Prepared for

Santee Cooper
One Riverwood Drive
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INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN – ASH POND A

WINYAH GENERATING STATION

Prepared by

Geosyntec consultants

engineers | scientists | innovators

104 South Main Street, Suite 115
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Project Number: GSC5242

October 2016

INTRODUCTION

Winyah Generating Station (WGS or the Site) is a 1,260 megawatt coal-fired steam electric generating facility owned and operated by South Carolina Public Service Authority (Santee Cooper). The Site is situated between Pennyroyal and Turkey Creeks and is located at 661 Steam Plant Drive in Georgetown, South Carolina. Coal combustion residuals (CCR) generated at WGS have been historically managed in existing CCR surface impoundments.

In response to the recently published CCR Rule (40 Code of Federal Regulations (CFR) Part 257), South Carolina Public Service Authority (Santee Cooper) retained Geosyntec Consultants, Inc. (Geosyntec) to prepare documentation for existing surface impoundments (SIs) at WGS. Pursuant to Section 257.82(c) of the CCR Rule, Geosyntec Consultants (Geosyntec) prepared this Inflow Design Flood Control System Plan for Ash Pond A at WGS.

Section § 257.82(a) of the Rule states that "*The owner or operator of an existing or new CCR surface impoundment or any lateral expansion of a CCR surface impoundment must design, construct, operate, and maintain an inflow design flood control system as specified in paragraphs (a)(1) and (2) of this section.*" The Preamble to the CCR Rule provides guidance on the documentation that should be provided for the Inflow Design Flood Control System Plan.

The inflow design flood control system for Ash Pond A at the Site consists of maintaining minimum operating freeboards for the SI. Justification and documentation of the adequacy of the inflow design flood control systems are presented in the sections below.

The work presented in this report was performed under the direction of Mr. C. Fabian Benavente, P.E., of Geosyntec in accordance with §257.82(c).

SURFACE IMPOUNDMENT DESCRIPTION

Ash Pond A, encompassing approximately 90 acres (ac), is located east of the power block. Ash Pond A is bounded by the Intake Canal to the north, the Cooling Pond to the east, Ash Pond B to the south, and the Discharge Canal to the west. Ash Pond A is separated from Ash Pond B by a divider dike, which traverses from west to east from the Discharge Canal to the Cooling Pond. Ash Pond A is bounded by perimeter dikes ranging from 20.0 feet (ft) to 24.5 ft to the east and 12.0 ft to 15.0 ft to the north (Thomas and Hutton, 2012). The minimum crest elevation of the Ash Pond A perimeter dikes is 38.8 ft National Geodetic Vertical Datum of 1929 (NGVD 29) (Thomas and Hutton, 2012). A Site Map including the surface impoundments and hydraulic features associated with Ash Pond A is provided in **Figure 1**.

Ash Pond A currently receives fly ash sluice, bottom ash sluice and boiler slag, and low volume wastewater from the existing coal-fired electric generating units. **Table 1** presents process water inflows into Ash Pond A. Ash Pond A also receives contact stormwater from the Unit 2 Slurry Pond. The Unit 2 Slurry Pond is equipped with a 6JSVE Thompson pump operating at a maximum capacity of 2,600 gallons per minute (gpm).

Table 1. Flow rates of process water conveyed to the Ash Pond A (Santee Cooper, 2015)

Process Water	Flow Rate (GPM)
Units 1 and 2 Hydroveyor Wastewater	3,364
Units 1 and 2 Low Volume Wastewater	550
Units 1 and 2 Bottom Ash Sluice Water	725
Units 3 and 4 Bottom Ash Sluice Water	1,460

Ash Pond A does not have an outfall structure but routes water southward through rim ditches and culverts to Ash Pond B. Ash Ponds A and B are hydraulically connected through a 30 inch (in.) diameter corrugated metal pipe (CMP), a 48 in. diameter smooth steel pipe, and a 42 in. diameter smooth steel pipe (Thomas and Hutton, 2016; Thomas and Hutton, 2012). In September 2016, Santee Cooper submitted a permit application to construct a spillway between the existing outlet pipes on the divider dike between Ash Pond A and Ash Pond B. The spillway with a base width of 100 ft., 10H:1V side slopes, and an invert elevation of 37 ft. NGVD29, will be constructed as soon as approval is received. This work is expected to be completed in October, 2016. Operational Plans are in place in case the design storm event occurs before the construction of the spillway is completed.

The operating level in Ash Pond B is maintained by a concrete riser structure with a top stop log elevation of 34.90 ft NGVD 29 (Thomas and Hutton, 2016). A 24 in. diameter smooth interior, corrugated exterior high density polyethylene pipe culvert with a downstream invert elevation of 17.99 ft NGVD 29 conveys water from the riser structure to the Discharge Canal of the Cooling Pond (Santee Cooper, 2012b; Thomas and Hutton, 2016). The average operating elevation provided by the Site from February 2011 through January 2016 is 34.1 ft (Santee Cooper, WGS, 2016).

CATCHMENT AREAS AND DESIGN STORM EVENT

During the design storm event Ash Ponds A and B will effectively operate as a single pond as the culverts and spillway provide a hydraulic connection between the ponds. The contributing watershed areas for Ash Ponds A and B are 90.6 ac and 65.7 ac, respectively. These areas were delineated using the dike crests to correspond to the ponds' direct drainage areas. A description of drainage areas is included in the Hydrologic and Hydraulic Analysis report, provided in Appendix A. Since Ash Pond A is classified as a low hazard potential surface impoundment (Geosyntec, 2016), the inflow design flood is the 100-year storm event.

STORAGE CAPACITIES

The available stormwater storage volume of Ash Pond A between elevations 34.0 ft and 38.8 ft NGVD 29 was calculated by developing an area-volume curve based on topographic data (Thomas and Hutton, 2012; Thomas and Hutton, 2016). The lowest contour surveyed within Ash Pond A is 34.0 ft NGVD 29. The minimum crest elevation of the Ash Pond A perimeter dikes is 38.8 ft NGVD 29. The surface area of each contour was measured and tabulated at each elevation. The available surface water volume in each 2 ft depth increment was calculated by averaging the surface area of the upper and lower contour and multiplying by the change in elevation between each contour. The cumulative storage volume of Ash Pond A between these elevations is 12.5 acre-feet (ac-ft). The area-volume data are presented in Appendix A.

Similarly, the available stormwater storage volume of Ash Pond B between elevations 34.0 ft and 39.7 ft NGVD 29 was calculated by developing an area-volume curve based on topographic and bathymetric data (Thomas and Hutton, 2012; Thomas and Hutton, 2016). The lowest contour surveyed within Ash Pond B is 34.0 ft NGVD 29 (note a bathymetric survey has not been completed for Ash Pond B and the normal operating water level is 33.8 ft). The minimum crest elevation of the Ash Pond B perimeter dikes is 39.7 ft NGVD 29. The surface area of each contour was measured and tabulated at each elevation. Next, the available surface water volume at each 2 ft depth increment was calculated by averaging the surface area of the upper and lower contour and multiplying by the change in elevation between each contour. The cumulative storage volume of Ash Pond B between these elevations is 220.3 ac-ft. The area-volume data are presented in Appendix A.

HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic and hydraulic analysis of Ash Ponds A and B were performed using *HydroCAD Version 10.0* software (HydroCAD, 2011). Process water and stormwater inflows into Ash Pond A, and outflows from Ash Pond B to the Cooling Pond via the Discharge Canal were used to compute maximum water elevation during the design storm event. Tailwater effects associated with discharge from Ash Pond B to the Discharge Channel were modeled using a fixed water surface elevation within the Discharge Channel and Cooling Pond. Appendix A presents the Hydrologic and Hydraulic analysis report and documents assumptions, rainfall abstractions, drainage areas, and model results.

ROUTING RESULTS

During the design storm event. Ash Ponds A and B will effectively operate as a single pond as the culverts and spillway provide a hydraulic connection between the ponds. As currently operated, Ash Pond A will not contain the 100 yr storm event. Ash Pond A does not have an existing emergency spillway. The construction of a spillway on the divider dike between Ash Ponds A and B is required to convey stormwater from Ash Pond A to Ash Pond B so the ponds contain the 100 yr storm event. A proposed spillway is included in the *HydroCAD* model and report (Appendix A). The spillway is currently under construction. Operational Plans are in place in case the design storm event occurs before the construction of the spillway is completed.

