ESCALANTE GENERATING STATION ACTIVE ASH LANDFILL CLOSURE PLAN

Tri-State Generation and Transmission Association, Inc.

Submitted To: Tri-State Generation and Transmission Association, Inc.
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1.0 INTRODUCTION

Tri-State Generation and Transmission Association, Inc. (Tri-State) owns and operates the Escalante Generating Station, a 273-megawatt coal-fired electric generating plant located near the town of Prewitt, New Mexico. Coal combustion residuals (CCRs) from the Escalante Generating Station are managed in the existing active Tri-State-owned CCR landfill (the Facility), which is located approximately three-quarters of a mile east of the power block. The Facility is located directly south of the inactive CCR landfill at the Escalante Generating Station (see Figure 1).

Golder Associates Inc. (Golder) has prepared this closure plan for the Facility on behalf of Tri-State to serve as the initial written closure plan required under 40 CFR 257.102(b). The Facility will be closed with CCRs left in place in accordance with the requirements of 40 CFR 257.102(d). This closure plan includes a narrative description of the measures that will be taken for closure of the Facility, a description of the final cover system that will be constructed for closure of the Facility, a description of the methods and procedures that will be used to install the final cover system, an estimate of the maximum inventory of CCRs that will be disposed in the Facility, an estimate of the largest area of the Facility that will require installation of a final cover system at any time during its active life, and a schedule for completing closure activities at the Facility.

2.0 NARRATIVE DESCRIPTION OF FACILITY CLOSURE

A final cover system will be installed over areas where CCR placement has reached the final grades (see Figure 1). The final cover system will be installed using conventional soil placement techniques and common earthmoving equipment, such as bulldozers, haul trucks, scrapers, and/or motor graders. Soils that are suitable for use in the final cover system will be obtained from select on-site stockpiles. Disruption of the integrity of the final cover system will be inhibited by compacting the underlying CCRs to establish a firm and unyielding subgrade prior to installation of the final cover system and by establishing a slope of approximately 2 percent across the top surface to provide positive drainage, limit ponding, and mitigate the potential effects of settling and subsidence. Monitoring and/or verification of final cover system installation will be conducted to help ensure that the constructed final cover system meets the design requirements. The final cover system will be vegetated using procedures that meet the requirements of the discharge permit for the Facility.

3.0 FINAL COVER SYSTEM

The final cover system for closure of the remaining active areas will be an evapotranspiration (i.e., store-and-release) cover system consisting of a 36-inch-thick water storage layer. The water storage layer will be composed of earthen material that is capable of storing moisture and sustaining native plant growth. This design meets the requirements for an alternative final cover system as described under 40 CFR 257.102(d)(3)(ii), as well as the final cover system design requirements included in the discharge permit for the Facility.

As demonstrated through unsaturated flow modeling performed using HYDRUS-1D, which is described in Appendix A, the water storage layer will provide a reduction in infiltration that is equivalent to that which would be provided by the infiltration layer in the prescriptive cover system, in accordance with 40 CFR 257.102(d)(ii)(A). The results of the unsaturated flow modeling indicated that percolation through the evapotranspiration cover system (i.e., net infiltration) is expected to be negligible. Additionally, the soils that will be used for the water storage layer in the evapotranspiration cover system will be derived from the same on-site stockpiles and placed using the same methods that would be used for the erosion layer in the prescriptive cover system. Thus, the water storage layer will provide protection from wind and water erosion that is equivalent to that which would be provided by the erosion layer in the prescriptive cover system, in accordance with 40 CFR 257.102(d)(ii)(B).

4.0   CLOSURE ESTIMATES

4.1.1   Maximum CCR Inventory Estimate

Golder used Autodesk Civil 3D to compare pre-development topographic information (provided by Tri-State and estimated by Golder) against the closure grades (see Figure 1). Soil volumes associated with the final cover system were then subtracted. The resulting estimate of the maximum CCR inventory to be contained in the Facility (i.e., at closure) is 5.1 million cubic yards.

4.1.2   Largest Area Requiring Final Cover

The largest area requiring installation of a final cover system during the remainder of the Facility's active life is estimated as 45 acres. This estimate may be reduced by phased closure of areas where placement of CCRs reaches the final grades during the active life of the Facility.

5.0   CLOSURE SCHEDULE

When placement of CCRs has reached the final grades, closure activities will commence within 30 days of the known final receipt. In the event of Facility inactivity, the closure schedule will be in accordance with 40 CFR 257.102(e)(2)(i). Notification of intent to close the Facility will be placed in the operating record prior to the commencement of closure activities. Phased closure of areas where placement of CCRs has reached the final grades prior to the known final receipt may be performed during the active life of the Facility.

Closure activities will be completed within 180 days after commencement of closure activities, although this timeframe may be extended in accordance with 40 CFR 257.102(f)(2)(i). Closure activities to be completed during this time include preparation of bid documents and solicitation of contractors' bids (2 months estimated duration), installation of the final cover system (3 months estimated duration), and preparation and submittal of as-built documents and certifications as required under 40 CFR 257.102(f)(3) (1 month estimated duration). At the current estimated CCR placement rates, the Facility is expected to reach capacity in approximately 65 years. On this basis, the year in which closure activities will be completed is estimated to be 2081.

Notification that closure of the Facility has been completed will be placed in the operating record within 30 days of the completion of closure activities. This notification will include certification by a qualified professional engineer that closure has been completed in accordance with the closure plan. Following closure of the Facility, Tri-State will record a notation on the deed to the property (or another instrument that is normally examined during title search) that will notify potential purchasers of the land that the land has been used as a CCR landfill and its use is restricted under post-closure care requirements described in the Facility's post-closure care plan. Within 30 days of recording the notation, notification will be placed in the operating record.

