Run-On and Run-off Control System Plan (2026)

Antelope Valley Station - CCR Landfill

Prepared for
Basin Electric Power Cooperative

Prepared by
Barr Engineering Co.

October 2026

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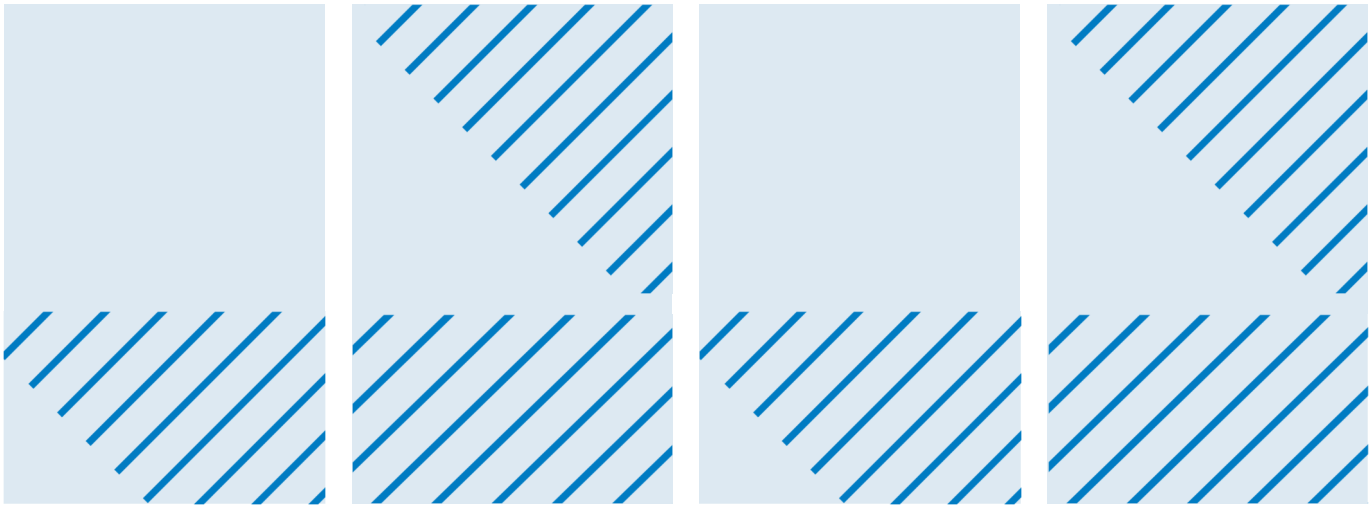
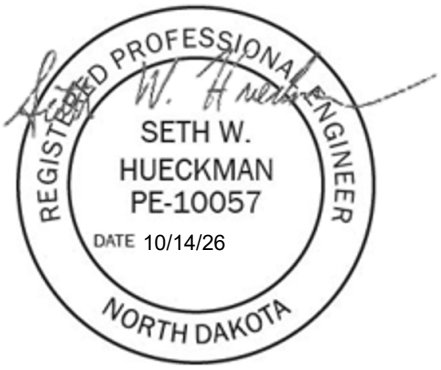


Certification

I hereby certify that I have or my agent has examined the facility and, being familiar with the provisions of NDAC 33.1-20-08, attest that this Coal Combustion Residuals landfill run-on and run-off control system plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and the requirements of NDAC 33.1-20-08-05.2. I certify that the plan is adequate for this facility and that procedures for recordkeeping and reporting have been established.



Seth. W. Hueckman
ND Registration #: PE-10057

10/14/2026
Date

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1 Introduction

Antelope Valley Station (AVS) is a lignite coal-fired power plant consisting of two units that generate about 900 megawatts (MW) combined. The power plant, owned and operated by Basin Electric Power Cooperative (Basin Electric), is located approximately eight miles northwest of Beulah in Mercer County, North Dakota. Coal ash from AVS is disposed at the Section 7 Landfill, regulated as a coal combustion residuals (CCR) landfill under Permit No. 0160 issued by the North Dakota Department of Environmental Quality (NDDEQ). CCR management is subject to the NDDEQ's standards for Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments per North Dakota Administrative code (NDAC) Chapter 33.1-20-08. This CCR run-on and run-off control system plan has been developed to satisfy the requirements described in NDAC 33.1-20-08-05.2, run-on and run-off controls for CCR landfills, as they apply to AVS's Landfill.