Ash Pond A contains the 72 hr, 100 yr storm event given the following assumption:

- Santee Cooper will construct a 100 ft wide spillway with an invert elevation of 37.0 ft NGVD 29 in the divider dike between Ash Ponds A and B. The spillway will be constructed with 10H:1V (Horizontal:Vertical) side slopes and will be located between the 48 in. diameter smooth steel pipe and the 42 in. diameter smooth steel pipe.

The resulting peak water surface elevation in Ash Pond A during the 100-yr storm event based on the hydraulic and hydrologic analysis (Appendix A) is shown in **Table 2**. Ash Pond A will effectively contain the 100-yr storm event and maintain a freeboard of 0.6 feet.

Table 2 – Peak Elevations and Freeboard

Event	*Elevation (NGVD 29) (ft)*	*Free Board (ft)*
Normal Operating Condition	34.90	3.9
100-Yr, 72-Hr	38.13	0.67

CERTIFICATION

This inflow design flood control system plan meets the requirements of this section (§257.82 Hydrologic and hydraulic capacity requirements for CCR impoundments.) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering, and no other warranty is provided in connection therewith. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Santee Cooper. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others. Although we were not able to independently verify such data, we did evaluate it to determine whether it was consistent with other information that we developed in the course of our performance of the scope of services.

Certified by:

Carlos F. Benavente Date 10/12/2016

C. Fabian Benavente, P.E. South Carolina License Number 32067
Senior Engineer

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Thomas and Hutton. (2016). *Topographic Survey of the Dike Crests at Santee Cooper Winyah Generating Station.*

FIGURES

LEGEND

POND BOUNDARY

0 500' 1000'

SCALE IN FEET

WINYAH GENERATING STATION
SITE MAP

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FIGURE 1

PROJECT NO: GSC5242

MARCH 2016

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APPENDIX A

Hydrologic and Hydraulic Analysis – Ash Pond A

Geosyntec consultants

COMPUTATION COVER SHEET

Client: **Santee Cooper** Project: **Winyah Generating Station** Project/ Proposal No.: **GSC5242** Task No. **01**

Title of Computations **Hydrologic and Hydraulic Analysis: Ash Pond A**

Computations by:	Signature	Sarah M. Herr	2/10/16
	Printed Name	Sarah Herr	Date
	Title	Senior Staff Engineer	
Assumptions and Procedures Checked by: (senior reviewer)	Signature	Brianna L. Wallace	10/11/16
	Printed Name	Brianna Wallace	Date
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Computations, Assumptions, and Procedures Checked by: (peer reviewer)	Signature	[signature]	10/11/16
	Printed Name	Hari Parthasarathy	Date
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Computations backchecked by: (originator)	Signature	Sarah M. Herr	10/11/16
	Printed Name	Sarah Herr	Date
	Title	Senior Staff Engineer	
Approved by: (pm or designate)	Signature	Brianna L. Wallace	10/11/16
	Printed Name	Brianna Wallace	Date
	Title	Senior Engineer	

Approval notes:

Revisions (number and initial all revisions)

No.	Sheet	Date	By	Checked by	Approval

Geosyntec consultants

Written by:	S. Herr	Date:	10/11/16	Reviewed by:	B. Wallace	Date:	10/11/16
Client:	Santee Cooper	Project:	Winyah Generating Station	Project/ Proposal No.:	GSC5242	Task No.:	01

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Client:	**Santee Cooper**	Project:	**Winyah Generating Station**	Project/ Proposal No.:	**GSC5242**	Task No.:	**01**

PURPOSE AND BACKGROUND

Winyah Generating Station (WGS or the Site) is a coal-fired, electric generating facility located in Georgetown County, South Carolina. The Site is located between Pennyroyal and Turkey Creeks, tributaries to the Sampit River, and is approximately four miles southwest of Georgetown.

The purpose of this computation package is to evaluate the hydraulic capacity of Ash Pond A to support spillway capacity assessment requirements, static factor of safety analyses, and hazard rankings required by the United States Environmental Protection Agency's (USEPA's) Coal Combustion Residual (CCR) Rule. Ash Pond A is regulated by the CCR Rule as an existing CCR surface impoundment. Under the CCR Rule, a low hazard ranking classification is associated with the 100 year (yr) precipitation event. Since Ash Pond A is a low hazard surface impoundment, the 100 yr storm frequency is analyzed herein.

Ash Pond A, encompassing approximately 90 acres (ac), is located east of the power block. Ash Pond A is bounded by the intake canal to the north, the Cooling Pond to the east, Ash Pond B to the south, and the Discharge Canal to the west. Ash Pond A is separated from Ash Pond B by a divider dike, which traverses from west to east from the Discharge Canal to the Cooling Pond. Ash Pond A is bounded by perimeter dikes ranging from 20.0 feet (ft) to 24.5 ft high on the east to 12.0 ft to 15.0 ft high on the north (Thomas and Hutton, 2012). The minimum crest elevation of the Ash Pond A perimeter dikes is 38.8 ft National Geodetic Vertical Datum of 1929 (NGVD 29) (Thomas and Hutton, 2012). A Site Map including the surface impoundments and hydraulic features associated with Ash Pond A is provided in **Figure 1**.

Ash Pond A currently receives fly ash sluice, bottom ash sluice and boiler slag, and low volume wastewater from the existing coal-fired electric generating units, as well as contact stormwater from the Unit 2 Slurry Pond. Ash Pond A does not have an outfall structure but routes water southward through rim ditches and culverts to Ash Pond B. Ash Ponds A and B are hydraulically connected through a 30 inch (in.) diameter corrugated metal pipe (CMP), a 48 in. diameter smooth steel pipe, and a 42 in. diameter smooth steel pipe (Thomas and Hutton, 2016; Thomas and Hutton, 2012).

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METHODOLOGY

Stormwater runoff volumes and associated discharges to Ash Ponds A and B were modeled using *HydroCAD Version 10.0* software (HydroCAD, 2011). *HydroCAD* utilizes frequency-based precipitation events, in conjunction with watershed properties, to calculate peak runoff by several accepted methods. The Soil Conservation System (SCS) Technical Release 20 (TR-20) method was applied in *HydroCAD* to calculate stormwater runoff volumes (SCS, 1982).

The following parameters and assumptions were selected for calculating stormwater runoff volumes for Ash Ponds A and B.

Rainfall

The 72 hour (hr) duration precipitation event was used in this analysis. The rainfall depth corresponding to the 72 hr duration precipitation event for the 100 yr frequency return period for the Site is 12.8 in. (NOAA, 2006). The design storm hyetograph was developed using SCS Type III rainfall distribution and was directly input into the *HydroCAD* model.

Drainage Areas and Curve Numbers

The contributing watershed areas for Ash Ponds A and B are 90.6 ac and 65.7 ac, respectively. These areas were delineated using the dike crests to correspond to the ponds' direct drainage areas. Each pond was assigned a curve number (CN) based on guidance provided in Technical Release 55 (TR-55) (SCS, 1986) representing the type of ground cover in that area. Ash Ponds A and B were assumed to be 90% CCR and 10% water (Weighted CN = 87) (Santee Cooper, 2012a). The contributing watershed areas and CNs are summarized in **Table 1** and were directly input to the *HydroCAD* model.

Time of Concentration and Open Channel Flow Calculations

The time of concentration represents the time required for runoff to flow from the most hydraulically remote point of the drainage area to the point under investigation. The flow path from the most remote point within Ash Pond A is characterized by sheet flow and channel flow (shown in **Figure 2**).

HydroCAD applied the Overton and Meadows formulation to calculate travel time for sheet flow for distances less than 300 ft (NRCS, 2010):

$$T_t = \frac{0.007(nL)^{0.8}}{P_{2-24}^{0.5} S^{0.4}}$$

where: T_t = travel time for over land sheet flow (hr);

n = Manning's roughness coefficient for sheet flow (--);

L = flow length (ft);

$P_{2\text{-}24}$ = 2 yr, 24 hr rainfall (in.); and

S = slope of hydraulic grade line (or land slope) (feet per feet [ft/ft]).

A Manning's roughness coefficient of 0.020 was used to represent sheet flow in Ash Pond A. The rainfall depth for the 2 yr, 24 hr frequency storm event is 4.38 in. (NOAA, 2006). The parameters used to model sheet flow within Ash Pond A are shown in **Table 2**.

Open channel flow travel time was calculated as:

$$T_t = \frac{L}{V}$$

where: T_t = travel time (seconds [s]);

L = flow length (ft); and

V = average velocity (feet per second [ft/s]).