6.0   CERTIFICATION

The undersigned attest to the completeness and accuracy of this closure plan and certify that the closure plan meets the requirements of 40 CFR 257.102(b). The undersigned further certify that the design of the final cover system meets the requirements of 40 CFR 257.102(d)(3).
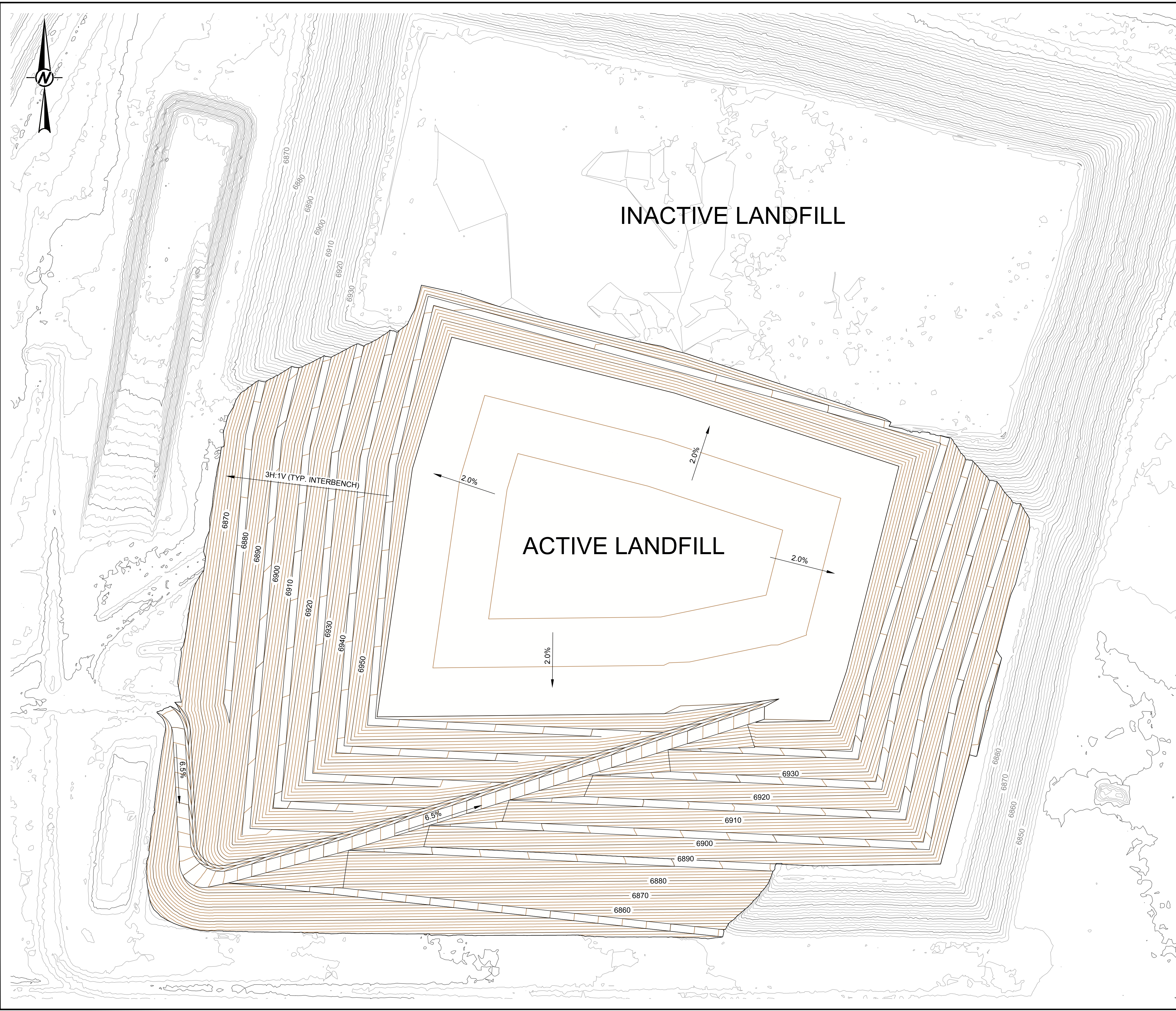
GOLDER ASSOCIATES INC.

Jason Obermeyer, PE
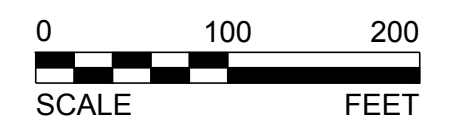Associate and Senior Engineer

Tammy Rauen, PE
Senior Project Engineer

FIGURE

LEGEND

EXISTING GROUND SURFACE CONTOURS

PROPOSED GROUND SURFACE CONTOURS

INACTIVE LANDFILL

ACTIVE LANDFILL

3H:1V (TYP. INTERBENCH)

2.0%

2.0%

2.0%

2.0%

6.5%

6.5%

6870
6880
6890
6900
6910
6920
6930
6940
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ESCALANTE

TITLE
CLOSURE GRADES

CONSULTANT

Golder Associates

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APPENDIX A
ASSESSMENT OF FINAL COVER HYDRAULIC PERFORMANCE

ASSESSMENT OF FINAL COVER HYDRAULIC PERFORMANCE

Tri-State Generation and Transmission Association, Inc. Escalante Generating Station – Active Coal Combustion Residuals Landfill

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1.0   INTRODUCTION

Tri-State Generation and Transmission Association, Inc. (Tri-State) has developed a closure plan for the active coal combustion residuals (CCR) landfill (the Facility) at the Escalante Generation Station, a 273-megawatt coal-fired electric generating plant located near Prewitt, New Mexico. This report has been prepared to demonstrate the suitability of the final cover system design that is presented in the closure plan.

The Facility accepts fly ash, bottom ash, and flue gas desulfurization material from Tri-State-owned Escalante Generating Station. As part of Facility closure, approximately 45 acres of final cover will be placed on the landfill side slopes and on the top plateau area. Two final cover design options have been evaluated for the Facility: 1) a prescriptive cover system meeting the requirements of 40 CFR 257.102(d)(3)(i), and 2) an evapotranspiration cover. This report presents the analysis and evaluation of predicted unsaturated flow and net infiltration through each cover, performed as a comparative assessment of hydraulic performance to help establish the equivalency of the evapotranspiration cover to the prescriptive cover in terms of net infiltration reduction, as required under 40 CFR 257.102(d)(3)(ii)(A). Net infiltration is defined as the water that infiltrates deep into the soil cover and the underlying CCRs and is not returned to the atmosphere through evaporation or transpiration.

2.0   SOIL-ATMOSPHERE MODEL CODE AND SETUP

Unsaturated flow modeling was performed using the one-dimensional soil-atmosphere modeling software HYDRUS-1D (Simunek et al. 2013). The HYDRUS-1D program is a finite-element model that numerically solves Richards' equation for variably saturated water flow. The HYDRUS-1D model code is widely accepted by the professional community for evaluating variably saturated flow and solute transport processes.