The existing landfill was first permitted by the North Dakota Department of Health, now NDDEQ, for solid waste disposal in 1995. The existing landfill currently consists of five cells, Cells 1-5. The first phase of liner construction was completed in 1996 with ash placement beginning the same year. A lined sump was constructed within Cells 1-4 in 2008 for the purpose of capturing run-off water within the landfill; since the last periodic update, this sump has been filled.

Partial sequential closure has been conducted on areas of the existing landfill that have been filled to final grade, with closure construction occurring in 2003, 2011, 2014, and 2016. Approximately 94 acres of the existing landfill is currently active; including Cell 5 and portions of Cells 1-4. Approximately 51 acres of the 103-acre CCR landfill footprint for Cells 1-4 have been closed using an engineered earthen cover system approved by the NDDEQ.

Construction of the most recent lateral expansion, Cell 5, was completed in 2022/2023. The lateral expansion included a composite liner constructed with a compacted clay liner overlain by a 60-mil high density polyethylene (HDPE) geomembrane liner. Future lateral expansions will consist of three additional landfill cells to the north, Cells 6-8, totaling approximately 96 acres. The existing landfill and lateral expansions are considered to be one CCR unit (Cells 1-8). This run-on and run-off control system plan has been developed to satisfy the requirements described in NDAC 33.1-20-08.05.2, run-on and run-off controls for CCR landfills.

2 Objectives

Per NDAC 33.1-20-08.05.2, the owner of an existing or new CCR landfill or any lateral expansion of a CCR landfill is required to design, construct, operate, and maintain a run-on and run-off control system.

In order to fulfill these objectives, the run-on and run-off control system plan must:

- provide documentation that the run-on control system adequately manages flow onto the active portion of the CCR unit during and following the peak discharge from a 25-year, 24-hour storm;
- provide documentation that the run-off control system adequately collects and controls at least the water volume from a 25-year, 24-hour storm;
- define recordkeeping requirements;
- define reporting requirements; and
- include a certification from a qualified professional engineer.

3 Run-on Control System

The purpose of a run-on control system is to prevent surface water from outside the lined CCR storage area from flowing onto the active landfill area. Site grading and existing topography near the landfill prevents surface drainage run-on onto the active portion of the CCR unit for events up to and exceeding a 25-year, 24-hour storm. Figure 1 shows that the proposed landfill perimeter dikes are elevated above the surrounding topography and that the surrounding area drains away from the landfill, with arrows added to illustrate surface drainage outside of the landfill.

The fully vegetated and closed portions of the landfill are graded to direct surface run-off to the nearest edge of the landfill, and then offsite to surrounding existing drainage systems. Undeveloped areas within the permit area have not been impacted and pre-existing drainage paths remain in place.

4 Run-off Control System

The purpose of a run-off control system is to prevent water that has come into contact with ash from draining offsite. All ash-contact surface water will be contained within the active areas of the landfill and leachate pond. Ash-contact water generated from the active areas of the landfill is controlled within the limits of the existing landfill through grading and ditches that route run-off from active landfill areas to the lined sump constructed within Cell 5. The ash-contact water and leachate generated from future Cells 6-8 will also be controlled within the lined limits of the landfill via additional ditches and lined sumps. Surface run-off will be intercepted in perimeter ditches and directed into the leachate collection system as described in this section and as illustrated on Figure 1. While the systems described in this plan will be used to control contact water run-off, site conditions at any given time during landfill develop may vary somewhat from the general layouts shown in this plan; however, AVS will implement control systems to manage contact surface water run-off consistent with this plan.

Site hydrology and hydraulics were modeled using HydroCAD Version 10.020-5c and Soil Conservation Service (SCS) methods. The design storm for the run-off control system is the 25-year, 24-hour storm event, which has a rainfall depth of 3.62 inches (reference: NOAA Atlas 14). Hydrology calculations are included in Appendix A.

Precipitation events typically produce minimal observed surface run-off from the approximately 52 acres of active landfill in Cells 1-4. Instead, water rapidly infiltrates and is held in the dry ash until it evaporates or is bound to the ash mass through chemical reaction. A lined sump was maintained within the limits of Cells 1-4, to collect any runoff from Cells 1-4 that did occur. As filling of Cells 1-4 progressed and the open area within Cells 1-4 was reduced, this lined sump was covered with ash and is no longer in use. Placed ash in this footprint is graded to direct any surface runoff towards the lined expansion cell's perimeter ditches, where it is managed by the leachate collection sump.