The open channel flow velocity was calculated using Manning's equation. The average velocity was computed assuming bank-full elevation as:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where: V = average velocity (ft/s);

n = Manning's roughness coefficient (--);

R = hydraulic radius (ft); and

S = slope of hydraulic grade line (or longitudinal channel slope for normal flow conditions) (ft/ft).

A Manning's roughness coefficient of 0.020 was used to represent open channel flow in Ash Pond A. Channel dimensions were estimated using topographic data, and these dimensions are summarized in **Table 3** (Thomas and Hutton, 2012). The hydraulic radius was computed as:

$$R = \frac{A}{P_w}$$

where: R = hydraulic radius (ft);

A = cross sectional flow area (square feet [sq ft]); and

P_w = wetted perimeter (ft).

The cross sectional flow area was calculated by:

$$A = (B + DZ)D$$

where: A = cross sectional flow area (sq ft);

B = bottom width of the channel (ft);

D = depth of the channel (ft); and

Z = side slope of the channel (horizontal run divided by vertical rise) (ft/ft).

The wetted perimeter was calculated by:

$$P_w = B + 2D\sqrt{1 + Z^2}$$

where: P_w = wetted perimeter (ft);

B = bottom width of the channel (ft);

D = depth of the channel (ft); and

Z = side slope of the channel (horizontal run divided by vertical rise (ft/ft).

The parameters used to describe open channel flow in Ash Pond A are presented in **Table 2**. The computed times of concentration for Ash Pond A are summarized in **Table 4**.

Flow within Ash Pond B is characterized entirely as open channel flow (shown in **Figure 3**). Open channel flow within Ash Pond B was characterized using the method previously described for Ash Pond A. The flow velocity was calculated using Manning's equation. A Manning's roughness coefficient of 0.020 was used to represent open channel flow in Ash Pond B. Channel dimensions were estimated using topographic data, and these dimensions are summarized in **Table 3** (Thomas and Hutton, 2012). The parameters used to describe flow within Ash Pond B are presented in **Table 2**. The resulting time of concentration is presented in **Table 4**.

Inflows

In the *HydroCAD* model, stormwater inflows associated with Ash Ponds A and B are represented by Sub-Catchments 1S and 2S, respectively. Ponds 3P and 4P represent Ash Ponds A and B, respectively. In addition to direct stormwater inflow, Ash Pond A receives contact stormwater from the Unit 2 Slurry Pond. As shown in **Figure 4**, the Unit 2 Slurry Pond is equipped with a 6JSVE Thompson pump (Thompson Pump, 2016). The maximum pump capacity, 2,600 gallons per minute (gpm) (5.79 cubic feet per second [cfs]), is utilized in the *HydroCAD* model since the design operating point is unavailable. This base flow is modeled as Node 5L in *HydroCAD* and contributes to the inflow to Pond 3P.

Ash Pond A also receives Units 1 and 2 low volume wastewater (550 gpm), Units 1 and 2 hydroveyor water and fly ash sluice (3,364 gpm), Units 1 and 2 bottom ash sluice water (725 gpm), and Units 3 and 4 bottom ash sluice water (1,460 gpm). The base flow considers process water when all four units are operational, resulting in an inflow of 6,099 gpm (13.59 cfs) (Santee Cooper, 2015). This base flow is modeled as Node 6L in *HydroCAD* and contributes to the inflow to Pond 3P. The *HydroCAD* model routing diagram is provided in **Appendix A**.

Storage Capacities

The available stormwater storage volume of Ash Pond A between elevations 34.0 ft and 38.8 ft NGVD 29 was calculated by developing an area-volume curve based on topographic data (Thomas and Hutton, 2012; Thomas and Hutton, 2016). The minimum crest elevation of the Ash Pond A perimeter dikes is 38.8 ft NGVD 29. The surface area of each contour was measured and tabulated at each elevation. The available surface water volume in each 2 ft depth increment was calculated by averaging the surface area of the upper and lower contour and multiplying by the change in elevation between each contour. The cumulative storage volume of Ash Pond A between these elevations is 12.5 acre-feet (ac-ft). The area-volume data are presented in **Table 5**.

Similarly, the available stormwater storage volume of Ash Pond B between elevations 34.0 ft and 39.7 ft NGVD 29 was calculated by developing an area-volume curve based on topographic and bathymetric data (Thomas and Hutton, 2012; Thomas and Hutton, 2016). A bathymetric survey has not been completed for Ash Pond B. The average operating elevation provided by the plant from February 2011 through January 2016 is 34.1 ft (Santee Cooper, WGS, 2016). Elevation 34.1 is used as the starting water surface elevation for Pond B in the model. The minimum crest elevation of the Ash Pond B perimeter dikes is 39.7 ft NGVD 29. The surface area of each contour was measured and tabulated at each elevation. Next, the available surface water volume at each 2 ft depth increment was calculated by averaging the surface area of the upper and lower contour and multiplying by the change in elevation between each contour. The cumulative storage volume of Ash Pond B between these elevations is 220.3 ac-ft. The area-volume data are presented in **Table 5**.

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Outlet Structures

The outlets from Ash Pond A to Ash Pond B are a 30 in. diameter CMP culvert with an upstream invert at 37.50 ft NGVD 29 and a downstream invert at 36.52 ft NGVD 29, a 48 in. diameter smooth steel pipe with an upstream invert at 35.49 ft NGVD 29 and a downstream invert at 35.28 ft NGVD 29, and a 42 in. diameter smooth steel pipe with an upstream invert at 36.20 ft NGVD 29 and a downstream invert at 35.70 ft NGVD 29 (Thomas and Hutton, 2016; Thomas and Hutton, 2012). These outlet pipes allow water to drain from Ash Pond A to Ash Pond B.

The operating level in Ash Pond B is maintained by a concrete riser structure with an internal length of 4 ft and an internal width of 4 ft (Santee Cooper, 2012b). The concrete riser structure has 4 ft long stop logs on a single face, and the top stop log elevation is 34.90 ft NGVD 29 (Santee Cooper, 2012b; Thomas and Hutton, 2016). A 24 in. diameter smooth interior, corrugated exterior high density polyethylene pipe culvert with a downstream invert elevation of 17.99 ft NGVD 29 conveys water from the riser structure to the Discharge Canal of the Cooling Pond (Santee Cooper, 2012b; Thomas and Hutton, 2016).

The tailwater effects associated with discharge from Ash Pond B to the Discharge Canal were modeled using a fixed water surface elevation within the Discharge Canal and Cooling Pond. This tailwater surface elevation was estimated by conservatively assuming 2.5 ft depth of water over the Cooling Pond emergency spillway during the 100 yr storm event. The top of the stop log bolted to the top of the concrete spillway of the Cooling Pond is at elevation 21.65 ft NGVD 29 (Thomas and Hutton, 2015). The water surface of the Discharge Canal and Cooling Pond was assumed to be at 24.15 ft NGVD 29 (21.65 ft NGVD 29 plus an additional 2.5 ft of water). The tailwater effects associated with the Discharge Canal and Cooling Pond were represented by Node 7L in the *HydroCAD* model.

RESULTS

As currently operated, Ash Pond A will not contain the 100 yr storm event. Ash Pond A does not have an existing emergency spillway. The construction of a spillway on the divider dike between Ash Ponds A and B is required to convey stormwater from Ash

Pond A to Ash Pond B so the ponds contain the 100 yr storm event. A proposed spillway is included in the *HydroCAD* model and report in **Appendix A**.

Ash Pond A contains the 72 hr, 100 yr storm event given the following assumption:

- Santee Cooper will construct a 100 ft wide spillway with an invert elevation of 37.0 ft NGVD 29 in the divider dike between Ash Ponds A and B. The spillway will be constructed with 10H:1V (Horizontal:Vertical) side slopes and will be located between the 48 in. diameter smooth steel pipe and the 42 in. diameter smooth steel pipe.

The spillway is currently under construction. Operational Plans are in place in case the design storm event occurs before the construction of the spillway is completed.

The resulting peak water surface elevation and storage volume for the 100 yr storm event is shown in **Table 6**. During this storm event, Ash Ponds A and B will effectively operate as a single pond as the culverts and spillway provide a hydraulic connection between the storage areas in both ponds.

