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(Reporter's Note: Part 1 of 2) I/A

SITE ANALYSIS AND REMOVAL PLAN

ASHEVILLE STEAM ELECTRIC GENERATING PLANT

REVISION 1

Prepared for

Duke Energy
550 South Tryon Street
Charlotte, North Carolina 28202

April 2017

Prepared by

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Project No. 7810160620

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EXECUTIVE SUMMARY

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Site Analysis and Removal Plan (Removal Plan) in support of the proposed closure of the Coal Combustion Residuals (CCR) Basins (Ash Basins) at the Asheville Steam Electric Generating Plant (Asheville Plant) located near Arden, North Carolina. The purpose of this Removal Plan is to seek the North Carolina Department of Environmental Quality's (NCDEQ) concurrence with the Duke Energy Progress, LLC (Duke) plan for closure of the Ash Basins located at the Asheville Plant. This Removal Plan is submitted to NCDEQ on behalf of Duke. The work to be performed in support of the closure of the Ash Basins is summarized in this document, which is consistent with the requirements of the Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities Rule (CCR Rule) [EPA, 2015] and the NC Coal Ash Management Act (CAMA). This Removal Plan is based on engineering and environmental factors minimizing the impacts to communities and managing cost. The drawings presented herein are accurate at the time of preparing this Removal Plan and are subject to change pending further discussion with Duke. The closure option entails excavation of CCR within the Ash Basins and transport for beneficial use or placement in an off-site permitted landfill.

The two Ash Basins located at the Asheville Plant include: (i) the 1982 Ash Basin; and (ii) the 1964 Ash Basin. Excavation of the 1982 Ash Basin was completed on September 30, 2016, and the basin was turned over for dam decommissioning and the construction of a natural gas combined cycle plant after an independent qualified professional engineer concluded that primary source ash had been removed from the basin. Duke estimates the tonnage of ash in the 1964 Ash Basin to be approximately 2.9 million tons as of December 31, 2016. Subsequent to removal of the ash pursuant to the Coal Combustion Residual Removal Verification Procedure, Duke will implement its Excavation Soil Sampling Plan, as referenced in the Construction Quality Assurance Plan, in a manner that meets the closure performance standards set out in Part II, Section 3.(c) of CAMA and Section 257.102(c) of the CCR Rule.

Assessment activities for the Asheville Plant were performed by SynTerra, Corp. (SynTerra) and were reported in a Comprehensive Site Assessment (CSA) report dated August 23, 2015, a CSA Supplement 1 dated August 31, 2016, a Corrective Action Plan (CAP) Part 1 dated November 20, 2015, and a CAP Part 2 dated February 19, 2016. Groundwater receptor surveys were conducted for the site. In addition to identification of receptors, the compiled data was used to develop a description of the site, surrounding area, geology, and hydrogeology, including a Site Hydrogeologic Conceptual Model (SCM). The Constituents of Interest (COI) identified from the Asheville Plant ash material and pore water sample analyses include antimony, arsenic, boron, chromium, cobalt, iron, manganese, sulfate, thallium, TDS, vanadium, and pH. These COIs are identified as exceeding either the 2L or Interim Maximum Allowable Concentrations (IMAC) in at least one ash pore water monitoring well. Groundwater trend analysis modeling showed that COIs with exceedances of the 2L or IMAC are identified in all compliance boundary wells at statistically elevated values over concentrations observed in designated background wells.

A preliminary geotechnical evaluation was performed and is presented in this Removal Plan. The results of the investigations indicate that the subsurface materials primarily consist of, from top to bottom, CCR (within the 1964 Ash Basin) or Dike Fill (at the perimeters of the basins) and residual soils (sitting on bedrock). A partially weathered rock zone was encountered at the transition between the residual soils and the bedrock (gray to dark gray, fine to medium-grained gneiss).

The closure of the Ash Basins will entail the following activities: CCR will be excavated and transported from the site for beneficial use or placement in an off-site permitted landfill. Per the current plan, after establishing the final design grades, the footprints of the 1982 Ash Basin will become the site for a planned combined cycle plant, and the 1964 Ash Basin footprint will be graded to drain. The potential future use of the 1964 Ash Basin is undetermined at this time. This Removal Plan also presents a summary of the engineering evaluation and analyses performed, as well as a Construction Quality Assurance (CQA) Plan.

A description of the existing stormwater and wastewater management facilities, as well as provisions for stormwater and wastewater management during and after ash basin closure are provided in this Removal Plan.

A Post-Closure Care Plan is provided, including the groundwater monitoring program currently under evaluation by NCDEQ. This Removal Plan presents the estimated milestones related to basin closure and post-closure activities.

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Definition
µg/L	Microgram per liter
2B	NCAC Title 15A, Subchapter 2B. Surface Water and Wetland Standards
2L	NCAC Title 15A, Subchapter 2L. Groundwater Classification and Standards
ASTM	American Society for Testing Materials
CAMA	Coal Ash Management Act
CAP	Corrective Action Plan
CCP	Coal Combustion Products
CCR	Coal Combustion Residual
CCR Rule	Coal Combustion Residuals Rule
CFR	Code of Federal Regulations
CMS	Closure Model Scenario
cm/sec	centimeters per second
CMP	Corrugated Metal Pipe
COI	Constituent of Interest
CQA	Construction Quality Assurance
CSA	Comprehensive Site Assessment
CY	Cubic Yards
DWQ	Division of Water Quality
DWR	Division of Water Resources (formerly DWQ)
EDXRF	Energy Dispersive X-Ray Fluorescence
EMP	Effectiveness Monitoring Plan
EPSC	Erosion Prevention and Sediment Control
FGD	Flue Gas Desulfurization
gal/min	gallons per minute
GAP	Groundwater Assessment Work Plan
GIS	Geographic Information System
HDPE	High Density Polyethylene
IMAC	Interim Maximum Allowable Concentrations
IMP	Interim Monitoring Plan
MDE	Maximum Design Earthquake
mL/g	milliliters per gram
MPD	Master Programmatic Document
MSD	Metropolitan Sewerage District
MW	Megawatt
NAVD 88	North American Vertical Datum of 1988
NCDENR	North Carolina Department of Environment and Natural Resources
NCDEQ	North Carolina Department of Environmental Quality (formerly NCDENR)
NOI	Notice of Inspection
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OM&M	Operations Maintenance and Monitoring
pcf	Pounds per Cubic Foot