Run-off from the surface of the active landfill will generally flow to the north, east and west perimeters. An interior perimeter ditch within the landfill and around the edge of the active face will be maintained to intercept ash-contact water and keep it from draining outside the lined limits of the landfill. Water that reaches the perimeter ditches will infiltrate into the drainage layer. The interior perimeter ditch length has an estimated length of 6,000 feet, which includes the total length of the west, north, and east sides of the open area (approximately 95 acres). The cross-sectional flow area of the interior perimeter ditch needs to be a minimum of 54 square feet to store the run-off captured from the 95 acres of open area (maximum open area) from the CCR landfill until the water infiltrates into the drainage layer. A minimum ditch depth

of 5 feet with 3 horizontal to 1 vertical (3H:1V) side slopes has been calculated to provide the required storage.

Water in the drainage layer will drain to and will be collected in leachate pipes that, in turn, drain to leachate sumps. The leachate collected in the sumps is then pumped to the leachate pond on the west side of the landfill expansion area.

5 Recordkeeping & Reporting

According to NDAC 33.1-20-08-05.2.c(2), Basin Electric will amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan. Additionally, Basin Electric will prepare periodic updates to the plan every five years (minimum).

Basin Electric will maintain a copy of the most recent version of the run-on and run-off control system plan in the facility's operating record, the plan will be made publicly available on the Basin Electric CCR web site, and Basin Electric will notify the NDDEQ State Director in compliance with the requirements of NDAC 33.1-20-08-08: Recordkeeping, notification, and posting of information to the internet.