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TABLES

Table 1 – Watershed Areas and Curve Numbers

Drainage Basin	Area (ac)	Weighted Curve Number (--)
Ash Pond A	88.954	87
Ash Pond B	65.693	87

Table 2 – Input Parameters Describing Sheet Flow and Open Channel Flow

Flow Path	Sheet Flow				Open Channel Flow				
	Land Slope (ft/ft)	*Manning's Roughness Coefficient (--)*	*Flow Length (ft)*	*2 Yr, 2 Hr Rainfall (in.)*	*Cross Sectional Area (sq ft)*	*Wetted Perimeter (ft)*	*Channel Slope (ft/ft)*	*Manning's Roughness Coefficient (--)*	*Flow Length (ft)*
Ash Pond A									
Sheet	0.0663	0.020	60	4.38	--	--	--	--	--
Channel	--	--	--	--	147	59.0	0.0025	0.020	3,100
Ash Pond B									
Channel	--	--	--	--	78	33.4	0.0025	0.020	3,650

Table 3 – Open Channel Dimensions

Flow Path	Channel Configuration	Side Slope Ratio (H:V) (ft:ft)	Bottom Width of the Channel (ft)	Depth of the Channel (ft)
Ash Pond A				
Channel	Trapezoidal	3:1	40	3
Ash Pond B				
Channel	Trapezoidal	2:1	20	3

Table 4 – Times of Concentration

Flow Path	Time of Concentration (minutes [min])
Ash Pond A	
Sheet	0.7
Channel	7.6
Ash Pond B	
Channel	9.3

Table 5 – Stage Storage Table (Thomas and Hutton, 2012; Thomas and Hutton, 2016)

Ash Pond A				**Ash Pond B**			
Elevation (NGVD 29) (ft)	*Area (ac)*	*Volume (ac-ft)*	*Cumulative Volume (ac-ft)*	*Elevation (NGVD 29) (ft)*	*Area (ac)*	*Volume (ac-ft)*	*Cumulative Volume (ac-ft)*
38.8	8.529	5.3	12.5	39.68	62.066	101.6	220.3
38	4.726	5.7	7.2	38	58.863	88.8	118.7
36	1.014	1.5	1.5	36	29.915	29.9	29.9
34	0.460	0.0	0.0	34	0.006	0.0	0.0

Table 6 – Peak Elevation and Volume

Storm Event	**Ash Pond A**		
	Elevation (NGVD 29) (ft)	*Volume (ac-ft)*	*Time (hr)*
100 Yr, 72 Hr	38.13	7.875	36.22

FIGURES

LEGEND

- POND BOUNDARY
- BOTTOM ASH SLUICE AND BOILER SLAG
- CONTACT STORMWATER FROM UNIT 2 SLURRY POND
- FLY ASH SLUICE AND LOW VOLUME WASTEWATER

0 500' 1000'
SCALE IN FEET

WINYAH GENERATING STATION
SITE MAP

Geosyntec consultants

FIGURE 1

PROJECT NO: GSC5242 | OCTOBER 2016

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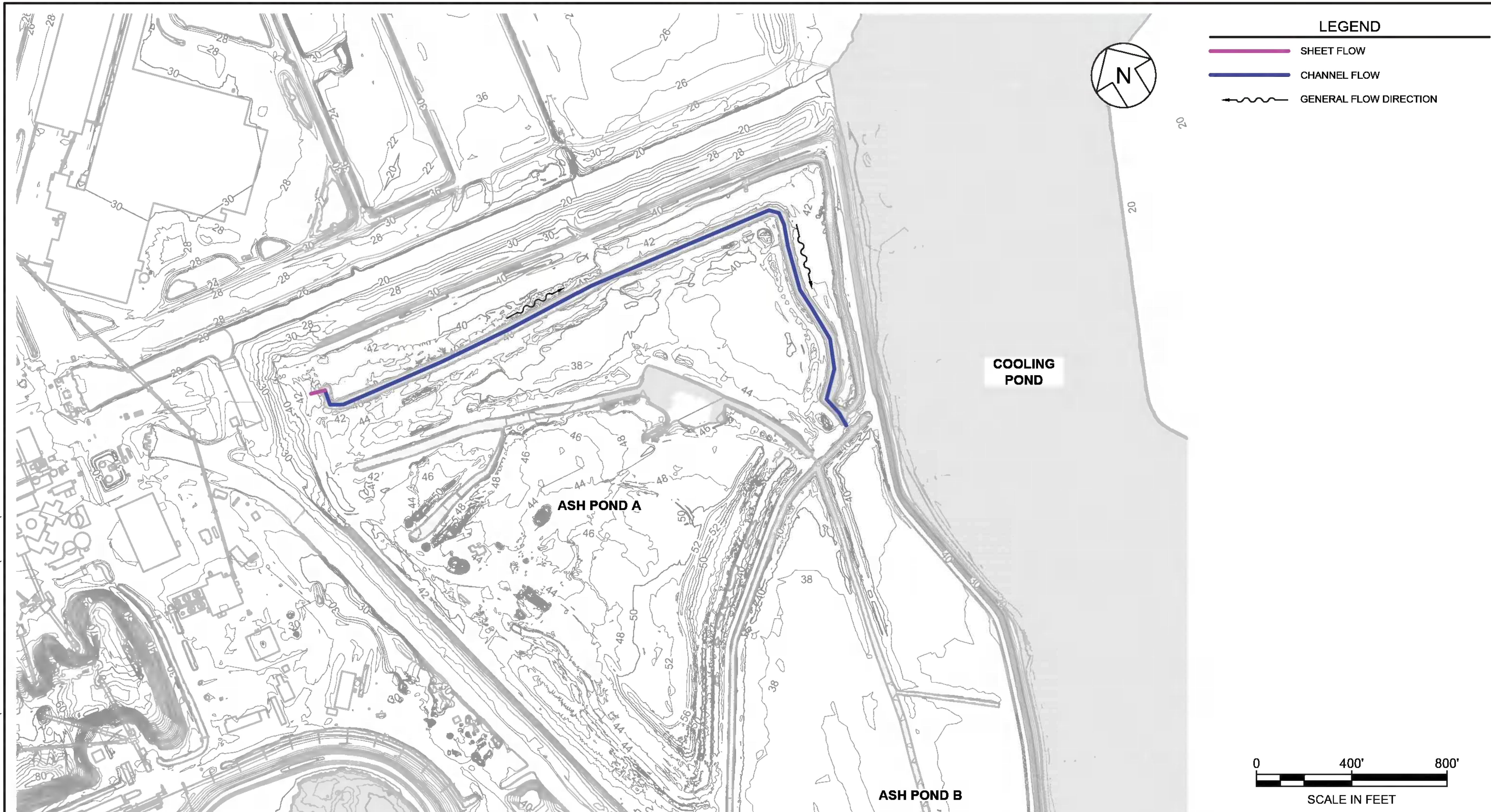