Cover model simulations were developed to be consistent with the requirements of the "Ground Water Discharge Permit Renewal and Modification, DP-206" for the site, which was issued by the New Mexico Environment Department (NMED) on February 10, 2015. The model profile for the prescriptive cover system and the uppermost zone of landfilled CCRs consists of an 18-inch erosion layer capable of supporting native plant growth, an 18-inch infiltration (barrier) layer with saturated vertical hydraulic conductivity no greater than 9.1 x 10^{-6} cm/s[1], and a 24-inch CCR layer. This profile also meets the prescriptive final cover requirements of the Environmental Protection Agency's 40 CFR Part 257, Subpart D, "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," specifically 40 CFR 257.102(d)(3)(i). The model profile for the evapotranspiration cover, also known as a "water balance" or "store-and-release" cover, and the uppermost zone of landfilled CCRs consists of a 36-inch water storage layer and a 24-inch CCR layer. The same material properties used for the erosion layer in the prescriptive cover are used for the water storage layer in the evapotranspiration cover, since 40 CFR 257.102(d)(3)(ii)(B) requires the water storage layer to provide equivalent protection from wind and water erosion. For the purposes of the soil-atmosphere modeling, the CCR layer is included in the models to assess net infiltration[2] below the depth of influence of evaporation and transpiration. The roots from the cover vegetation were simulated to extend to the bottom depth/base of each cover. Consequently, the depth of influence of transpiration is slightly greater than the 3-foot cover thickness, and a relatively thin layer of CCRs is included for model consistency with expected conditions. The thickness of the CCR layer is consistent between the two cover models to allow for direct comparison of the results.

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[1] The Facility's bottom liner system consists of native soil. Based on flexible-wall permeability testing of a representative sample obtained at the Facility, the saturated vertical hydraulic conductivity of the native soil (as remolded to conditions representative of the Facility's bottom liner) is approximately 9.1 x 10^{-6} cm/s. Since this hydraulic conductivity is lower than 1 x 10^{-5} cm/s, the governing hydraulic conductivity for the infiltration layer under 40 CFR 257.102(d)(3)(i)(A) is 9.1 x 10^{-6} cm/s.

[2] Net infiltration is distinct from surface infiltration in that net infiltration represents water that will penetrate deep into the profile, while some amount of surface infiltration may be returned to the atmosphere as a result of evaporation and/or transpiration. Consequently, net infiltration can only be assessed below the depth of influence of evaporation and transpiration.

3.0 SOIL-ATMOSPHERE MODEL INPUTS

This section summarizes soil cover and CCR material properties, vegetation properties, the climate record, initial conditions, and boundary conditions used for the unsaturated flow modeling and net infiltration analysis.

3.1 Material Properties

Material properties were developed for the modeling primarily using geotechnical laboratory test results for representative materials collected at the Facility. Based on index test results for a representative soil sample collected from an on-site stockpile, as well as field soil classification, surface soils at the site are considered appropriate for use in the final cover. These soils will be used to construct either the erosion layer and infiltration layer in the prescriptive cover or the water storage layer in the evapotranspiration cover. The soil cover sample (Site Soil) classifies as a clayey sand (SC), according to the Unified Soil Classification System (USCS). In addition, a representative sample of disposed CCRs was collected from the inactive ash landfill at the site. The CCR sample (LF Ash) classifies as a low-plasticity silt (ML), according to the USCS.

Additional testing was conducted on each of the two samples (Site Soil and LF Ash), including flexible-wall permeability testing to estimate the saturated vertical hydraulic conductivity (K_{sat}) of the materials and soil water characteristic curve (SWCC) testing to estimate the unsaturated hydraulic properties of the materials. Flexible-wall permeability testing was conducted on the Site Soil sample at 85% and 95% compaction, relative to the standard Proctor maximum dry density, to estimate the range in K_{sat} for the different soil cover layers. Flexible-wall permeability testing was conducted on the LF Ash sample at 95% compaction, relative to the standard Proctor maximum dry density, to estimate K_{sat} for the in-situ material. Soil water characteristic curve testing was conducted on the Site Soil sample at 85% and 92% compaction, relative to the standard Proctor maximum dry density, and on the LF Ash sample at 95% compaction, relative to the standard Proctor maximum dry density.

The Site Soil sample at 85% compaction represents a typical degree of compaction for a cover layer that is capable of supporting native plant growth, so the K_{sat} for this sample (9.8×10^{-6} cm/s) was used to simulate the erosion layer in the prescriptive cover and the water storage layer in the evapotranspiration cover. The K_{sat} estimated from the Site Soil sample at 95% compaction was used only as a guide to help assign an appropriate hydraulic conductivity to the infiltration layer in the model for the prescriptive cover. It was considered that the as-constructed infiltration layer would potentially have a K_{sat} that is somewhat lower than the governing value (9.1×10^{-6} cm/s, as described in Section 2.0). To better represent as-constructed conditions for the infiltration layer, an estimated K_{sat} of 5×10^{-6} cm/s (roughly half of the governing value) was used to simulate the infiltration layer. This estimated K_{sat} meets the prescriptive final cover requirements of the Environmental Protection Agency's "Standards for the Disposal of Coal

Combustion Residuals in Landfills and Surface Impoundments," specifically 40 CFR 257.102(d)(3)(i)(A). The LF Ash sample at 95% compaction (K_{sat} estimated as 4.5×10^{-6} cm/s) represents a typical degree of compaction for the CCR layer directly underlying the final cover system.

The soil water characteristic curve provides the laboratory-measured relationship between soil suction and volumetric water content, which is then used to estimate the relationship between volumetric water content and unsaturated hydraulic conductivity. The van Genuchten model (van Genuchten 1980) was used to fit the SWCC laboratory data and estimate the unsaturated hydraulic properties of the materials. The SWCC laboratory data and model fits for the cover material (Site Soil at 85% and 92% compaction relative to the standard Proctor maximum dry density) and the CCR sample (LF Ash at 95% compaction relative to the standard Proctor maximum dry density) are provided in Figure A-1. The parameters associated with the model fits were used directly in the model. Table A-1 summarizes the hydraulic properties of the soil cover samples and the CCR sample used for modeling infiltration.