Acronym/ Abbreviation	Definition
Plant	Asheville Steam Electric Generating Plant
PMP	Probable Maximum Precipitation
psf	Pounds per Square Foot
PWR	Partially Weathered Rock
RCP	Reinforced Concrete Pipe
RSL	USEPA Regional Screening Level
S.B.	Senate Bill
SCM	Site Conceptual Model
SPLP	Synthetic Precipitation Leaching
SPT	Standard Penetration Test
TBD	To be determined
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
Tsf	Tons per square foot
UNCC	University of North Carolina, Charlotte
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
XRD	X-Ray Diffraction

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Oct 30 2019

TABLE OF CONTENTS

Tables

Figures

Appendices

Appendix A	Waste Inventory Analysis (1964 Ash Basin)
Appendix B	Comprehensive Site Assessment Report (CSA), August 23, 2015 (SynTerra, 2015a); and CSA Report Supplement 1, August 31, 2016 (SynTerra, 2016b)
Appendix C	Corrective Action Plan (CAP) Part 1, November 20, 2015 (SynTerra 2015b), and CAP Part 2 February 19, 2016 (SynTerra, 2016a); Updated Flow and Transport Modeling Report, March 17, 2017 (Falta et al, 2017)
Appendix D	Engineering Evaluations and Analyses of Closure Design Grading Plans for the 1982 Ash Basin
Appendix E	Dam Decommissioning and Ash Removal Closure Plan Drawings for the 1982 Ash Basin
Appendix F	Construction Quality Assurance Plan
Appendix G	Post-Closure Operations Maintenance and Monitoring (OM&M) Plan
Appendix H	Closure and Post-Closure Care Cost Estimates
Appendix I	NPDES Permit No. NC0000396 2016 Permit Renewal Supplemental Information Package

RECORD OF REVISION

Revision Number	Revision Date	Section Revised	Reason for Revision	Description of Revision
0	12/2016	N/A	N/A	Initial Issue
1	04/2017	8,12	Response to NCDEQ	Revised Executive Summary, Sections 8.1 and 8.2 to address NCDEQ comments; Included schedule milestone dates in Section 12.1, and included cost estimate information in Section 12.2 and Appendix H; and added Appendix I
2				

1. INTRODUCTION

Duke intends to close the 1982 and 1964 Ash Basins at the Asheville Steam Electric Generating Plant (Plant). Both basins will be closed by removal of the coal ash for transport for beneficial use or an off-site fully lined landfill. The purpose of this document is to outline and present the plan and objectives to achieve closure for the ash basins and meet the requirements of the North Carolina Coal Ash Management Act (CAMA) and the Coal Combustion Residuals (CCR) Rule (CCR Rule).

1.1 Site Analysis and Removal Plan Objectives

The objective of this Site Analysis and Removal Plan (Removal Plan) is to set out the process for closing the 1982 and 1964 Ash Basins at the Plant in accordance with applicable regulations, including the Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities Rule (CCR Rule) (EPA, 2015) and the North Carolina Coal Ash Management Act (CAMA) for closure of CCR surface impoundments.

1.2 Document Organization

Although closure of the CCR surface impoundments at the Asheville facility is solely controlled by Part II, Sections 3.(b) and 3.(c) of CAMA (and not N.C.G.S. § 130A-309.214), for purposes of consistency with the closure plans for those non-high-priority Duke facilities to which N.C.G.S. § 130A-309.214 applies, this Removal Plan is structured to follow generally the closure plan elements set forth in N.C.G.S § 130A-309.214(a)(4).

2. GOVERNING REGULATIONS

2.1 Federal CCR Rules

The CCR Rule was published in the Federal Register on April 17, 2015. This rule regulates CCR as a nonhazardous waste under Subtitle D of the Resource Conservation and Recovery Act. The effective date of the rule is October 19, 2015.

Written closure plan requirements are set forth in 40 CFR § 257.102(b)(1) of the CCR Rule and are summarized in **Table 2-1** of this document. **Table 2-1** provides a cross reference between each regulatory closure plan requirement and the corresponding Removal Plan section(s) where that requirement is addressed.

The CCR Rule requires that a history of construction be developed for each CCR unit as described in 40 CFR § 257.73(c)(1), and 40 CFR §257.105(f)(9) requires that this history of construction be maintained in the facility's written operating record. In addition, §§ 257.106(f)(8) and 257.107(f)(8) require notification of the availability of the history of construction to the State Director and posting of this information on the publicly accessible CCR Website, respectively. The History of Construction Report (Amec Foster Wheeler 2016a) has been developed as a primary source of information reported in the Removal Plan and to satisfy these record keeping requirements.

2.2 North Carolina

In August 2014, the North Carolina General Assembly passed Senate Bill (S.B.) 729 (known as CAMA), which lists specific regulatory requirements for CCR surface impoundment closure. For the Plant, "surface impoundment," as defined in N.C.G.S. § 130A-309.201(6), is interpreted to include the 1982 Ash Basin and 1964 Ash Basin. Part II, Section 3(b) of CAMA deems the Plant a "high-priority" site and specifically requires closure by August 1, 2019, which entails dewatering the ash basins to the maximum extent practicable and removing and transferring CCR from basins to a lined landfill or structural fill. However, the North Carolina Mountain Energy Act of 2015 extended the closure date to August 1, 2022. Note that ash removal is required to be complete by August 1, 2022; however, dam decommissioning and final grading of the former ash basin areas and completion of corrective actions to restore groundwater quality, if needed, as provided in N.C.G.S. § 130A-309.204, may extend beyond this date. CAMA's closure plan requirements applicable to non-high-priority sites were codified at N.C.G.S. § 130A-309.214(a)(4), which requires plans for such sites to include the elements listed below. Although, as noted in Section 1.2 above, N.C.G.S. § 130A-309.214 is not specifically applicable to the Plant, which is a high-priority site required to close pursuant to Part II, Sections 3.(b) and 3.(c) of CAMA, this Removal Plan relies on N.C.G.S. § 130A-309.214(a)(4) solely to inform its organization.