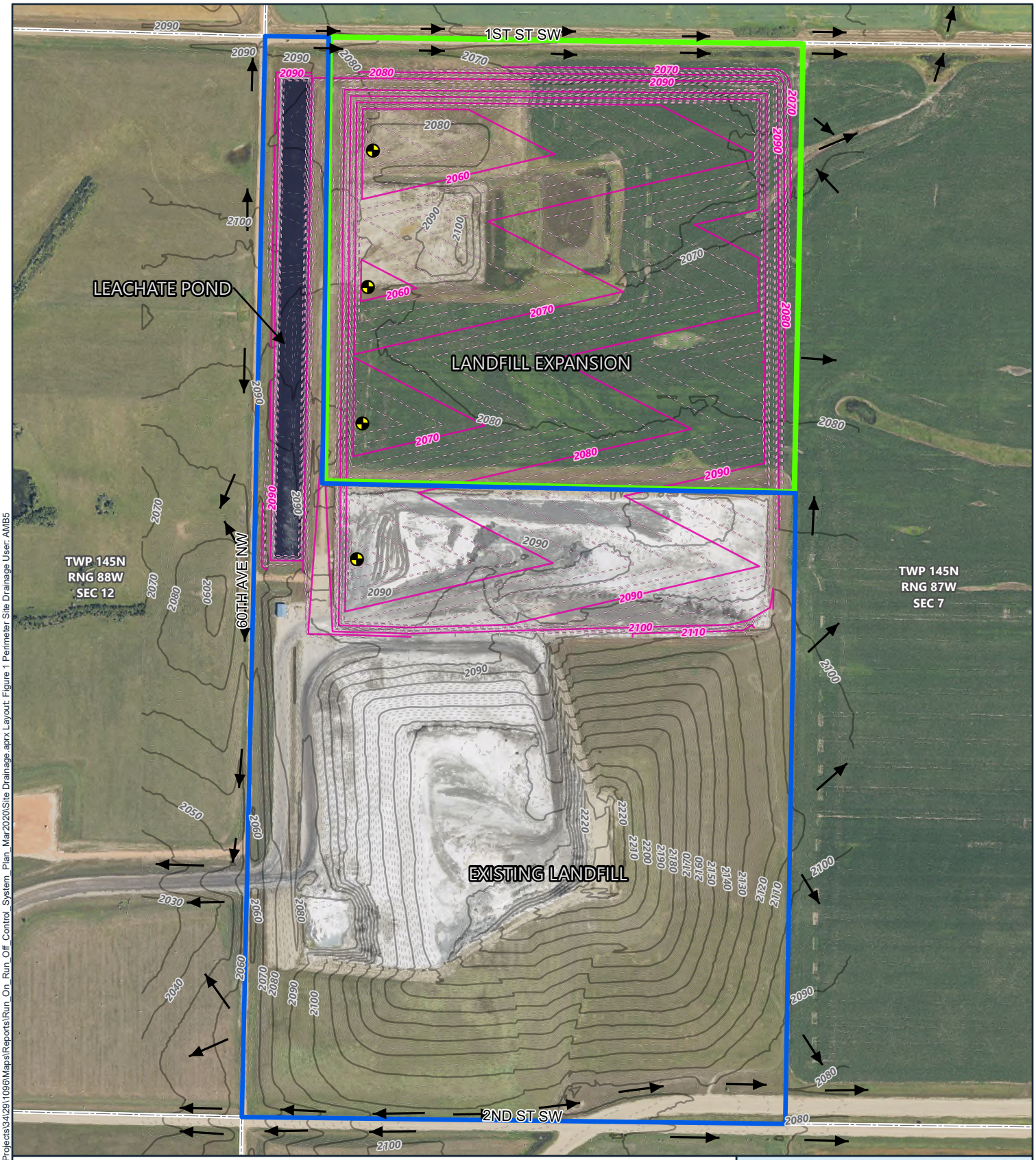
6 References

Barr, 2021. Coal Combustion Residual Landfill Run-On and Run-Off Control System Plan, Basin Electric Power Cooperative Antelope Valley Station, October 2021.

Basin, 2016. Coal Combustion Residual Landfill Run-On and Run-Off Control Plan, Basin Electric Power Cooperative Antelope Valley Station, October 2016.

NOAA Atlas 14 Point Precipitation Frequency Estimates: North Dakota. National Weather Service. https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nd. Accessed September 30, 2026

Figures



Landfill Expansion
Existing Landfill Limits
Public Land Survey Section
Leachate Collection Sump
Flow Direction

Existing 10-foot Contour
Existing 2-foot Contour
Proposed Liner 10-foot Contour
Proposed Liner 2-foot Contour

Imagery: USDA-FSA NAIP (2025)

N

0 300 600
Feet

Note: Elevations are in the NGVD29 datum.

Perimeter Site Drainage
Basin Electric Power Cooperative
Antelope Valley Station Landfill
Mercer County, North Dakota

FIGURE 1

BARR

Bar Footer: ArcGISPro 3.7.1, 2026-09-30 12:27 File: I:\Projects\34\29\11096\Maps\Reports\Run_On_Run_Off_Control_System_Plan_Mar2020\Site Drainage.aprx Layout: Figure 1 Perimeter Site Drainage User: AMB5

Appendix A

HydroCAD Report and Calculations

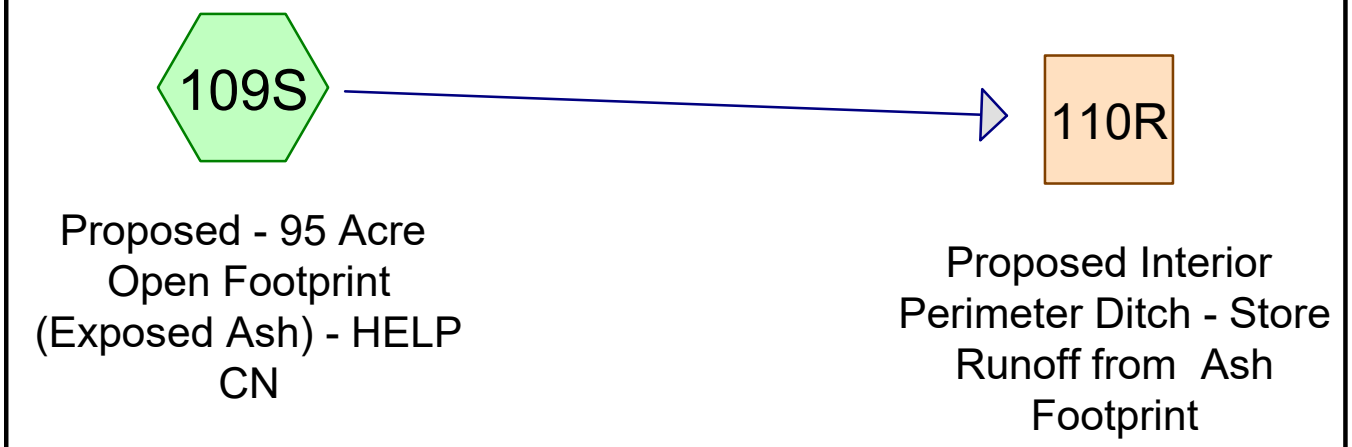
AVS CCR Landfill Run-on/Run-off Calculations (Interior Perimeter Ditch Required Capacity)