3.2   Vegetation Data

Four inputs are required for the soil-atmosphere model to simulate transpiration by local vegetation, including leaf area index (LAI), root distribution with depth, total root depth, and water uptake parameters (critical suction limits), which define the relationship of transpiration with soil suction. Vegetation inputs were developed for the reclamation seed mix, considering the surrounding undisturbed vegetation community. The surrounding undisturbed vegetation community at the Facility is characterized as Inter-Mountain Basins Semi-Desert Shrub Steppe (USGS GAP 2011). These are dry, open grasslands with a mix of low- to medium- height shrubs. This semi-arid shrub-steppe is typically dominated by grasses, with open shrub layer. Characteristic grasses include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Distichlis spicata*, *Hesperostipa comata*, *Pleuraphis jamesii*, *Poa secunda*, and *Sporobolus airoides*. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include *Atriplex canescens*, *Artemisia tridentata*, *Chrysothamnus greenei*, *Chrysothamnus viscidiflorus*, *Ephedra spp.*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Krascheninnikovia lanata*.

The Natural Resource Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) recommended the following reclamation seed mix for the site:

- 35% 'Lovington' Blue Grama (*Boutelous gracilis*)
- 15% 'Arriba' Western Wheatgrass (*Pascopyrum smithii*)
- 10% Intermediate Wheatgrass (*Thinopyrum intermedium*)
- 10% 'Paloma' Indian Ricegrass (*Oryzopsis hymenoides*)
- 15% Sand Dropseed (*Sporobolus cryptandrus*)
- 15% 'Salado' Alkali Sacaton (*Sporobolus airoides*)

Additional seed %:

■ 10% Fourwing Saltbrush (*Atriplex canescens*)

■ 10% Globemallow (*Sphaeralcea*)

The LAI distribution describes the ratio of leaf surface area to the soil surface area. HYDRUS requires an annual LAI distribution. The annual LAI distribution for the grassland used in the simulations is provided in Figure A-2. The annual LAI distribution selected for the site assumes a range from 0.03 in the winter to 0.60 during the peak growing season. The specified plant growth season is between March and October when the average temperature is above 41°F (biological zero). The abrupt increase at the end of July corresponds to the typical arrival of the summer rains.

The root density function allocates water removal from the model domain. The root density function and the maximum rooting depth for the simulations were truncated at the base of the cover at 91 cm (3.0 feet), with a cumulative distribution having 50% of the roots above 15 cm (0.5 feet) (Schenk and Jackson 2002 and 2003). The grassland cumulative root distribution used in the simulations is provided in Figure A-3.

The water uptake parameters (critical suction limits) include wilting point, initial transpiration, decreased transpiration, and transpiration rate. Wilting point is the soil-water content at the soil-water potential where a particular plant species either wilts or becomes dormant (Ritchie 1981). Wilting point is typically about 15,000 cm for crop plants; 25,000 to 30,000 cm for prairie grasses; and may exceed 60,000 cm for some desert shrubs. The critical suction limits selected for the model include 30,000 cm for wilting point, 1,000 cm for the point at which plant transpiration decreases (Gardner 1983), and 10 cm for the point where transpiration ceases due to anaerobic conditions resulting from saturated or near-saturated conditions. The default critical transpiration rates in HYDRUS (Simunek et al. 2013) were used for the simulations, i.e., a lower potential transpiration rate of 0.1 cm/day and an upper potential transpiration rate of 0.5 cm/day.

3.3   Climate Data

A long-term climate record was developed for the Facility to provide inputs of precipitation, potential evaporation, and potential transpiration for the soil-atmosphere model. A long-term climate record in close proximity and elevation to the site provides the most appropriate model inputs. If an on-site long-term climate record is not available, then a co-located precipitation and potential evapotranspiration (PET) record close to the site can be adjusted to simulate site conditions and provide a synthetic climate record. Co-location of precipitation and PET data is required since these two parameters are highly correlated and using data that are not co-located could introduce error into the model.

For the Facility, the closest co-located precipitation and potential evapotranspiration data record is located at the Albuquerque International Airport, approximately 86 miles southeast of the site. The Thoreau

meteorological station is the station that is in closest proximity and elevation to the site. Information about the meteorological stations is summarized in Table A-2. Only a limited climate dataset exists at the Thoreau station, i.e., less than 40 years of data (NOAA 2016a), and the data are insufficient to calculate daily potential evapotranspiration. As a result, data from the Albuquerque International Airport meteorological station (NOAA 2016b, 2016c) were adjusted to represent the Thoreau dataset based on a linear regression analysis of the overlapping records of these two stations. The linear regression analyses included comparisons between each station's monthly precipitation and monthly PET, calculated using the Blaney-Criddle method of Hargreaves (1985) model.

Potential evapotranspiration was calculated daily by the National Weather Service of the U.S. National Oceanic and Atmospheric Administration using a Penman-type PET method, as provided in the Albuquerque International Airport climate dataset (NOAA 2016c). Although PET was calculated for the Thoreau station on a monthly basis for the linear regression analysis, the Blaney-Criddle method of Hargreaves (1985) model is not appropriate for estimating PET for time periods less than a month (Allen et al. 1998). The climate data measured at the Thoreau station are not sufficient to calculate daily potential evapotranspiration for use in soil-atmosphere modeling. In addition, potential evapotranspiration data were not available for the full period of record for which precipitation data are available at the Albuquerque International Airport station. As a result, the precipitation-PET relationship at the Albuquerque International Airport station was used as a guide to extend the calculated PET record to match the extent of the precipitation record. The method to extend the calculated PET was developed based on the month of the year, whether or not precipitation occurred on a given day, the magnitude of the precipitation, and whether or not precipitation occurred the previous day.

Climate records were compiled from the adjusted Albuquerque International Airport dataset and the original Thoreau dataset. Albuquerque precipitation data and PET data were adjusted to represent climate at the Thoreau station, based on the linear regression analyses, and the dataset was then reduced to exclude missing and incorrect data. Following the data reduction, an 84-year period of record was compiled for the Facility.

The annual range of precipitation over the 84-year climate record is as follows:

- Driest year in 1950 with annual precipitation = 5.1 inches
- Average year in 1978 with annual precipitation = 10.8 inches, nearest to annual average precipitation of 10.7 inches/year for the synthetic climate
- Wettest year in 1941 with annual precipitation = 19.6 inches
- Wettest 5-year period from 1983 to 1987 with average annual precipitation = 13.8 inches

Potential plant transpiration was estimated using the Ritchie and Burnett (1971) equation, which is based on potential evapotranspiration and LAI estimates for the site, as described in Section 3.2. Potential

evaporation was then calculated as the difference between potential evapotranspiration and potential transpiration. Annual precipitation, potential evaporation, and potential transpiration for the 84-year period of climate record are presented in Figure A-4. Figure A-4 demonstrates that the climate record for the site represents a moisture-limited environment where PET far exceeds precipitation.