WINYAH GENERATING STATION
ASH POND A FLOW PATH

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FIGURE 2

PROJECT NO: GSC5242 | OCTOBER 2016

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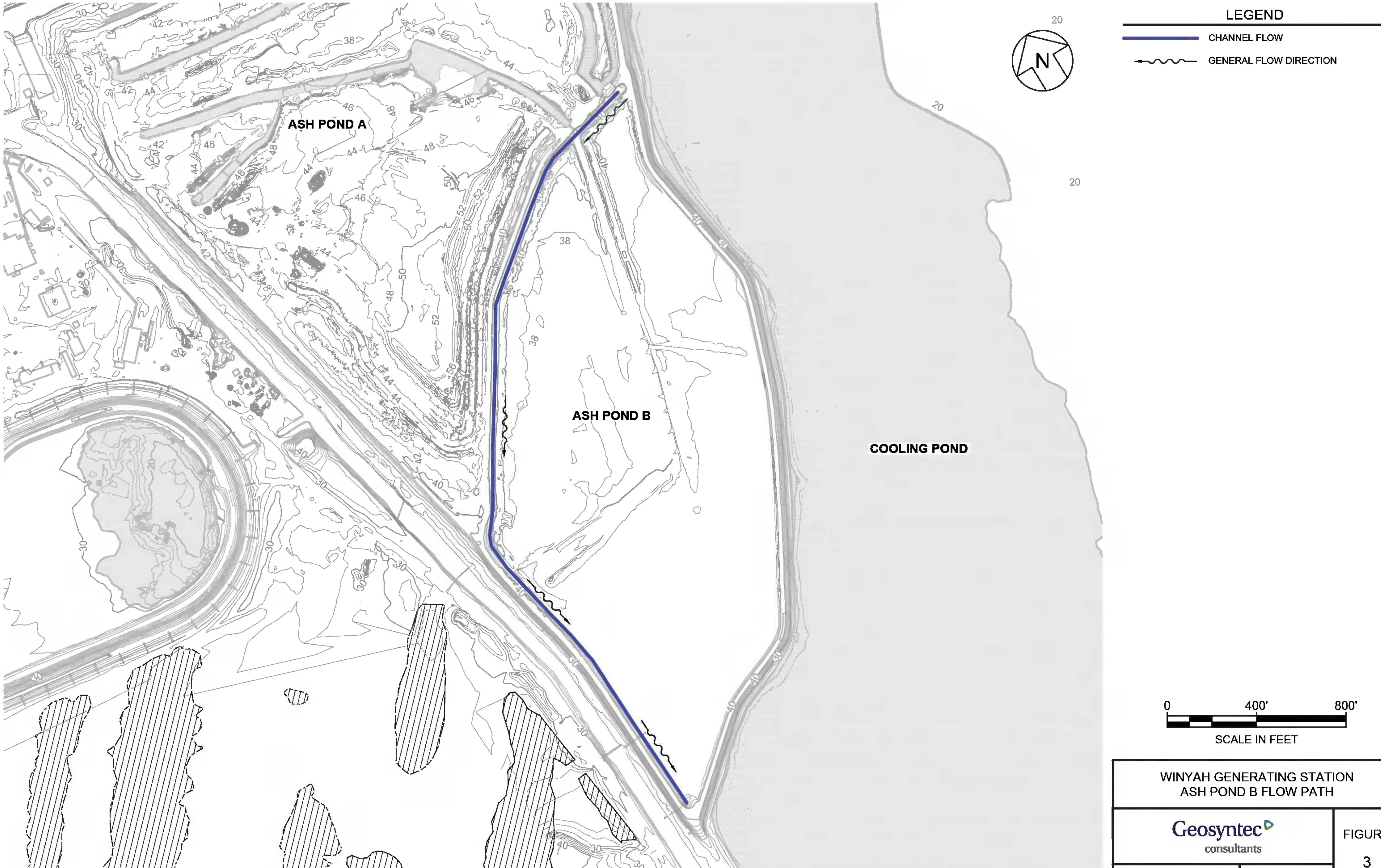

WINYAH GENERATING STATION
ASH POND B FLOW PATH

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FIGURE 3

PROJECT NO: GSC5242

OCTOBER 2016

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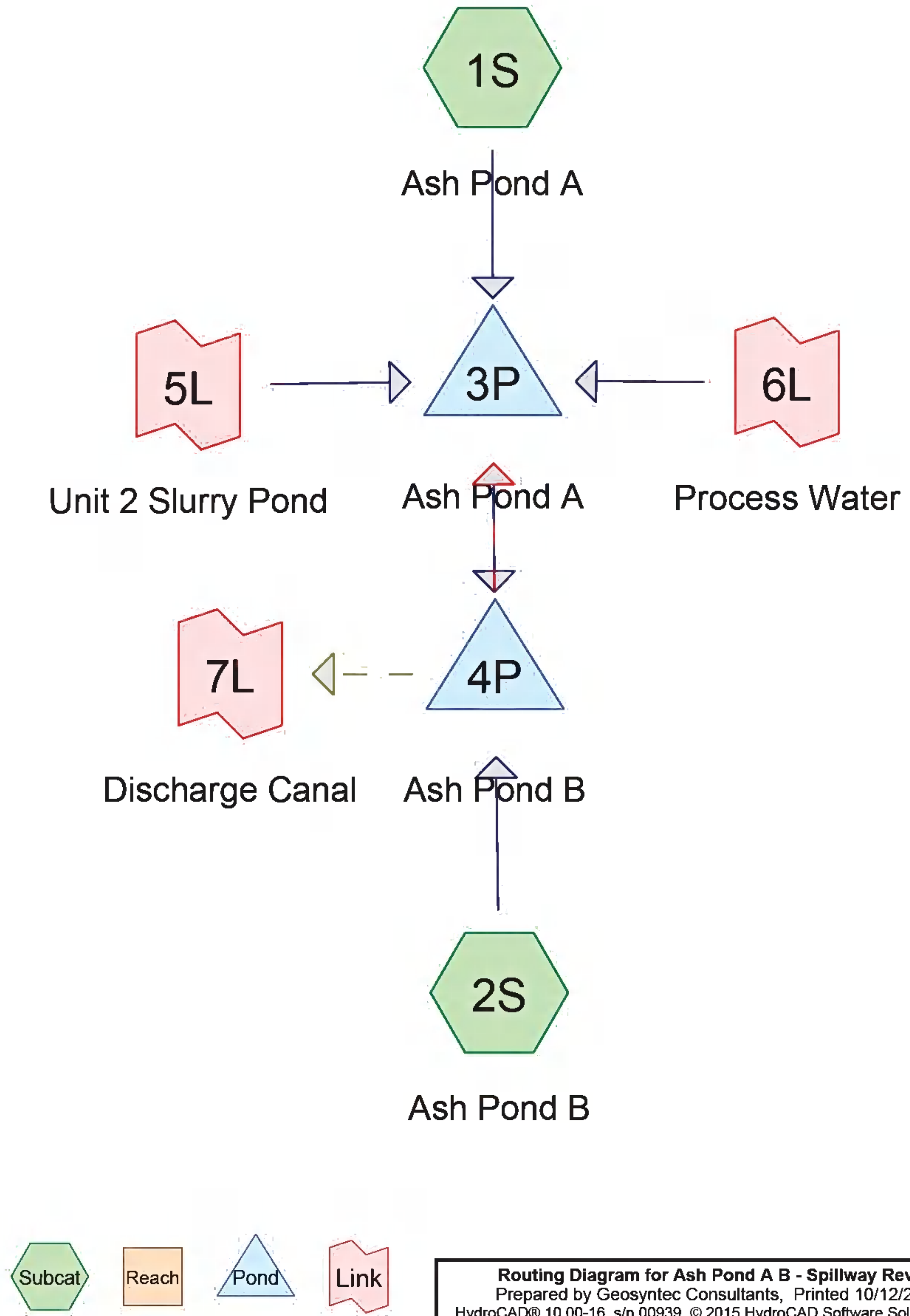
Figure 4 – Photographs of Unit 2 Slurry Pond Pump

APPENDICES

APPENDIX A



Routing Diagram for Ash Pond A B - Spillway Revision
Prepared by Geosyntec Consultants, Printed 10/12/2016
HydroCAD® 10.00-16 s/n 00939 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
154.647	87	90% Ash and 10% Water Surface (1S, 2S)
154.647	**87**	**TOTAL AREA**

Time span=0.00-600.00 hrs, dt=0.01 hrs, 60001 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment1S: Ash Pond A Runoff Area=88.954 ac 0.00% Impervious Runoff Depth=11.17"
Flow Length=3,160' Tc=8.3 min CN=87 Runoff=403.49 cfs 82.775 af

Subcatchment2S: Ash Pond B Runoff Area=65.693 ac 0.00% Impervious Runoff Depth=11.17"
Flow Length=3,650' Slope=0.0025 '/' Tc=9.3 min CN=87 Runoff=294.30 cfs 61.130 af

Pond 3P: Ash Pond A Peak Elev=38.13' Storage=7.875 af Inflow=422.87 cfs 1,043.751 af
Primary=55.02 cfs 839.100 af Secondary=320.83 cfs 206.216 af Outflow=375.85 cfs 1,045.316 af

Pond 4P: Ash Pond B Peak Elev=37.17' Storage=74.828 af Inflow=347.09 cfs 900.215 af
Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Tertiary=21.76 cfs 865.546 af Outflow=21.76 cfs 865.546 af

Link 5L: Unit 2 Slurry Pond Manual Hydrograph Inflow=5.79 cfs 287.112 af
Primary=5.79 cfs 287.107 af

Link 6L: Process Water Manual Hydrograph Inflow=13.59 cfs 673.896 af
Primary=13.59 cfs 673.884 af

Link 7L: Discharge Canal Inflow=21.76 cfs 865.531 af
Primary=21.76 cfs 865.531 af

Total Runoff Area = 154.647 ac Runoff Volume = 143.905 af Average Runoff Depth = 11.17"
100.00% Pervious = 154.647 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Ash Pond A

