APPENDIX D – ASH LEACHATE SEEPAGE MODELING METHODOLOGY AND INPUT DATA

This appendix describes the methodology followed in estimating rates of ash leachate seepage associated with the coal ash structural fill at the Bivens Industrial Park. This appendix also provides supporting details for the evaluation of potential impacts of coal ash disposal on local surface water and groundwater resources considered in the Affected Environment and Environmental Consequences sections.

Estimation of Daily Leachate Seepage Rates

The Hydrologic Evaluation of Landfill Performance (HELP) model of Schroeder et al. (1994) was used to estimate leachate seepage rates from the ashfill. To facilitate modeling, the 59-acre ashfill proposed to receive coal ash was divided into two subregions: (1) current Phase 1 Area and (2) proposed Phase 2 area.

All model simulations include a geologic buffer 3 feet thick overlying the Camden chert formation. The buffer would be overlain by a geosynthetic clay liner (GCL) and 1-foot-thick bottom ash drainage blanket prior to deposition of fly ash.

For the No Action Alternative, model simulations include three potential cap designs for the final Phase 1 ashfill (Table D-1). Capping options include a 2-foot-thick vegetated soil cover, a 2-foot-thick vegetated soil cover underlain by a GCL, or a 2-foot-thick vegetated soil cover underlain by a flexible membrane liner (FML). Model simulations for the No Action Alternative are assumed to occur over a 40-year post-closure time interval.

Alternatives associated with Phase 2 expansion of the ashfill are potential operational impacts, and these are identified in Table D-1. HELP simulations were used to predict water budget components for uncapped stacking intervals of the Phase 2 expansion area for 3-, 6-, and 10-year periods; corresponding to 1/3, 2/3, and completed Phase 2 ashfill. Leachate estimates for the Phase 2 stacking intervals include the Phase 1 area with existing vegetated soil cover. Subsequent HELP simulations were used to predict operational impacts for a 40-year post-closure period of three possible capping alternatives (Table D-1) for both Phase 1 and Phase 2 areas.

In addition to alternatives associated with surface caps, differences between the Phase 1 and Phase 2 areas include fly ash thicknesses, bottom slopes, and aerial extents. Measured and assumed dimensions used in separate HELP models are provided in Table D-2.

Table D-1. Summary of Hydrologic Evaluation of Landfill Performance Model Scenarios

Phase	Case	Scenario	Phase 1 Cap	Phase 2 Cap
1	1	40-year post-closure of Phase 1 area	Vegetated soil cover	N/A
1	2	40-year post-closure of Phase 1 area	Vegetated soil cover and GCL	N/A
1	3	40-year post-closure of Phase 1 area	Vegetated soil cover and FML	N/A
1 and 2	4	Phase 1 existing; Phase 2 stack 1/3 complete (3-year)	Vegetated soil cover	Uncovered
1 and 2	5	Phase 1 existing; Phase 2 stack 2/3 complete (6-year)	Vegetated soil cover	Uncovered
1 and 2	6	Phase 1 existing; Phase 2 stack at completion (10-year)	Vegetated soil cover	Uncovered
1 and 2	7	40-year post-closure of Phases 1 and 2 area	Vegetated soil cover	Vegetated soil cover and GCL
1 and 2	8	40-year post-closure of Phases 1 and 2 area	Vegetated soil cover and GCL	Vegetated soil cover and GCL
1 and 2	9	40-year post-closure of Phases 1 and 2 area	Vegetated soil cover and FML	Vegetated soil cover and FML
1 and 2	10	Phase 1 existing; Phase 2 stack at completion (10-year)	Vegetated soil cover and GCL	Uncovered
1 and 2	11	Phase 1 existing; Phase 2 stack at completion (10-year)	Vegetated soil cover and FML	Uncovered
1 and 2	12	Phase 1 existing; Phase 2 stack at completion (10-year)	Vegetated soil cover and FML	Uncovered
1 and 2	12A	Phase 1 existing; Phase 2 stack 1/3 complete (3-year)	Vegetated soil cover and FML	Uncovered
1 and 2	12B	Phase 1 existing; Phase 2 stack 2/3 complete (6-year)	Vegetated soil cover and FML	Uncovered
1 and 2	12C	Phase 1 existing; Phase 2 stack at completion (10-year)	Vegetated soil cover and FML	Uncovered

Note: All designs include a 1-foot thick bottom ash drainage blanket and underlying GCL on Phase 1.