3.4   Initial Conditions and Boundary Conditions

The top boundary condition of the model was defined by atmospheric input of daily precipitation, potential evaporation, and potential transpiration, while also allowing for surface runoff. The bottom boundary condition was defined as free drainage, which is equivalent to a unit vertical hydraulic gradient. To condition the soil moisture profile to average climate conditions, soil moisture was equilibrated to typical precipitation, potential evaporation, and potential transpiration by applying one hundred cycles of the average year, i.e., 1978, prior to the start of the 84-year long-term climate record.

4.0 PREDICTIVE SIMULATIONS

4.1 Base Case

Base case predictive simulations were performed for the prescriptive cover and the evapotranspiration cover using the material properties, vegetation properties, climate inputs, and other model parameters described in the previous sections. The model profiles for the two base case simulations are summarized in Table A-3.

4.2 Sensitivity Analyses

To assess the sensitivity of the base case models to heterogeneity in material properties and variability in vegetation, additional simulations were analyzed which incorporate the following changes (separately):

- Increase the saturated vertical hydraulic conductivity (K_{sat}) of the erosion layer (prescriptive cover system) and water storage layer (evapotranspiration cover) by one order of magnitude. K_{sat} for the Site Soil sample at 85% compaction relative to the standard Proctor maximum dry density was increased from 9.8 x 10^{-6} cm/s (base case) to 9.8 x 10^{-5} cm/s.

- Decrease leaf area index of the grassland by 20%. The annual LAI distribution for grassland presented in Figure A-2 was decreased by 20%, e.g., the maximum grassland LAI was 0.48.

5.0   SOIL-ATMOSPHERE MODEL RESULTS

5.1   Predicted Net Infiltration and Predicted Water Balance

Based on results from the base case simulations and the sensitivity analyses of the prescriptive cover and the evapotranspiration cover, net infiltration through each cover is predicted to be negligibly small, i.e., < 0.01 inches per year on average, in all model simulations.   This is a consequence of potential evapotranspiration far exceeding precipitation, as shown in Figure A-4.

Table A-4 provides a summary of the predicted long-term water balance for each cover simulation, with rates averaged over the 84-year climate record. Since the combined effect of evaporation from the soil cover and transpiration by grassland is significant and does not vary appreciably between the base case simulations and the sensitivity simulations, the results provided below include the range in predicted water balance fluxes for all simulations.

Based on the simulation results over the 84-year period of climate record, the predicted water balance fluxes for the prescriptive cover system are approximately the same as the fluxes for the evapotranspiration cover. For both cover systems, the water balance fluxes and comparisons of these fluxes to the annual average precipitation at the Facility are as follows:

- Net Infiltration = < 0.01 inches/year = negligible
- Evaporation = 6.8 to 7.1 inches/year = 63 to 66% of annual average precipitation
- Transpiration = 2.9 to 3.6 inches/year = 27 to 34% of annual average precipitation
- Runoff = < 0.01 to 0.8 inches/year = < 8% of annual average precipitation
- Change in Storage = minimal = < 1% of annual average precipitation

6.0　CONCLUSIONS

Results from the soil-atmosphere modeling indicate that evaporation from the soil cover is the dominant water balance flux. In combination with transpiration by grassland for each cover, these two fluxes account for the removal of more than 92 percent of precipitation, on average. For the sensitivity simulations in which the erosion layer (prescriptive cover) and water storage layer (evapotranspiration cover) K_{sat} was increased by one order of magnitude relative to the base case, the plant transpiration and soil evaporation are predicted to increase in each cover system in response to the increased availability of water. Similarly, the predicted runoff and the predicted net infiltration for these sensitivity simulations are expected to be negligibly small. For the sensitivity simulations in which the vegetation LAI was decreased by 20%, for both the prescriptive cover and the evapotranspiration cover, the transpiration is predicted to decrease slightly while the evaporation is predicted to increase slightly and the predicted net infiltration is expected to remain negligibly small.

Considering long-term variations in climate, these results indicate that an evapotranspiration cover is expected to perform as well as the prescriptive cover since both cover systems are highly effective at storing and releasing water back to the atmosphere. In accordance with 40 CFR Part 257, Subpart D, the water storage layer in the evapotranspiration cover is expected to achieve an equivalent reduction in net infiltration relative to the infiltration layer (plus the erosion layer) in the prescriptive cover.

Likewise, considering short-term flux variations due to greater intensity climate cycles, both covers are still expected to perform well. Results from modeling of the short-term responses of each cover system to the wettest single year and wettest 5-year period indicate that the evaporation rate and transpiration rate are predicted to increase and the predicted net infiltration is expected to remain negligibly small.

7.0   REFERENCES

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TABLES

Table A-1: Summary of Hydraulic Properties for the Soil-Atmosphere Model

Sample ID	Soil Layer	USCS Classification	Compaction (%)	MDD (pcf)	MC (%)	OMC (%)	K_{sat} (cm/s)	θ_R	θ_S	alpha (1/cm)	n	l
			Geotechnical Test Data[1]					**Unsaturated Hydraulic Characteristics[1,2]**				
Site Soil @ 85% MDD[3]	Erosion Layer, Water Storage Layer	Clayey sand (SC)	85	120.0	5.2	11.6	9.8E-06	0	0.394	0.014	1.24	0.5
Site Soil @ 92% MDD[4]	Infiltration Layer		92		7.0		5E-06[5]	0	0.367	0.007	1.25	0.5
LF Ash[5]	CCR Layer	Low-plasticity silt (ML)	95	85.2	30.3	22.9	4.5E-06	0.04	0.450	0.004	1.32	0.5

Notes:

(1) Test data are from samples collected at the site.

(2) Unsaturated hydraulic characteristics for all three samples are estimated from van Genuchten (1980) model fit to Golder laboratory data, as shown in Figure A-1.

(3) The degree of compaction for the specimens representing the erosion layer and the water storage layer is typical for non-barrier layers. The moisture content is as-sampled.

(4) The degree of compaction and moisture content for the specimen representing the infiltration layer are based on estimates of as-constructed conditions.

(5) A laboratory permeability test was not conducted at 92% compaction. K_{sat} was assigned in the soil-atmosphere model to represent estimated as-constructed conditions.