A closure plan will be required for each CCR surface impoundment subject to N.C.G.S. § 130A-309.214(a)(4) regardless of its risk classification. CAMA defines the requirements for these closure plans in N.C.G.S. §130A-309.214(a)(4). The CAMA closure plan regulations are summarized in **Table 2-2** for reference. The Closure Plan shall include the following:

- Facility description;
- Site maps;
- Hydrogeologic, geologic, geotechnical characterization results;
- Groundwater potentiometric maps and extent of contaminants of concern;
- Groundwater modeling;
- Description of beneficial reuse plans;
- Removal Plan drawings, design documents, and specifications;
- Description of the construction quality assurance and quality control program;
- Description of wastewater disposal and stormwater management provisions;
- Description of how the final disposition of CCR will be provided;
- List of applicable permits to complete closure;
- Description of post-closure monitoring and care plans;
- Estimated closure and post-closure milestone dates;
- Estimated costs of assessment, corrective action, closure and post-closure care; and
- Future site use description.

In addition to the closure pathway and closure plan requirements, CAMA outlines groundwater assessment and corrective action requirements summarized as follows:

- Submit Groundwater Assessment Plans by December 31, 2014;
- Within 180 days of Groundwater Assessment Plan approval, complete a groundwater assessment and submit a Groundwater Assessment Report; and
- Provide a Corrective Action Plan (if required) within 90 days (and no later than 180 days) of Groundwater Assessment Report completion.

The groundwater assessment and corrective action activities for the Plant are currently being developed by SynTerra Corp. (SynTerra). The *Comprehensive Site Assessment (CSA) Report* for the Plant was completed on August 23, 2015 (SynTerra 2015a). Duke has been in correspondence with the NCDEQ and has received permission to submit a Corrective Action Plan (CAP) in two parts. The first part of the CAP was submitted on November 20, 2015, and includes background information; a brief summary of the CSA findings; a brief description of site geology and hydrogeology; a summary of the previously completed receptor survey; a description of NCAC Title 15A Subchapter 2L. Groundwater Standards (2L Standards) and NCAC Title 15A NCAC Subchapter 2B. Surface Water Standards (2B Standards) exceedances;

proposed site-specific groundwater background concentrations; a description of the site conceptual model; and groundwater flow, and transport modeling (SynTerra 2015b). The second part of the CAP was submitted on February 19, 2016, and includes risk assessment, alternative methods for achieving restoration, conceptual plans for recommended corrective actions, implementation schedule, and a plan for future monitoring and reporting (SynTerra 2016a).

The CSA Supplement 1 was also issued on August 31, 2016, and addresses the following (SynTerra 2016b):

- Summary of groundwater monitoring data through July 2016;
- Reponses to NCDEQ review comments pertaining to the CSA;
- Update on the development of provisional background groundwater concentrations (through April 2016 data);
- Findings from assessment activities conducted since the submittal of the CSA report, including data gaps previously identified in the CSA; and
- Description of planned additional assessment activities.

On March 17, 2017, an updated groundwater modeling report was prepared for SynTerra (Falta, et al 2017). This study updated the groundwater flow and constituent transport model that was previously developed for the site in 2015.

3. FACILITY DESCRIPTION AND EXISTING SITE FEATURES

3.1 Surface Impoundment Description

3.1.1 Site History and Operations

The Plant is a coal-combustion generating facility that began commercial operation in 1964. Ash basins, which support operations at the Plant, were expanded or otherwise modified in 1971, 1999, and 2000. As shown on **Figure 1**, the facility is located in Buncombe County in Western North Carolina, approximately 8 miles south of the City of Asheville, and is within the U.S. Geological Survey (USGS) Skyland Quadrangle. The center of the facility is at the approximate coordinates: latitude 35°28'N, longitude 82°32'W. The Plant is situated on approximately 786 acres, including areas on both sides of Interstate 26 (I-26).

The Plant consists of two coal-fired generating units with a combined power generating capacity of 376 megawatts (MW), two combustion turbine units with a combined 324 MW capacity, two CCR units known as the 1982 Ash Basin and the 1964 Ash Basin, and obtains makeup water from Lake Julian. **Figure 2** includes an aerial photo of the Plant that also shows the associated and surrounding features.

The two ash basin dams fall under the jurisdiction of the NCDEQ Division of Energy, Mineral and Land Resources, Land Quality Section, Dams Program and are listed under State ID Number BUNCO-089 (1982 Ash Basin) and BUNCO-097 (1964 Ash Basin). According to the current NCDEQ hazard-rating criteria, the dams are considered to be large, high-hazard structures, falling under Class C dam classification based on potential breach impacts to potential loss of life and/or economic damage.

Fly ash and bottom ash have been deposited within the facility's two ash basins by hydraulic sluicing. Ash is currently sluiced to the Rim Ditch system, where it is dewatered and temporarily stored within the 1964 Ash Basin. Ash is later removed and transported off-site for beneficial reuse or proper disposal. Decant water from the Rim Ditch is pumped through a center pond filter system to the stilling basin located to the north of the 1964 Ash Basin, and then out through NPDES Outfall 001. Some stormwater and wastewater from portions of the Plant site is routed into the Duck Pond and then pumped into to the head of the Rim Ditch for treatment.

