for an engineered trench are independent of the cross-section orientation and bounding relative to a slit trench design.

- Based upon practical considerations (i.e., subsided compartment hole size ≥ 10 feet, non-crushable content ≤ 10 percent, and one-hole minimum to be considered a subsided case), a recommended parameter space for subsidence is one to six holes over a 600-foot slope length, a hole size of 10 feet to 60 feet, and 1.6% to 10% subsidence.

- Based on historical data for non-crushable content in E-Area slit trenches, a 4% subsidence (mean of non-zero data) case should be considered using the bounding upslope-intact-area to subsided-area ratio ($Area_{UAi}/Area_{SAi}$) equal to 24.

- Because future practices may differ from past disposals, a 6.7% subsidence case with two 20-foot subsided compartments is also recommended. This case lies near the center of the current and expected future E-Area trench operational window. The conservative upper bound of $Area_{UAi}/Area_{SAi}$ for this case is equal to 14.

One Hole Case (Engineered Trench vs. Slit Trench)

Engineered trench is a more extreme case than slit trench as shown below

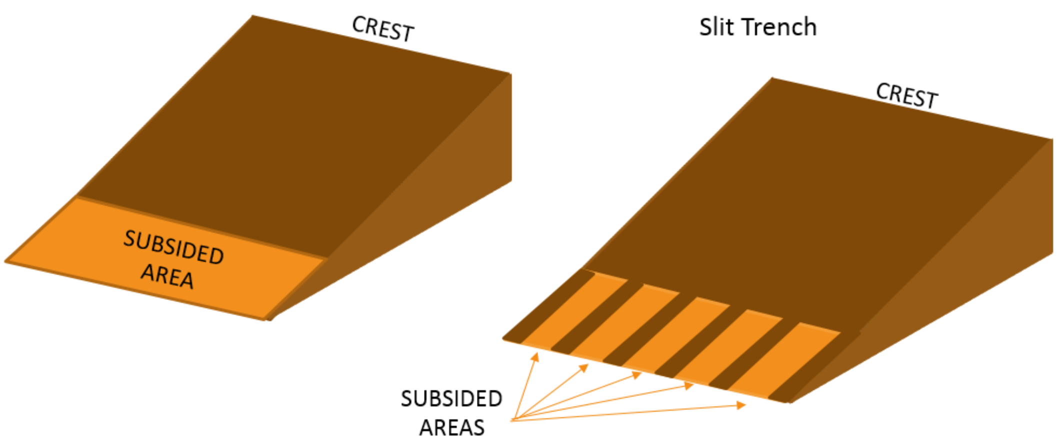


Figure 19. PORFLOW Cross-Section Running Parallel to Crest of Cap – Subsided Case

One Hole at Base (maximizes edge effects at base of cap)

$I_{subsided}$ → function of y_i which is f(% subsidence)
$I_i \neq f(x_i)$ → constant across cap width

Engineered trench represents bounding case relative to slit trench

Subsided case infiltration rates for Figure 1, Section E cross-section still apply

10% Subsided Case
3% Slope, 585 ft Slope Length

Relative Time (yr)	InfiltrationRate (in/yr)
8.8	15.78
15	0.10
44.8	0.10
144.8	163.3
244.8	163.3
324.8	162.8
434.8	162.1
444.8	161.0
484.8	158.5
524.8	156.1
704.8	144.8
1144.8	113.4
1944.8	71.5
2767.8	59.1
3344.8	58.6
5744.8	58.1
10144.8	58.2