(6) The degree of compaction for the specimens representing the CCR layer corresponds with standard Proctor compactive effort and is similar to that of the landfilled CCRs. The moisture content is as-sampled.

USCS = Unified Soil Classification System

MDD = standard Proctor maximum dry density

pcf = pounds per cubic foot

MC = remold moisture content

OMC = standard Proctor optimum moisture content

K_{sat} = saturated vertical hydraulic conductivity

θ_R = residual water content

θ_S = saturated water content

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Table A-2: Meteorological Stations used for Escalante Generating Station[1] Long-Term Climate Record

Station	Location	Elevation (feet above mean sea level)	Period of Record	Climate Data	Data Source
Thoreau	9 miles west of site	7,140	1953 to 1992	Precipitation	(NOAA 2016a)
Albuquerque International Airport	86 miles southeast of site	5,309	1931 to Present	Precipitation and Potential Evapotranspiration[2]	(NOAA 2016b, 2016c)

Notes:
(1) Escalante Generating Station is located near Prewitt, NM, at an elevation of approximately 6,860 feet above mean sea level.
(2) Potential Evapotranspiration data for the Albuquerque station are only available from 1948 to 1999.

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Table A-3: Summary of Base Case Predictive Simulations

		Prescriptive Cover
		Grass Vegetation
	Thickness of Layer (feet)	Sample ID
Erosion Layer	1.5	Site Soil @ 85% MDD
Infiltration Layer	1.5	Site Soil @ 92% MDD
CCR Layer	2	LF Ash

		Evapotranspiration Cover
		Grass Vegetation
	Thickness of Layer (feet)	Sample ID
Water Storage Layer	3	Site Soil @ 85% MDD
CCR Layer	2	LF Ash

Note:
MDD = standard Proctor maximum dry density

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Table A-4: Summary of Predicted Long-Term Water Balance for Final Cover

Cover Type	Sensitivity Type	Evaporation	Transpiration	Runoff	Net Infiltration
		84-year Average (inches/year)[1]			
Base Case Model					
Prescriptive		6.77	3.07	0.84	<0.01
Evapotranspiration		6.76	3.06	0.83	<0.01
Sensitivity Simulations					
Prescriptive	Erosion Layer and Water Storage Layer (Site Soil @ 85% MDD) K_{sat} increased to 9.8E-05 cm/s	7.08	3.60	<0.01	<0.01
Evapotranspiration		7.08	3.59	<0.01	<0.01
Prescriptive	Decreased LAI by 20%	6.91	2.93	0.84	<0.01
Evapotranspiration		6.91	2.92	0.84	<0.01

Notes:

(1) Average annual precipitation for the site climate record is 10.7 inches/year.