Following is a brief summary from the History of Construction report (Amec Foster Wheeler 2016a) of each of the Ash Basins.

<u>1964 Ash Basin and Equalization Basin</u>

The 1964 Ash Basin Dam was part of the original steam plant construction designed by Ebasco in 1962. The dam was constructed as a compacted, random earth fill embankment with a design crest elevation of approximately 2125 feet. The 1964 Ash Basin has a drainage area of approximately 75 acres according to the NCDEQ dam database.

In 1970–71, the dam was extended and raised approximately 30 feet to a planned crest elevation of 2157.5 feet to provide additional ash storage. This raising necessitated a separator dike east of the main dam. Recent survey information shows a spot crest low point elevation of approximately 2157.3 feet (North American Vertical Datum of 1988 [NAVD 88]). Sluicing of ash to the 1964 Ash Basin ceased in 1982 with the construction of the 1982 Ash Basin.

In 2005, an engineered wetlands treatment system for flue gas desulfurization (FGD) process wastewater was constructed within the northwestern portion of the 1964 Ash Basin. The system consisted of two equalization basins that routed wastewater from the FGD process to a series of lined ponds that contained vegetation to treat the wastewater. The constructed wetlands and equalization basins were designed by Parsons E&C (now known as Worley Parsons).

In 2012, a 1964 Dam improvement project was initiated to improve the stability of the dam. This improvement project included:

- Extension of the core of the dam along the crest;
- Installation of a toe drain along the base of the downstream slope of the dam that routes collected water into an existing concrete structure;
- Abandonment of the 30-inch-diameter concrete spillway pipe and riser by grouting in-place;
- Construction of a riprap buttress along the toe of the dam; and
- Modification of the path for discharge from the wetlands system and 1982 Ash Basin.

In parallel with the dam improvements, a drainage improvement project designed by MACTEC (now Amec Foster Wheeler) was completed to redirect the outflow from the 1982 Ash Basin riser structure into buried piping (high density polyethylene [HDPE] encased in flowable fill) installed within the 1964 Ash Basin area to the interior of the Duck Pond, and from the Duck Pond to a new outlet structure at the French Broad River. With this project, the spillway for the 1964 Ash Basin is located within the Duck Pond in the northeast corner of the basin and connected to the drainage pipe system installed in 2012. For more detailed information and area capacity curves for the basin, refer to the History of Construction report (Amec Foster Wheeler 2016a).

The equalization basins and engineered wetlands were removed to provide an area to temporarily place ash excavated from the 1982 Ash Basin. During 2016, wastewater flows and treatment were adjusted to facilitate the excavation of the 1982 Basin. The center pond filters were constructed at the end of the Rim Ditch and commissioned to replace the treatment provided by the Duck Pond. Infrastructure was developed to dewater the Duck Pond to the head of the Rim Ditch, and subsequently, the low volume waste and stormwater that flowed into the 1982 Basin and pumped to the Rim Ditch was re-routed to the Duck Pond. All treated effluent is discharged to Outfall 001.

1982 Ash Basin and Separator Dike

The 1982 Ash Basin Dam was designed by CP&L Engineers and W.L. Wells in 1981. The ash basin dam was constructed of compacted random earth fill in 1981–82 and ash storage began in 1982 (when the 1964 Ash Basin was removed from service).

The dam is approximately 1500 feet long with a design crest elevation at 2165 feet. Recent survey information before dam decommissioning activities began showed spot elevations ranging from 2164.5 feet to 2165.7 feet (NAVD 88). The west end of the dam joins the abutment of the 1964 Ash Basin Dam and the east end ties into a natural knoll. An internal drainage blanket connected to toe-drainage piping provides seepage control. The 1982 Ash Basin has a drainage area of approximately 70 acres, according to the NCDEQ dam database.

When the 1964 Ash Basin dam was raised in 1970–71, a Separator Dike was constructed across a topographic low area on the east side of the 1964 Ash Basin. The 1982 Ash Basin design included raising the Separator Dike due to the planned higher crest elevation of the 1982 Ash Basin Dam. The Separator Dike was built on a native soil base; fill for the dike was not placed on ash.

The outfall skimmer was near the southwest corner of the 1982 Ash Basin. It connected to a drainage pipe that was installed in 2012 that runs below the constructed wetlands (now removed) and the northern portion of the 1964 Ash Basin, before connecting to a stilling basin and concrete outfall structure at the French Broad River. For more detailed information and area capacity curves for the basin, refer to the History of Construction report (Amec Foster Wheeler 2016a).

The 1982 Ash Basin began to reach capacity in 2007. To facilitate continued Plant operations, an ash excavation plan was developed to increase ash storage capacity. As part of this plan, ash was transported to the Asheville Regional Airport (Airport) and beneficially used as structural fill. The structural fill project areas 1, 4, and 3 were completed in 2015. In October 2015, operations began to transport ash to an off-site fully lined landfill near Homer, Georgia. As ash removal operations were conducted within the 1982 Ash Basin, the outfall skimmer was disconnected from the drainage pipe, because sufficient volume existed in the 1982 Ash Basin to store the PMP storm event. Ash removal within the 1982 Ash Basin was completed on September 30, 2016, and decommissioning of the dam is currently underway.

3.1.2 Estimated Volume of CCR Materials in Impoundments

The volume of CCR material contained in the ash basins is presented below. Throughout this document, ash volumes are expressed as tons using the conversion of 1.2 tons per cubic yard (tons/yd^3). Excavation of the 1982 Ash Basin was completed on September 30, 2016, and the Basin was turned over for dam decommissioning and the construction of a natural gas combined cycle plant.