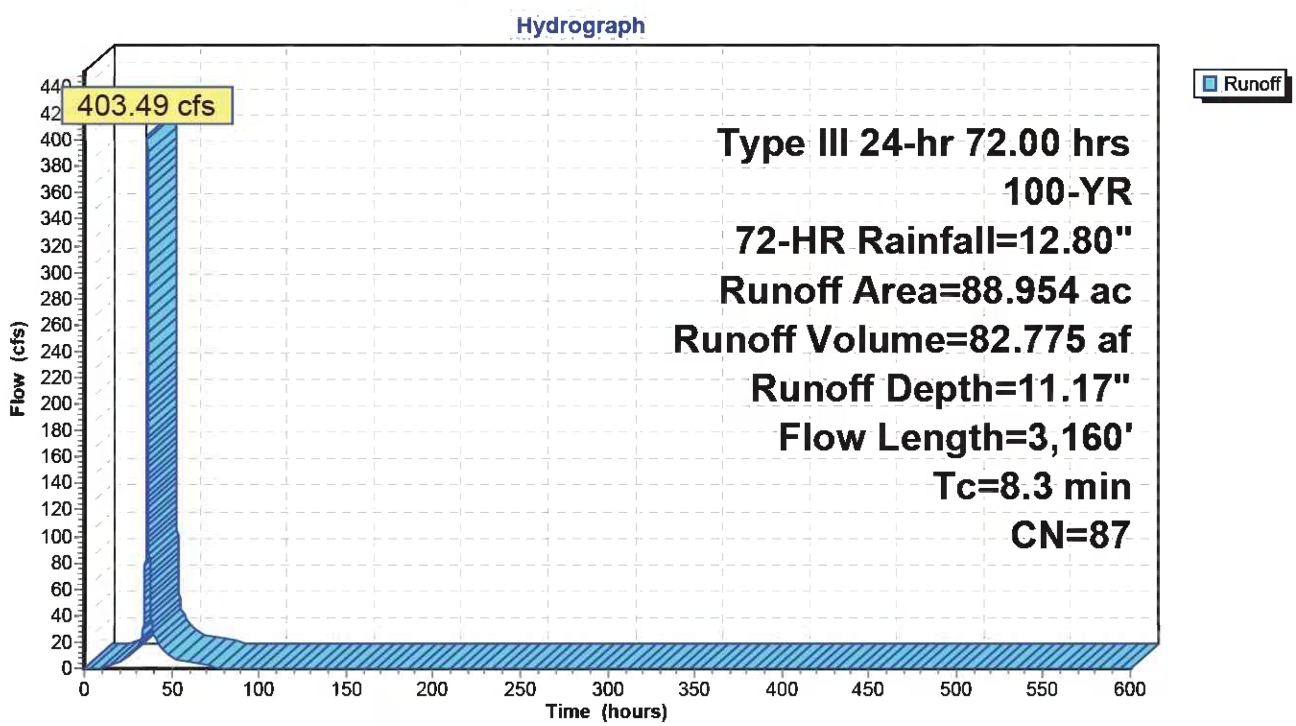
Runoff = 403.49 cfs @ 36.12 hrs, Volume= 82.775 af, Depth=11.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs
Type III 24-hr 72.00 hrs 100-YR, 72-HR Rainfall=12.80"

	Area (ac)	CN	Description
*	88.954	87	90% Ash and 10% Water Surface
	88.954		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	60	0.0663	1.45		**Sheet Flow, Sheet Flow** n= 0.020 P2= 4.38"
7.6	3,100	0.0025	6.83	1,003.66	**Channel Flow, Channel Flow** Area= 147.0 sf Perim= 59.0' r= 2.49' n= 0.020
8.3	3,160	Total			

Subcatchment 1S: Ash Pond A



Summary for Subcatchment 2S: Ash Pond B

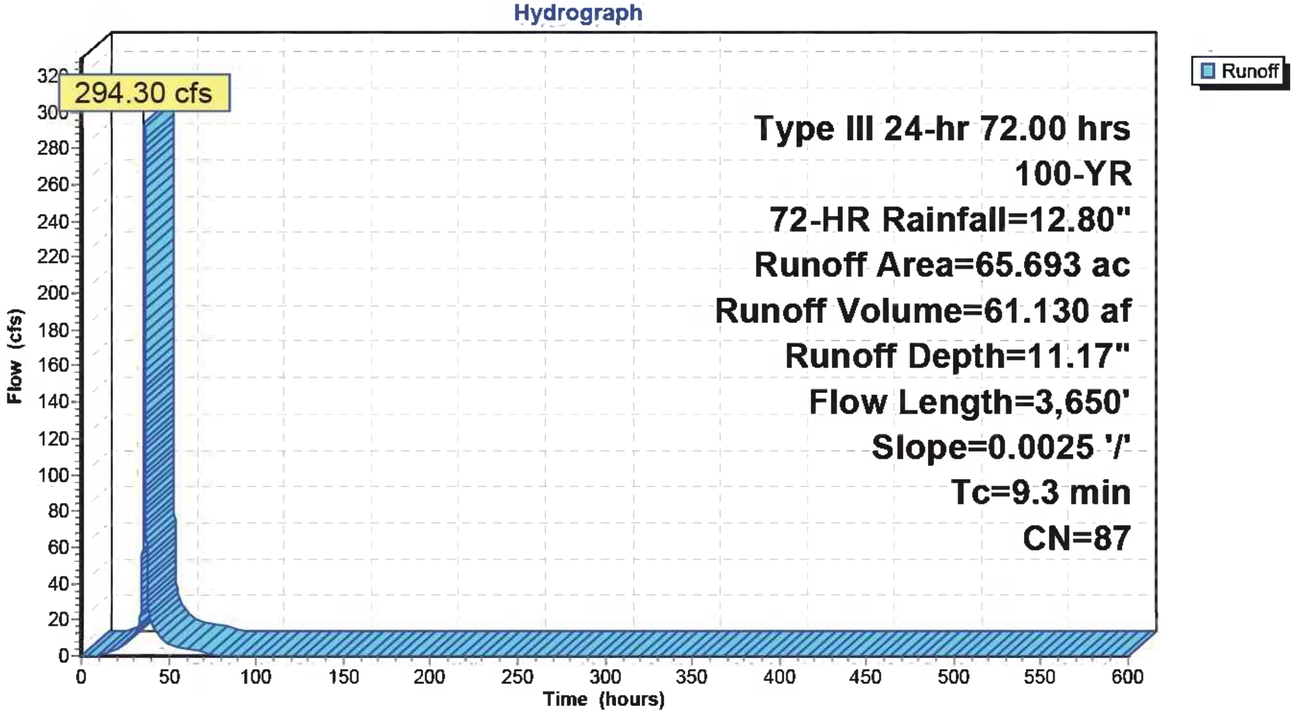
Runoff = 294.30 cfs @ 36.13 hrs, Volume= 61.130 af, Depth=11.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs
Type III 24-hr 72.00 hrs 100-YR, 72-HR Rainfall=12.80"

	Area (ac)	CN	Description
*	65.693	87	90% Ash and 10% Water Surface
	65.693		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	3,650	0.0025	6.54	510.06	**Channel Flow, Channel Flow** Area= 78.0 sf Perim= 33.4' r= 2.34' n= 0.020

Subcatchment 2S: Ash Pond B



Summary for Pond 3P: Ash Pond A

Inflow = 422.87 cfs @ 36.12 hrs, Volume= 1,043.751 af
Outflow = 375.85 cfs @ 36.22 hrs, Volume= 1,045.316 af, Atten= 11%, Lag= 6.3 min
Primary = 55.02 cfs @ 36.22 hrs, Volume= 839.100 af
Secondary = 320.83 cfs @ 36.22 hrs, Volume= 206.216 af

Routing by Sim-Route method, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs
Starting Elev= 37.50' Surf.Area= 3.798 ac Storage= 5.083 af
Peak Elev= 38.13' @ 36.22 hrs Surf.Area= 5.350 ac Storage= 7.875 af (2.792 af above start)

Plug-Flow detention time= 123.4 min calculated for 1,040.233 af (100% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	34.00'	12.516 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