Total Runoff Volume and Drainage Layer Infiltration Computations

Item	Quantity	Notes:
Area (ac) =	95	
Ash Curve Number =	**82**	Note: Used 81.6 from HELP model and HydroCAD rounded to 82
Time of Concentration (min) =	8.6	Note: Used 100' length for sheet flow at a land slope of 4%, Used 560' and 4% shallow concentrated flow component
Total Runoff Volume (acre-feet) =	14.9	
Total Runoff Volume (cubic feet) =	649,043	
Interior Perimeter Ditch Length (ft) =	6,000	Note: Assume 3 active cells open, perimeter ditches on the East, North and West sides draining towards leachate collection sumps
Channel Depth (ft) =	5	
Channel Sideslopes (H:V) =	3:1	
Channel Inlet Invert El (ft) =	2,090.0	
Channel Outlet Invert El (ft) =	2,084.0	
Channel Slope % =	0.1	
Slope Length with Exposed Sand Layer (ft)	5.83	
Exposed Sand Layer Surface Area (ft^2)	34,980	
Sand Drainage Layer Infiltration (Referred to as Exfiltration Rate in HydroCAD (cfs)) =	**11.48**	Note: This is assumed as the hydraulic conductivity of the sand layer (k = 1 x 10^{-2} cm/s) multiplied by the exposed leachate collection system sand layer surface area in the in the channel.

Note: HydroCAD was used to calculate runoff volume minus exfiltration and then hand computations below were used to size interior perimeter ditch.

Item	Quantity	Notes:
Runoff Volume Minus Exfiltration (acre-feet) =	7.42	
Runoff Volume Minus Exfiltration (cubic feet) =	323,214	
Perimeter Ditch Length (ft) =	6,000	
Required Ditch Cross Section Area (ft^2) =	**53.9**	This was computed by taking the runoff volume minus exfiltration divided by the perimeter ditch length.
Channel Bottom Width (ft) =	0	
Channel Depth (ft) =	5	
Channel Sideslopes (H:V) =	3:1	
Designed Channel Cross-Section Area (ft^2) =	**75**	
Total Ditch Storage Capacity (cubic feet) =	**450,000**	
Remaining Ditch Capacity During 25-Year Storm (cubic feet) =	**126,786**	This was computed by taking the total ditch storage capacity minus the 25-year/24-hour runoff volume minus exfiltration (runoff that drains into leachate collection system drainage layer)



Note: Interior ditch geometry shown in this HydroCAD model was arbitrarily selected and is not consistent with the designed ditch geometry. The purpose of developing this model was to calculate the volume of runoff the interior perimeter ditch must store from a 25-year/24-hour precipitation event.

Subcat Reach Pond Link

Routing Diagram for Basin SW-Interior Perimeter Ditch _Oct 2026
Prepared by Barr Engineering, Printed 10/2/2026
HydroCAD® 10.20-5c s/n 00604 © 2023 HydroCAD Software Solutions LLC

Summary for Subcatchment 109S: Proposed - 95 Acre Open Footprint (Exposed Ash) - HELP CN

Runoff = 285.84 cfs @ 12.00 hrs, Volume= 14.900 af, Depth= 1.88"
Routed to Reach 110R : Proposed Interior Perimeter Ditch - Store Runoff from Ash Footprint

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=3.62"

Total Runoff Volume from 25-yr/24-hr Storm

	Area (ac)	CN	Description
*	95.000	82	HELP Model CN
	95.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	100	0.0400	0.43		**Sheet Flow, Sheet flow towards ditch - max 100'** Fallow n= 0.050 P2= 2.01"
4.7	560	0.0400	2.00		**Shallow Concentrated Flow, Shallow concentrated flow toward ex** Nearly Bare & Untilled Kv= 10.0 fps
8.6	660	Total			

Summary for Reach 110R: Proposed Interior Perimeter Ditch - Store Runoff from Ash Footprint

Inflow Area = 95.000 ac, 0.00% Impervious, Inflow Depth = 0.94" for 25-yr event
Inflow = 274.36 cfs @ 12.00 hrs, Volume= 7.422 af, Incl. 11.48 cfs Inflow Loss
Outflow = 89.24 cfs @ 12.16 hrs, Volume= 7.421 af, Atten= 67%, Lag= 9.3 min

Runoff Volume from 25-yr/24-hr Storm After Including Drainage Losses into Exposed Leachate Collection System Sand Layer

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.83 fps, Min. Travel Time= 35.4 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 220.8 min

Peak Storage= 189,390 cf @ 12.16 hrs
Average Depth at Peak Storage= 2.64' , Surface Width= 19.87'
Bank-Full Depth= 4.00' Flow Area= 64.0 sf, Capacity= 230.15 cfs

4.00' x 4.00' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 3.0 '/' Top Width= 28.00'
Length= 6,000.0' Slope= 0.0010 '/'
Inlet Invert= 2,092.60', Outlet Invert= 2,086.60'