The volume of ash currently in the 1964 Ash Basin is estimated to be approximately 2,900,000 tons as of December 31, 2016 (Duke Energy 2016). A Waste Inventory Analysis, dated January 2015 (Amec Foster Wheeler 2015c), was performed for the 1964 Ash Basin. Since that date some ash from the 1982 Ash Basin was temporarily placed in the 1964 Ash Basin ash stack in 2016. The plant also continues to generate ash resulting from the operation of the coal-fired units, until they are retired from operation. The Waste Inventory Analysis is an estimation of the volume of ash present at the time, but does not include the subsequent ash placed within the basin due to ash stacking operations or generation ash production.

The Waste Inventory Analysis calculations were performed using historical ground surface topographic information from historical design drawings or USGS mapping, and used AutoCAD Civil 3D software to compare the historical ground surface elevation contours with current conditions. In these calculations, an approximate pre-fill ground surface was generated, and pre-fill grades were compared to current North Carolina Flood Plain Mapping LIDAR topography. The Waste Inventory Analysis for the 1964 Ash Basin (including report and calculations) is included with this document as **Appendix A**. All of the ash will be removed from the 1964 Ash Basin prior to dam decommissioning and ash basin closure.

3.1.3 Description of Surface Impoundment Structural Integrity

A Reconstitution of Ash Basin Design (Amec Foster Wheeler 2015e) was performed for the 1982 and 1964 Ash Basins that compiled and analyzed pertinent information regarding the integrity of the embankments. As summarized below, this report examined the geotechnical properties, structural elements (spillways), and hydrology and hydraulics of the basins. The report compiled and analyzed existing reports and evaluations for the ash basins, and addressed data gaps with additional analyses and conclusions for the site. Additional information is presented in the History of Construction Report (Amec Foster Wheeler 2016a) in reference to the hydrologic and hydraulic studies performed after the issuance of the Reconstitution of Ash Basin Design report.

In addition, an additional geotechnical stability analysis was performed by AECOM (AECOM 2016) for the 1964 Ash Basin dam. This analysis analyzed the potential for liquefaction and seismic stability of the embankment to determine if stability improvements to the dam were needed. Based on a review of the historical documents and additional data gathered, the following conclusions were reached for the ash basins and related structures:

Geotechnical analyses show:

- The minimum factors of safety for the 1964 Ash Basin Dam, 1982 Ash Basin Dam, the Separator Dike and the Equalization Basin dike were greater than the target factor of safety requirements for applicable loading conditions at all locations analyzed.
- Seismic Site Class C and D were determined to be appropriate for the 1982 Dam/Separator Dike and Equalization Basin/1964 Dam area, respectively, prior to analysis of liquefaction.
- Based on the Standard Penetration Test (SPT) analyses, widespread liquefaction of the foundation soils of the embankments is not anticipated for the design seismic event. The dams and dikes are not susceptible to liquefaction, and post-earthquake shearing failures of the impoundments are not anticipated. Displacements of the dam/dike crests are not expected.

Structural analyses show:

- The riser structure at the former Duck Pond within the 1964 Ash Basin could not be evaluated due to lack of information regarding the timber pile foundation system. By inspection, it was concluded that this structure was not designed for seismic events and it would likely fail under seismic loading conditions.
- The 1982 Ash Basin riser and outfall pipe were determined to be in poor condition. However, those structures have been abandoned as of the date of this Removal Plan.

Hydrologic and Hydraulic:

- All ash has been removed from the 1982 Ash Basin, and dam decommissioning activities are currently underway. The drawings for the dam decommissioning (**Appendix E**) address the sequencing of grading for removal of the embankment and backfilling to prohibit impounding water, and management of stormwater during this process.
- The total storm volume in the 1964 Ash Basin for the full PMP event is approximately 183.7 acre feet, and the available storage volume is approximately 192.9 acre feet (Amec Foster Wheeler 2016a).

3.1.4 Sources of Discharges into Surface Impoundments

The 1964 Ash Basin currently receives low volume stormwater, sluice water, and stormwater from the switchyards and gypsum pad. Both ash basins receive stormwater from their associated drainage areas. The sluicing operations and effluent discharges from the Plant have historically been routed to the ash basins. However, only the 1964 Ash Basin currently supports ongoing operations with the Duck Pond and the Rim Ditch. Ash is directed to the Rim Ditch, where generation ash is sluiced, recovered, and temporarily placed in the 1964 Ash Basin.

The discharge of effluent from the Plant's operation is permitted under NPDES Permit NC0000396 authorized by the NCDEQ Division of Water Resources (DWR).

3.1.5 Existing Liner System

Based on historical documents, the 1982 and 1964 Ash Basins are not lined.

3.1.6 Inspection and Monitoring Summary

Weekly, monthly, and annual inspections of the ash management facilities are conducted at the Plant consistent with the North Carolina CAMA and CCR Rule and in accordance with the Operations & Maintenance (O&M) Manual (Amec Foster Wheeler 2015d). The findings presented in this section are tracked and resolved in the pertinent work management system.

Independent third-party inspections are performed once every year to promote the design, operation, and maintenance of the surface impoundment in accordance with generally accepted engineering standards.

Annual inspections are performed to gather information on the current condition of the dams and appurtenant works. This information is then used to establish needed repairs and repair schedules, to assess the safety and operational adequacy of the dam, and to assess compliance activities with respect to applicable permits, environmental and dam regulations. Annual inspections are also performed to evaluate previous repairs.