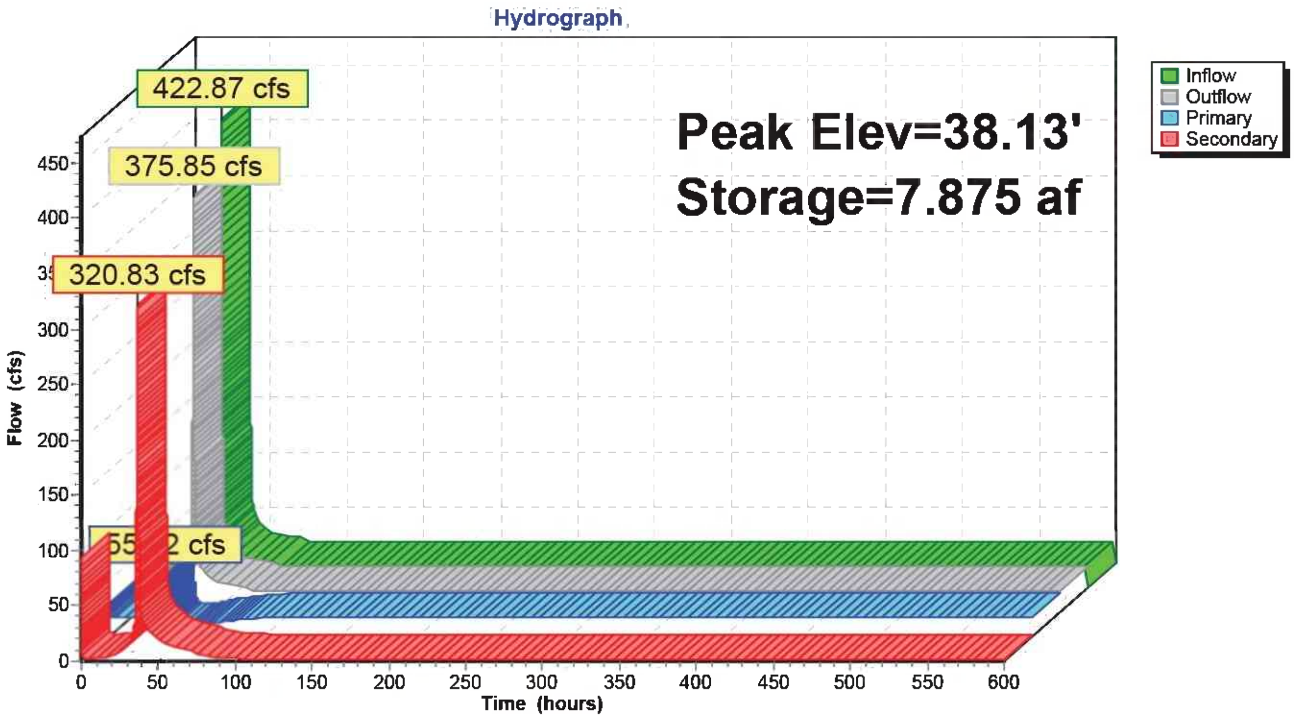
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
34.00	0.460	0.000	0.000
36.00	1.014	1.474	1.474
38.00	4.726	5.740	7.214
38.80	8.529	5.302	12.516

Device	Routing	Invert	Outlet Devices
#1	Primary	37.50'	**30.0" Round Culvert 1** L= 40.8' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 37.50' / 36.52' S= 0.0240 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf
#2	Primary	35.49'	**48.0" Round Culvert 2** L= 30.9' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 35.49' / 35.28' S= 0.0068 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 12.57 sf
#3	Primary	36.20'	**42.0" Round Culvert 3** L= 24.6' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 36.20' / 35.70' S= 0.0203 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 9.62 sf
#4	Secondary	37.00'	**100.0' long x 12.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Primary OutFlow Max=55.01 cfs @ 36.22 hrs HW=38.13' TW=36.80' (Dynamic Tailwater)
1=Culvert 1 (Inlet Controls 2.08 cfs @ 2.14 fps)
2=Culvert 2 (Barrel Controls 32.60 cfs @ 5.25 fps)
3=Culvert 3 (Inlet Controls 20.33 cfs @ 3.74 fps)

Secondary OutFlow Max=320.77 cfs @ 36.22 hrs HW=38.13' (Free Discharge)
4=Broad-Crested Rectangular Weir (Weir Controls 320.77 cfs @ 2.84 fps)

Pond 3P: Ash Pond A



Summary for Pond 4P: Ash Pond B

Inflow =	347.09 cfs @	36.14 hrs,	Volume=	900.215 af
Outflow =	21.76 cfs @	41.98 hrs,	Volume=	865.546 af, Atten= 94%, Lag= 350.4 min
Primary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af
Tertiary =	21.76 cfs @	41.98 hrs,	Volume=	865.546 af

Routing by Sim-Route method, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs
Starting Elev= 34.14' Surf.Area= 2.100 ac Storage= 0.147 af
Peak Elev= 37.17' @ 41.98 hrs Surf.Area= 46.848 ac Storage= 74.828 af (74.681 af above start)

Plug-Flow detention time= 1,529.0 min calculated for 865.384 af (96% of inflow)
Center-of-Mass det. time= 799.9 min (18,019.4 - 17,219.6)

Volume	Invert	Avail.Storage	Storage Description
#1	34.00'	220.274 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
34.00	0.006	0.000	0.000
36.00	29.915	29.921	29.921
38.00	58.860	88.775	118.696
39.68	62.066	101.578	220.274

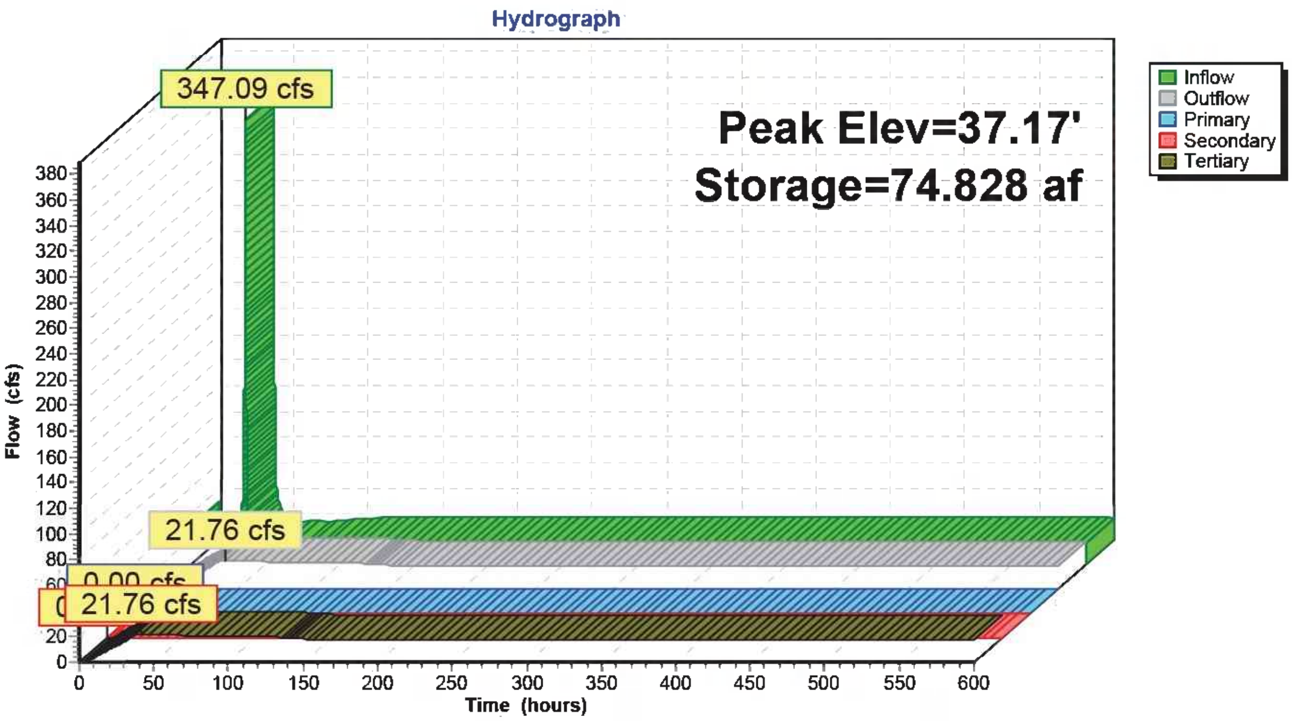
Device	Routing	Invert	Outlet Devices
#1	Tertiary	31.21'	**21.6" Round Culvert** L= 113.3' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 31.21' / 17.99' S= 0.1167 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 2.54 sf
#2	Device 1	34.90'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#3	Primary	37.50'	**30.0" Round Culvert 1** L= 40.8' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 36.52' / 37.50' S= -0.0240 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf
#4	Primary	35.49'	**48.0" Round Culvert 2** L= 30.9' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 35.28' / 35.49' S= -0.0068 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 12.57 sf
#5	Primary	36.20'	**42.0" Round Culvert 3** L= 24.6' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 35.70' / 36.20' S= -0.0203 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 9.62 sf
#6	Secondary	37.00'	**100.0' long x 12.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=34.14' TW=37.50' (Dynamic Tailwater)
3=Culvert 1 (Controls 0.00 cfs)
4=Culvert 2 (Controls 0.00 cfs)
5=Culvert 3 (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=34.14' TW=37.50' (Dynamic Tailwater)
6=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Tertiary OutFlow Max=21.76 cfs @ 41.98 hrs HW=37.17' TW=24.15' (Dynamic Tailwater)
1=Culvert (Inlet Controls 21.76 cfs @ 8.55 fps)
2=Sharp-Crested Rectangular Weir (Passes 21.76 cfs of 39.66 cfs potential flow)