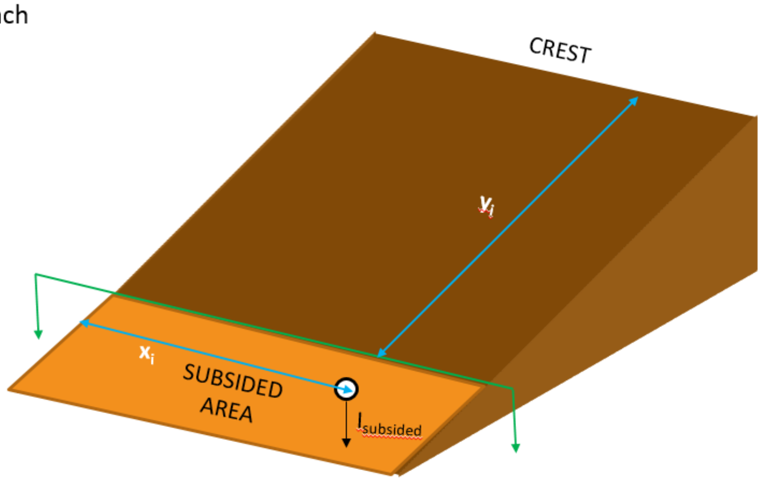


Figure 20. PORFLOW Parallel Cross-Section for Subsided Case– Single Hole at Cap Base

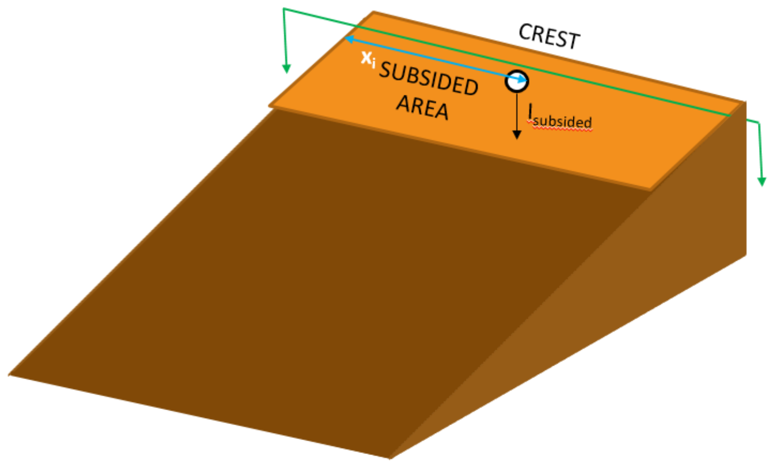
One Hole at Crest (zero run-on from upslope)

$I_{subsided} \neq f(x_i) \rightarrow$ constant across cap width

Engineered trench represents bounding case relative to slit trench

100% Subsidence Case infiltration rates for Figure 1, Section E cross-section apply

Time after Installation of Cap (yr)	Average Infiltration Rate Over Total Cap Surface (in/yr)
0	16.4687
100	16.4673
180	16.4750
290	16.4800
300	16.4800
340	16.4767
380	16.4812
560	16.4715
1000	16.4431
1800	16.2356
2623	16.0666
3200	16.0826
5600	16.1278
10000	16.1785



Check: $I_{100\%\ Sub}$ (in/yr) $\rightarrow$ Rainfall – Evapotranspiration $\cong$ 16 in/yr

Figure 21. PORFLOW Parallel Cross-Section for Subsided Case– Single Hole at Cap Crest

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Distribution List

timothy.brown@srnl.doe.gov
alex.cozzi@srnl.doe.gov
david.crowley@srnl.doe.gov
david.dooley@srnl.doe.gov
a.fellinger@srnl.doe.gov
samuel.fink@srnl.doe.gov
jeff.griffin@srnl.doe.gov
nancy.halverson@srnl.doe.gov
connie.herman@srnl.doe.gov
john.mayer@srnl.doe.gov
daniel.mccabe@srnl.doe.gov
frank.pennebaker@srnl.doe.gov
luke.reid@srnl.doe.gov
boyd.wiedenman@srnl.doe.gov
bill.wilmarth@srnl.doe.gov

sebastian.aleman@srnl.doe.gov
tom.butcher@srnl.doe.gov
Thomas.Danielson@srnl.doe.gov
kenneth.dixon@srnl.doe.gov
James.Dyer@srnl.doe.gov
gregory.flach@srnl.doe.gov
lee.fox@srs.gov
luther.hamm@srnl.doe.gov
thong.hang@srnl.doe.gov
ginger.humphries@srs.gov
ralph.nichols@srnl.doe.gov
Roger.Seitz@srnl.doe.gov
Ira.Stewart@srs.gov
kevin.tempel@srs.gov
Tad.Whiteside@srnl.doe.gov
Jennifer.Wohlwend@srnl.doe.gov
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