In May 2016, an annual inspection of the Plant ash basin dams was performed (Amec Foster Wheeler 2016b). This inspection included observations of the ash basin dams, discharge towers, and drainage pipes. In addition to the field observations of the physical features of the impoundments, this annual inspection included a review of available design documents and inspection records. This report included findings from previous inspections including, but not limited to, the following documents:

- AMEC Environment & Infrastructure, Inc., “2014 Annual Ash Basin Dam Inspection, Asheville Steam Electric Station,” January 14, 2015;
- Amec Foster Wheeler, “2015 Annual Ash Basin Dam Inspection, Asheville Plant,” May 9, 2016;
- AMEC Environment & Infrastructure, Inc., “2012 Five-Year Independent Consultant Inspection, Cooling Lake Dam and Ash Pond Dams, Asheville Steam Electric Plant,” February 19, 2013;
- S&ME Inc., “Construction Repair Certification Report, 1964 Ash Basin Dam Improvements (Phase II), Progress Energy Asheville Plant,” December 18, 2012;
- NCDENR Notice of Inspection Reports for 1964 Ash Pond Dam (BUNCO-097) dated April 30, 2010; May 6, 2011; February 22, 2012; April 19, 2013; and April 1, 2014;
- AMEC Environment & Infrastructure, Inc., “2013 Report of Limited Field Inspection, Cooling Lake Dam and Ash Pond Dams, Duke Energy Progress – Asheville Steam Electric Plant,” August 5, 2013;
- AMEC Environment & Infrastructure, Inc., “2014 Report of Limited Field Inspection, Cooling Lake Dam and Ash Pond Dams, Duke Energy Progress – Asheville Steam Electric Plant,” August 28, 2014;
- AMEC Environment & Infrastructure, Inc., “Asheville Plant, BUNCO-089-H, BUNCO-097-H Observations, 8/27/2014 through 10/2/2014, Buncombe County, North Carolina,” September 8, 2014, through October 6, 2014;
- NCDENR Notice of Inspection Reports for 1982 Ash Pond Dam (BUNCO-089) dated May 5, 2010; May 6, 2011; February 22, 2012; April 19, 2013; and April 1, 2014;
- Dewberry & Davis, Inc., “Final Coal Combustion Waste Impoundment Dam Assessment Report, Site 7, 1982 Pond & 1964 Pond, Progress Energy Carolinas, Asheville, North Carolina,” Revised Final September 11, 2009;
- Stantec, “Asheville Plant – Field Reconnaissance,” 2014.

The 2016 annual inspection, dated September 12, 2016, states that the "inspection did not identify features or conditions in the inspected ash basin dams, their outlet structures or their spillways that indicate an imminent threat of impending failure hazard. Review of critical analyses suggests the design conforms to current engineering state of practice to a degree that no immediate actions are required other than the recent and ongoing surveillance and monitoring activities already being practiced."

Summary recommendations were developed for both the 1982 and 1964 Ash Basin Dams. The recommendations are summarized in **Table 3-1** and **Table 3-2** for the 1982 and 1964 Ash Basin Dams, respectively.

Table 3-1: 1982 Ash Basin Dam Summary Recommendations (Amec Foster Wheeler 2016b)

Ref. No.	Recommendations	2016 Annual Inspection Status
1982 AP-2009-1 (EPA)	Take precautions to not mow slope when wet or take necessary measures to not create ruts up and down slope.	No ruts observed along slope of embankment.
1982 AP-2009-2 (EPA)	Vegetative cover needs to be established in bare areas.	Bare areas noted during weekly inspections are seeded as required to establish vegetation. Bare areas were not observed during the annual inspection.
1982 AP-2009-3 (EPA)	Small animal burrows found on downstream slope should be filled with appropriate material.	Animal burrows observed and filled with appropriate material as necessary. Continue monitoring
1982 AP-2010 (NCDENR)	Animals should be removed from dam and burrows repaired.	Animal burrows observed and filled with appropriate material as necessary. Continue monitoring.
1982 AP-2010-2013 (NCDENR)	Monitor wet area noted about halfway up downstream slope near left abutment.	No wet area noted on downstream slope. Monitoring of this area continues with weekly inspections.
1982 AP-2012-2014 (NCDENR)	Monitor wetness noted at toe on right abutment and near toe drains.	No wet area noted at the toe on right abutment and near the toe drains. Monitoring of this area continues.
1982 AP-2012-1	Plant personnel should continue to perform their monthly inspections and measurements at the weir and piezometers. The measurements at the weir should not be performed during or within about 12 hours after rainfall events.	Inspections and monthly measurements are continuing.
1982 AP-2012-2	Cut trees and bushes growing within the riprap lined upstream slope. The grass and weeds growing in this area do not need to be cut or killed.	Ash excavation continues. Upper portion of upstream face has established vegetation. Vegetation should be established in lower portion of upstream face. (Note: As of December 2016, ash excavation is complete and dam decommissioning activities are in progress.)
1982 AP-2014-1a (NCDENR)	Repair rutted area along left abutment toe road.	Continue to monitor and repair erosion areas as necessary.

Ref. No.	Recommendations	2016 Annual Inspection Status
1982 AP – 2014-1b (NCDENR)	Monitor mole holes noted on downstream slope.	No evidence of mole activity during inspection.
1982 AP-2014-2	Slope protection should be implemented on the upstream face of the dam during the ash removal process.	Ash excavation continues. Upper portion of upstream face has established vegetation. Vegetation should be established in lower portion of upstream face. (Note: As of December 2016, ash excavation is complete and dam decommissioning activities are in progress.)
1982 AP-2014-4 (Stantec ASH-5)	Establish grass vegetation or other erosion control measures on external slope of separator dike.	Continue to monitor and establish vegetation and other erosion control measures as necessary. (Note: As of December 2016, Riprap has been added to this slope in lieu of vegetation repairs.)
1982 AP 2014-8	Monthly inspection of the dam and measurements of water elevations at the piezometers and seepage flow at the weirs should continue	Inspections and measurements are continuing.