Pond 4P: Ash Pond B



Summary for Link 5L: Unit 2 Slurry Pond

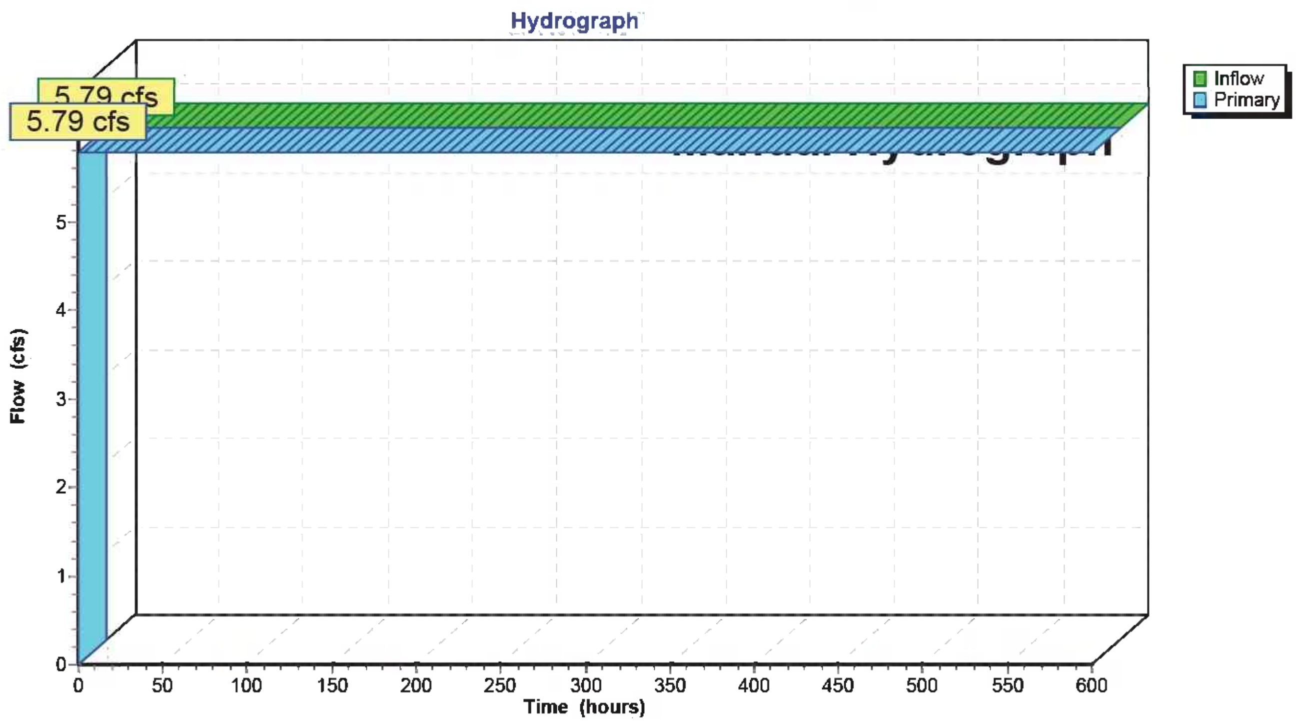
Inflow = 5.79 cfs @ 0.00 hrs, Volume= 287.112 af
Primary = 5.79 cfs @ 0.01 hrs, Volume= 287.107 af, Atten= 0%, Lag= 0.6 min

Primary outflow = Inflow, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs

61 Point manual hydrograph, To= 0.00 hrs, dt= 10.00 hrs, cfs =

5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
5.79									

Link 5L: Unit 2 Slurry Pond



Summary for Link 6L: Process Water

Inflow	=	13.59 cfs @	0.00 hrs, Volume=	673.896 af
Primary	=	13.59 cfs @	0.01 hrs, Volume=	673.884 af, Atten= 0%, Lag= 0.6 min

Primary outflow = Inflow, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs

61 Point manual hydrograph, To= 0.00 hrs, dt= 10.00 hrs, cfs =

13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
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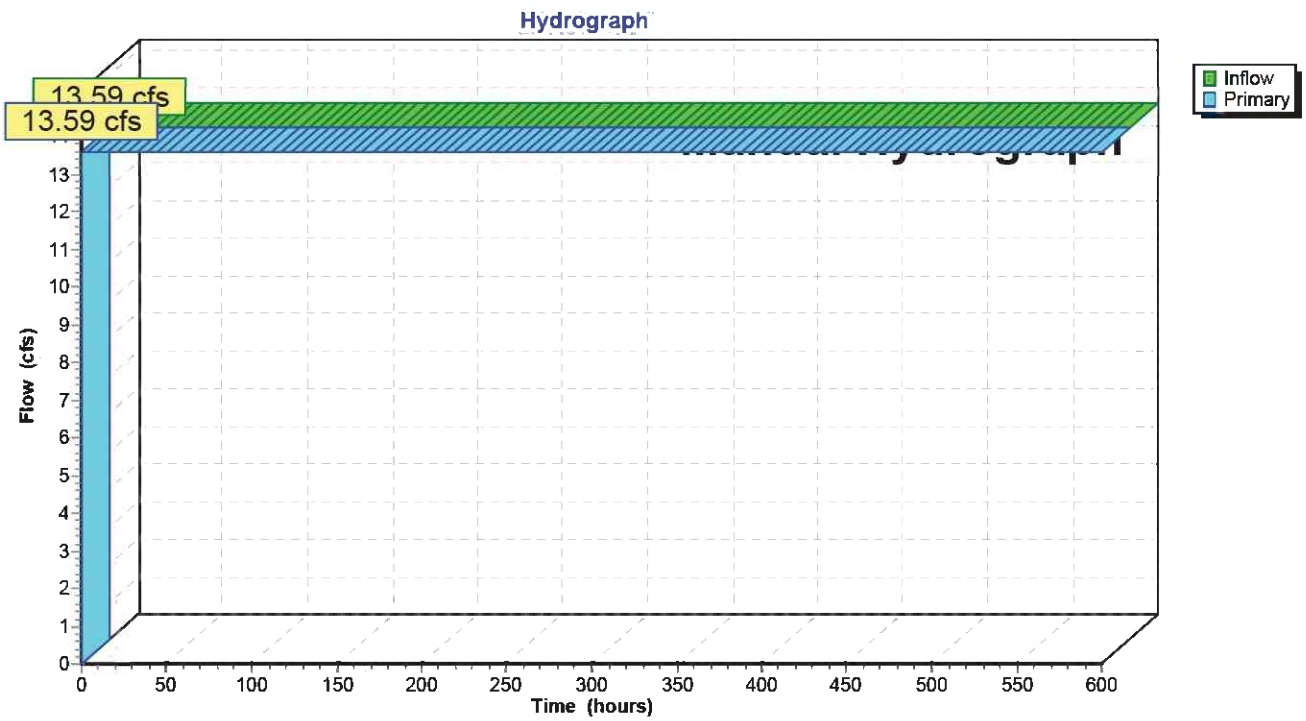
13.59									

Link 6L: Process Water



Summary for Link 7L: Discharge Canal

Inflow	=	21.76 cfs @	41.98 hrs,	Volume=	865.531 af
Primary	=	21.76 cfs @	41.99 hrs,	Volume=	865.531 af, Atten= 0%, Lag= 0.6 min

Primary outflow = Inflow, Time Span= 0.00-600.00 hrs, dt= 0.01 hrs

Fixed water surface Elevation= 24.15'

Link 7L: Discharge Canal