Table D-2. Geometry of Phase 1 and Phase 2 Ashfills

		Phase I			Phase II			Phase I & II
Feature	**Units**	**Existing Phase I**	**Final Phase I without Phase II**	**Final Phase I with Phase II Expansion**	**1/3 Complete Phase II**	**2/3 Complete Phase II**	**Complete Phase II**	**Final Phase I and Phase II Expansion**
Footprint	acre	36.9	40.1	31.9	30.3	30.3	30.3	62.3
Side slopes	acre	13.2	17.4	9.6	0.3	4.5	8.5	20.5
Working surface	acre	23.6	22.6	22.3	21.1	20.2	19.4	41.7
average ash thickness	ft	62.0	62.0	varies	20.0	44.0	71.0	varies
Assumed working surface elevation	ft-MSL	502.0	502.0	502.0	446.0	470.0	500.0	502.0
Approx. base elevation of exisiting ash	ft-MSL	437.0	437.0	437.0	426.0	426.0	426.0	varies
Top Surface Slope	%	2.5	2.0	2.0	2.0	2.0	2.0	2.0
Bottom slope	%	4.76	4.76	varies	2.5	2.5	2.5	varies

Notes:
All side slopes = 33 %
All cap designs include 2-ft of vegetated cover
All models include 1-ft thick bottom ash drainage blanket and underlying GCL
Footprint is horizontal extent of combined working surface sideslope that covers ash

Hydraulic properties used in the HELP simulations are presented in Table D-3. Ash data represent average characteristics derived from laboratory testing of three fly ash samples (Young et al. 1993). The vegetated soil properties, except for hydraulic conductivity, were obtained from Schroeder et al. (1994) for a soil loam. Vegetated soil hydraulic conductivity (2.2x10-5 centimeters per second) represents the maximum measured value from five laboratory permeability tests conducted from samples of cover material on the Phase 1 area (personal communication, Nancy Sullivan, TriAD Inc., December 5, 2008). Properties of the bottom ash drainage layer were obtained from Schroeder et al. (1994) with the exception of hydraulic conductivity, which is based on Law Engineering Inc. (1995) measurements for TVA bottom ashes. GCL properties were obtained from TriAD (2008) and Schroeder et al. (1994). The FML parameters represent a high-quality geomembrane (no pinhole defects) with one installation defect per acre and good placement quality. Assumptions include: an experienced geosynthetics crew would be used for FML installation, and third-party construction quality assurance would be provided for the project. Properties assumed for the lowermost barrier soil are identical to the vegetated soil.

Table D-3. Hydraulic Properties Applied in Hydrologic Evaluation of Landfill Performance Simulations

Media Type	Total Porosity	Field Capacity[1]	Wilting Point[2]	Initial Moisture Content (cm^3/cm^3)	Hydraulic Conductivity (cm/s)
Vegetated Soil	0.46	0.23	0.12	0.23	2.2×10^{-5}
Fly Ash	0.42	0.31	0.075	varies	1.6×10^{-5}
Bottom Ash	0.53	0.15	0.06	0.15	4.7×10^{-3}
GCL	0.75	0.75	0.4	0.75	5.0×10^{-9}
FML	NA	NA	NA	NA	1.0×10^{-13}
Barrier Soil	0.46	0.23	0.12	0.23	2.2×10^{-5}

[1] *Moisture content at pressure head of -0.33 bar.*

[2] *Moisture content at pressure head of -15 bars.*

Initial volumetric moisture content for the most media layers was arbitrarily set at field capacity. An initial moisture content of 0.22 was applied to new fly ash based on average field water contents measured for JOF ash samples (Velasco and Boggs 1992). For simulations involving Phase 2 stacking, initial moisture content for 6- and 10-year simulations was assigned to existing ash (20- and 42-foot thicknesses, respectively) based on output of previous HELP simulations. This resulted in initial moisture content of existing ash ranging from 0.28–0.32.

Meteorological data required for HELP simulations were synthetically generated using “Weather Generator,” which utilizes the weather generation algorithm developed by the Agricultural Research Service of the U.S. Department of Agriculture (USDA). Weather Generator also includes the weather station database compiled by USDA containing statistically accurate summaries of the required meteorological data for major weather stations located within the U.S. The Weather Generator application for the HELP modeling effort described in this appendix used data from the National Weather Service reporting station at Nashville International Airport, in Nashville, Tennessee.

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