Table 3-2: 1964 Ash Basin Dam Summary Recommendations (Amec Foster Wheeler 2016b)

Ref. No.	Recommendations	2016 Annual Inspection Status
1964 AP-2009-2 (EPA)	Establish a program to have rip-rapped slope cleared of vegetation at least once every year.	Riprap slope is sprayed with herbicide as necessary to kill vegetation.
1964 AP-2010&2011-1 (NCDENR) & 2014-1	Monitor seepage at toe of dam on right abutment where 1971 section over 1964 section begins.	This area of seepage is monitored for change during monthly and weekly inspections. Observed to be similar to previous inspections.
1964 AP-2012-1	Recommended that safety inspection of the 1964 Ash Pond Dam should continue annually.	Annual inspections performed by Amec Foster Wheeler.
1964 AP-2012-2	Regularly remove trees and bushes from the face of the dam.	D/S Slope of dam is sprayed with herbicide as necessary to kill young trees and bushes.
1964 AP-2012-4	Consider installing a flow monitoring weir at the outfall from the concrete structure that collects flow from the toe drains.	Flow meters that were previously installed at toe drain outlets and flow rates are recorded monthly by Duke personnel.
1964 AP-2014-2	Consider installing a flow monitoring device at the outfall of the corrugated HDPE culvert beneath the toe road along the right abutment to monitor seepage from the upstream area where 1971 section over 1964 section begins. In the interim, measure flow with pan and stopwatch.	Flow monitoring device installed in October 2015. Flow is visually monitored and recorded during weekly inspections. Flow is collected into a two inch diameter PVC pipe and discharges into the toe drain outlet structure.
1964 AP-2014-4 (Stantec ASH-6)	Future inspections of the pipe should be performed without water flowing. (Note: this refers to Stantec's Video inspection of the HDPE pipe installed in 2012 between MH#1 in 1964 pond and the new stilling basin outside the 1964 pond.)	Future inspection videos should be performed at a 5-year interval with no flow in the pipe.

Ref. No.	Recommendations	2016 Annual Inspection Status
1964 AP-2014-5	Stability analyses should be performed to improve the adequacy of supporting technical documentation.	Additional analysis performed by AECOM. Based on report dated March 31, 2016, the 1964 Ash Pond Dam is stable for the static and seismic loading conditions outlined in the Duke programmatic guidelines and CCR Rules.
2015-1 Structural (Amec Foster Wheeler)	The riser structure at the Duck Pond within the 1964 Ash Pond could not be evaluated due to lack of information regarding the timber pile foundation system. By inspection, we conclude that this structure was not designed for seismic events and it would likely fail under seismic loading conditions.	Duke evaluating condition to determine appropriate action.
2015-2 Geotechnical (Amec Foster Wheeler)	Slope Stability Analyses: The pseudo seismic acceleration must be updated to meet the requirements of the MPD. Slope stability analyses should be performed for the section at stations 10+00 (where an alluvial layer was indicated) and 13+50 for the downstream section under static and pseudo static load cases.	Additional analysis performed by AECOM. Based on report dated March 31, 2016, the 1964 Ash Pond Dam is stable for the static and seismic loading conditions outlined in the Duke programmatic guidelines and CCR Rules.
2016-1 (Duke Energy weekly inspections)	Small section of riprap on southern downstream slope near abutment road has bare soil. Bare soil should be covered with additional riprap.	Area should be repaired in near future (Duke Work Order # 9583222-3).
2016-2 (Duke Energy weekly inspections)	Northern upstream slope has areas of bare soil and erosion rills in where grading has occurred from the temporary ash stacking project. These areas shall be revegetated.	Bare areas on the northern upstream slope will be revegetated in near future.
2016-3 (Duke Energy weekly inspections)	Erosion along south abutment road.	Erosion shall be continued to be monitored and repaired as necessary.
2016-3 (Duke Energy weekly inspections)	Seepage noted on divider dike on downstream slope into the 1982 basin.	The seep will continue to be monitored during weekly inspections. No flow was observed during the annual inspection.

3.2 Site Maps

3.2.1 Summary of Existing CCR Impoundment Related Structures

A site map that includes a summary of the CCR impoundment-related structures is included as **Figure 3**. This map illustrates the following features that are associated with the CCR units:

- Property boundary (determined from Buncombe County GIS);
- Location of main steam Plant;
- Identification of the CCR surface impoundments and their approximate boundaries;
- 500-foot compliance boundary for the basins (developed from SynTerra information);
- Location of the existing Primary Spillway System and associated features;
- Locations of the Rim Ditch and Decant Basin operations;

- Location of center pond filter system and associated features;
- Drainage culverts downstream of the Ash Basins and under Interstate I-26.

3.2.2 Receptor Survey

SynTerra completed a report, *Drinking Water Well and Receptor Survey for Asheville Steam Electric Plant*, September 2014 (SynTerra 2014a), and later updated it with the *Supplement to Drinking Water Well and Receptor Survey for Asheville Steam Electric Plant*, November 2014 (SynTerra 2014b). The receptor surveys were further updated in the CSA under Section 4.0 (SynTerra 2015a) and in the CSA Supplement 1 (SynTerra 2016b), and Receptor Information with human and ecological receptors, pathways, and their risks associated with exposure to coal ash-derived constituents that maybe present in soil, sediments, surface water, and groundwater are described in Section 5.0 of the CAP part 2 (SynTerra 2016a). Results of the two receptor surveys, and risk assessment updates from the CSA, CAP parts 1 and 2 are herein referred to collectively as receptor surveys, are summarized as follows.

Completion of the receptor surveys included the collection, compilation, and assessment of electronic and field data. Publicly available electronic data used in receptor surveys includes the following sources:

- NCDEQ Division of Environmental Health;
- NC OneMap GeoSpatial Portal;
- DWR Source Water Assessment Program online database;
- County geographic information system;
- Environmental Data Resources, Inc.;
- USGS National Hydrography Dataset.

In addition to the collection and assessment of electronic data, SynTerra completed a visual reconnaissance by driving along public roadways and obtaining information from local property owners using questionnaires. These activities were completed within an approximate 0.5-mile radius of the facility compliance boundary. The goals of these surveys were to identify land development and use, and additional potential water supply wells, including detailed well completion information when possible.

The entire dataset for the receptor surveys was collected to satisfy requirements stipulated by the following:

- CAMA 2014 – North Carolina S.B. 729;
- Notice of Regulatory Requirements received by Duke on August 13, 2014.