MDD = standard Proctor maximum dry density

K_{sat} = saturated vertical hydraulic conductivity

LAI = leaf area index
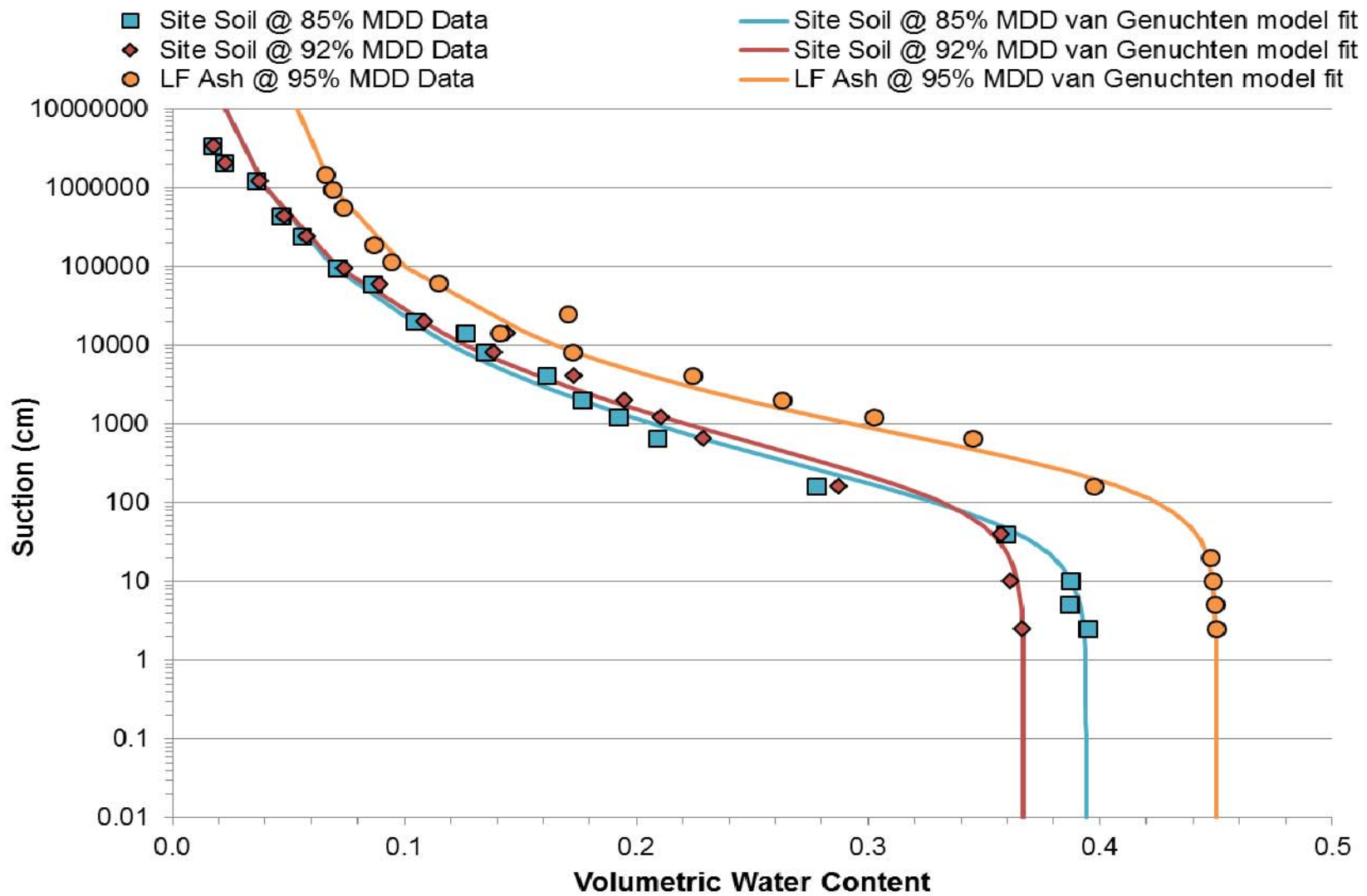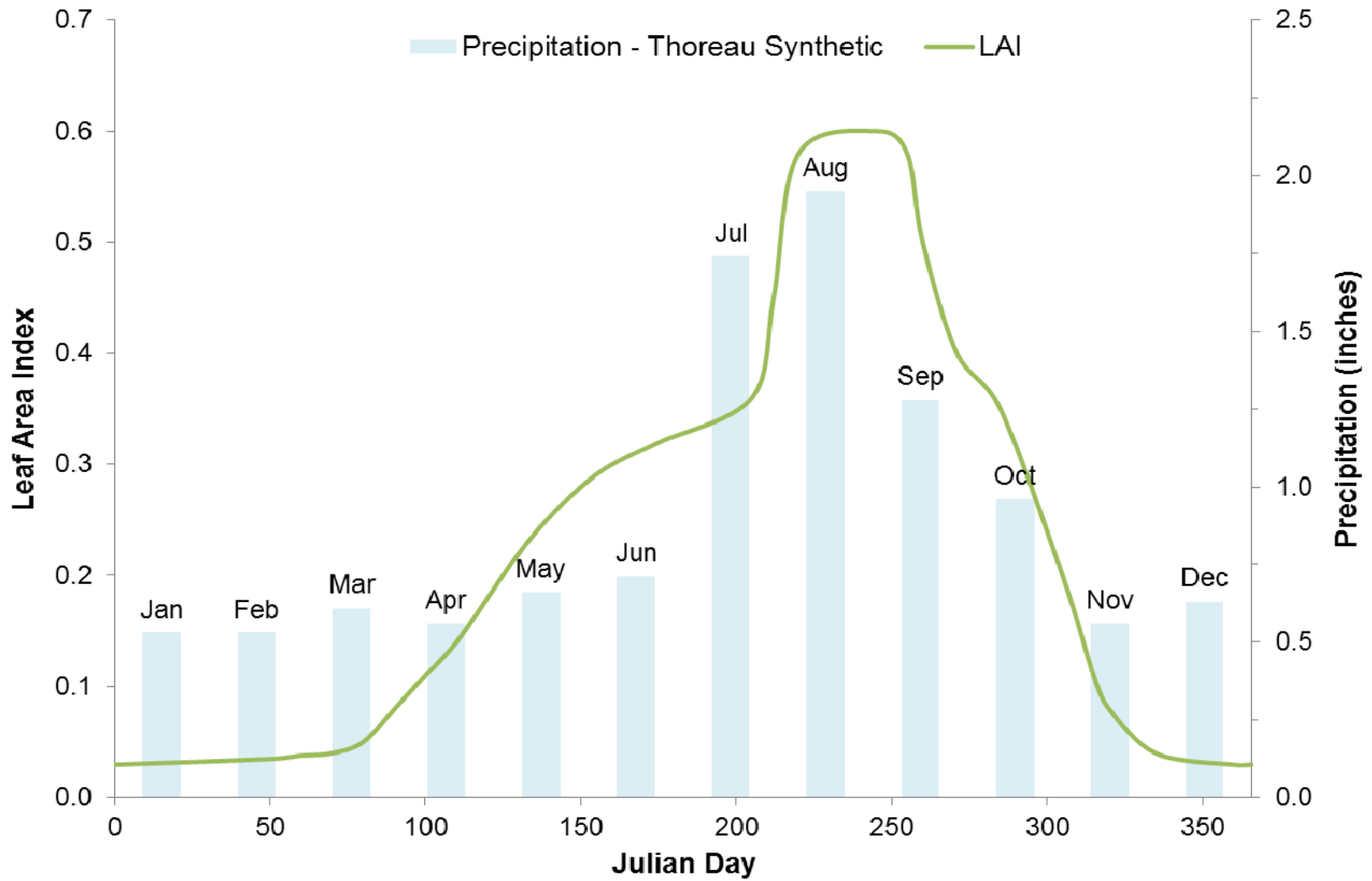
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FIGURES

Figure A-1
Soil Water Characteristic Curves for Soil Layers in the Soil-Atmosphere Model
Escalante Generating Station
Active CCR Landfill Final Cover Soil-Atmosphere Modeling

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Figure A-2
Leaf Area Index for the Soil-Atmosphere Model
Escalante Generating Station
Active CCR Landfill Final Cover Soil-Atmosphere Modeling
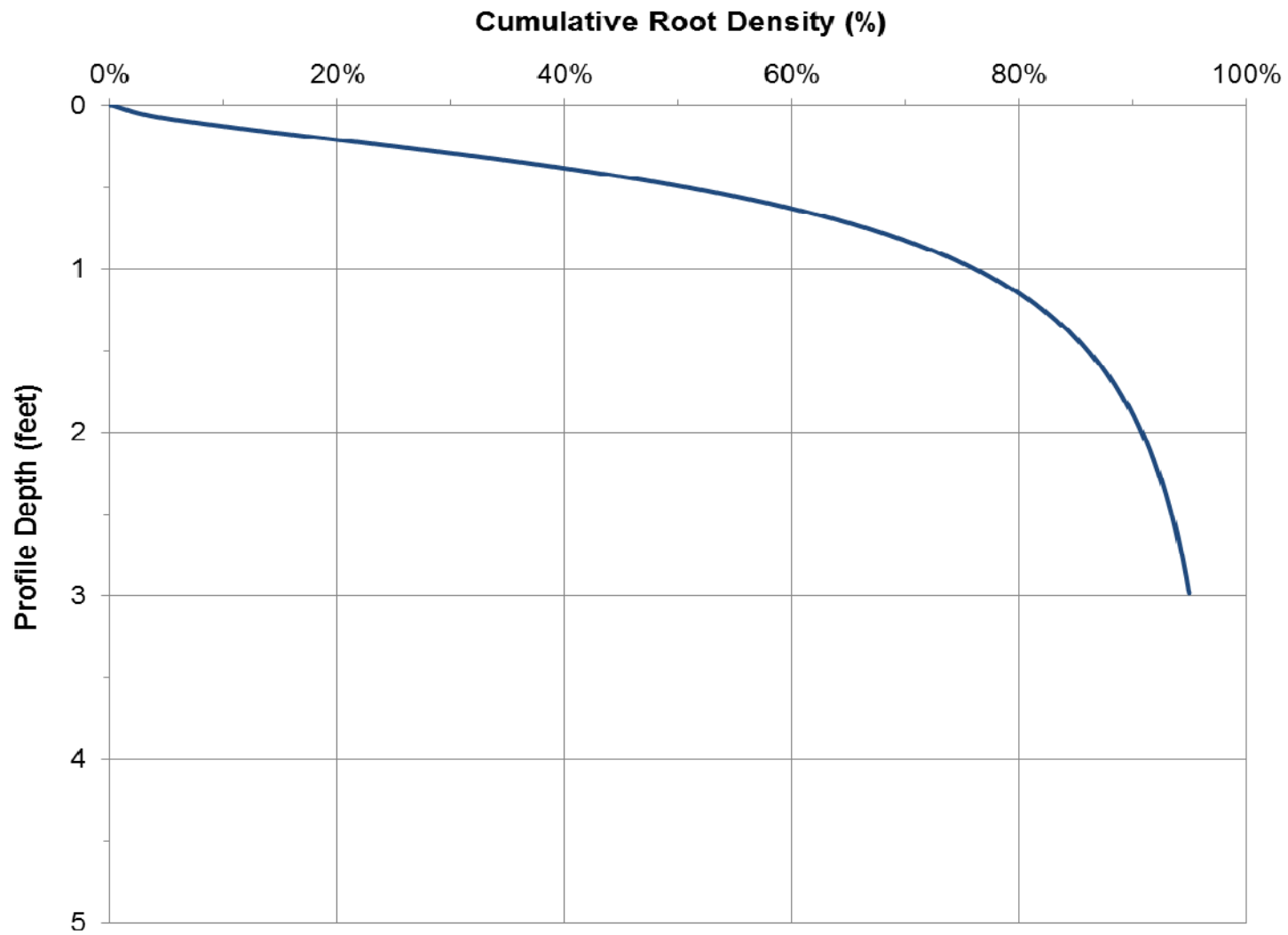**Golder Associates**

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Figure A-3

New Mexico Grassland Average Cumulative Root Distribution

Escalante Generating Station

Active CCR Landfill Final Cover Soil-Atmosphere Modeling

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Note: Roots truncated at base of soil cover at 3 foot depth.

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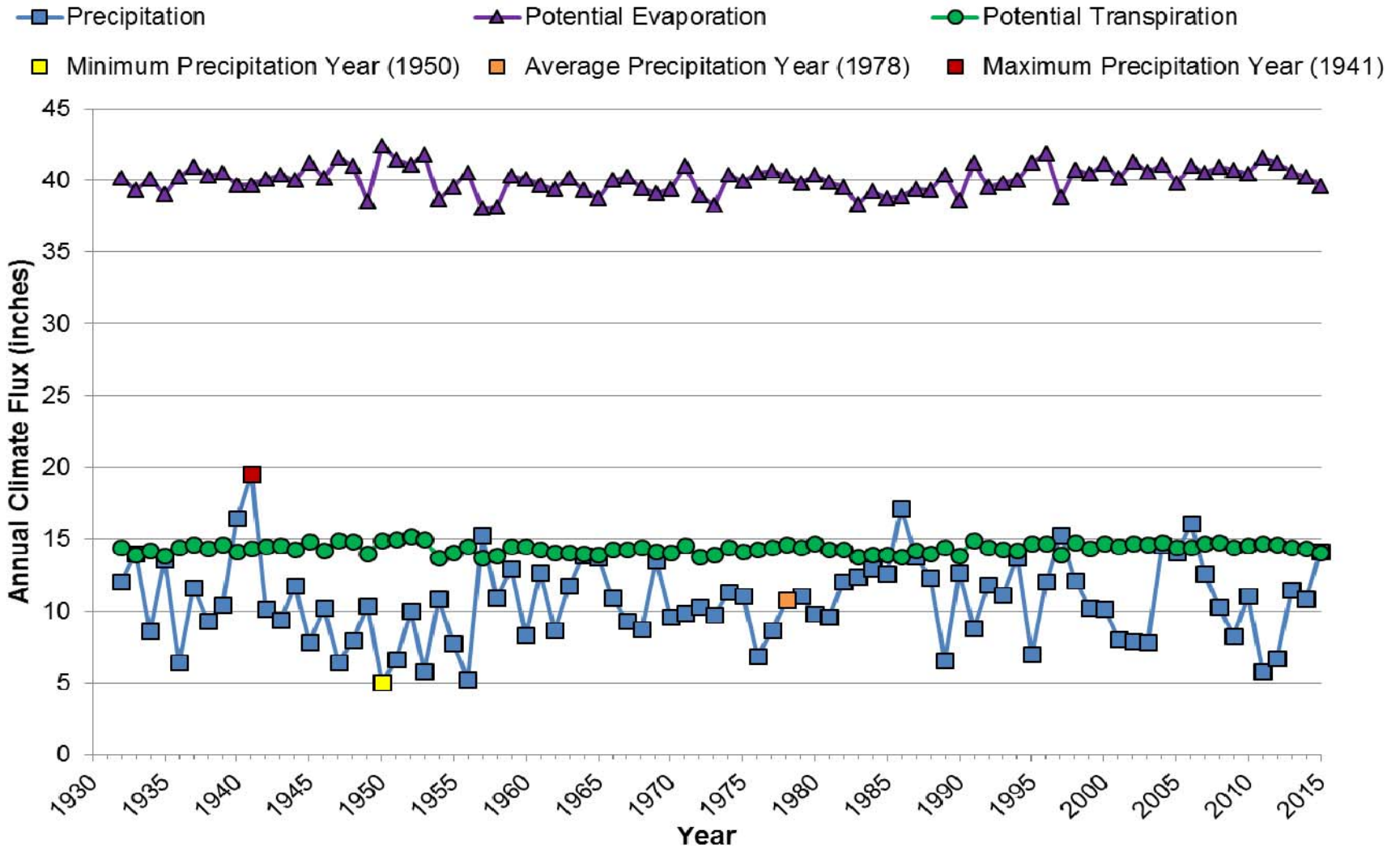
Figure A-4

Annual Precipitation, Potential Evaporation, and Potential Transpiration for the Soil-Atmosphere Model

Escalante Generating Station

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