In addition to identification of receptors, the compiled data was used to develop a description of the site, surrounding area, geology, and hydrogeology, including a Site Hydrogeologic Conceptual Model (SCM) which are documented in Sections 4.0 and 5.0 of this document.

The results of the receptor surveys conclude the following:

- No public municipal water supply wells exist within the 0.5-mile radius of the compliance boundary. The closest public municipal water supply wells are more than 2 miles from the Site, and produce water from bedrock at depths between 320 to 500 feet below ground surface in areas separated from groundwater near the Asheville Plant by topographic and groundwater divides including the French Broad River;
- Forty private water supply wells and 3 springs were identified within the 0.5-mile radius of the compliance boundary (**Figure B-1, Appendix B**). However, most of the residences receive potable water from municipal water lines, and not all private water wells have been field verified. Additionally, most of these wells are potentially isolated by topographic and groundwater divides, including being west of the French Broad River, or are upgradient of the groundwater flow direction (**Figure B-1, Appendix B**);
- Four of the water supply wells had iron, manganese, sulfate, and TDS above 2L, and NCDEQ recommended that the associated residents use an alternate drinking water supply;
- Five of the 40 private water supply wells within the 0.5-mile radius of the compliance boundary are on the east side of the French Broad River, south of the ash basin along the residential road Bear Leah Trail. A municipal water supply line was completed in 2016 (**Figure B-1, Appendix B**), and the existing private wells along Bear Leah Trail were abandoned in 2016 (SynTerra 2016b);
- Human health exposure media includes potentially impacted groundwater, soil, surface water and sediments with exposure pathways including ingestion, inhalation and dermal contact of the exposure media;
- Potential ecological receptors include aquatic (e.g., fish, benthic invertebrates), semi-aquatic (e.g., piscivorous birds and mammals), and terrestrial (e.g., terrestrial invertebrates, plants, mammals, passerine birds, raptors) receptors;
- While some constituents are found in various media at greater concentrations in the source areas relative to background, many constituents that exceed screening criteria occur at naturally elevated levels.

The identified public and private water supply wells are listed in **Table B-3 of Appendix B**. The table summarizes the following information:

- Map well ID (for figures referenced within the report);
- Property address;
- Property owner;
- Parcel ID number;
- Source of drinking water;

- Well use;
- Approximate distance from compliance boundary (feet);
- Well depth (feet);
- Well casing or open hole depth (feet).

Six of the private water supply wells (DW-3, DW-14, DW-19, DW-27, DW-32, and DW-34) identified within the 0.5-mile radius of the compliance boundary were sampled by NCDEQ for water quality parameters and constituents, including drinking water constituents and parameters, presented in **Table B-1, Appendix B**, between February and July 2015. Two of the sampled wells (DW-3 and DW-19) are on the east side of the French Broad River and south of the Plant. The other four sampled wells (DW-14, DW-27, DW-32, and DW-34) are west of the French Broad River, and south and west of the Plant (**Figure B-1, Appendix B**). Analytical results are further discussed in the CSA.

In 2016, Duke began assessing the water supply wells to understand if the concentrations reflect natural conditions or other potential source areas west of the French Broad River (such as agricultural run-off, use of pesticides, or detergents in septic tank systems). Groundwater underflow across the French Broad River would not be anticipated under natural conditions. Therefore, the assessment is focused on understanding the reason for the constituent concentrations observed (SynTerra 2016b).

Duke collected additional groundwater samples from the former water supply wells on Bear Leah Trail prior to well abandonment and from water supply wells located on the west side of the French Broad River (AS-9, AS-11, AS-13, AS-14, and AS-20) using the available well pumps. Analytical results are further discussed in the CSA Supplement 1, and results are depicted on **Figures 1-14, 1-20, 1-23, 1-47, and 1-50 (Appendix B)**.

The risk assessment synopsis in Section 5.0 of part 2 of the CAP also states that media exposure estimates were less than their respective risk-based concentrations (RBCs) for current use exposure to groundwater with respect to construction and commercial worker exposure via dermal and incidental ingestion pathways. Additionally, Haley and Aldrich (2015) performed an analysis of the groundwater data collected by NCDEQ from 8 private drinking water wells located less than 0.5 miles of the Asheville facility, and 13 private drinking water wells located within a 2 to 10 mile radius of the Asheville facility that concluded the testing provided no evidence for a coal ash management unit release related impact. However, based on lowest observed adverse effect level-derived toxicity reference values, the baseline ecological risk assessment identified potential risk to wildlife from barium, manganese, molybdenum, selenium, and vanadium in seeps and seep soils within the immediate ash basin area (SynTerra 2016a). The settling pond was also identified as a potential risk to wildlife associated with selenium exposure, and in the French Broad River the selenium lowest observed adverse effect level-based HQ was 1 for the meadow vole receptor. However, SynTerra states that the food chain model for risk is an over estimate and selenium is not expected to pose unacceptable risks to ecological receptors in the French Broad River floodplain.

Part 2 of the CAP, Section 2.6, also states numerous wells have been abandoned since completion of the CSA and are provided in Appendix A of Part 2 of the CAP.

3.2.3 Existing On-Site Landfills

No existing on-site landfills are present at the Asheville Plant.

3.3 Monitoring and Sampling Location Plan

SynTerra provided a groundwater monitoring and sampling location plan in the CSA for future monitoring. The monitoring well locations of both historical and planned sampling are shown on **Figure 2-1 and Figure 16-1 of Appendix B**.

3.3.1 Interim Groundwater Monitoring Plan

The groundwater monitoring and sampling location plan is a longer-term, future sampling plan described under Section 16.0 of the CSA. The goals of this plan are to collect sufficient data to determine site-specific background water quality concentrations, support current interpretations of Site data, and to monitor for temporal trends.

The Interim Groundwater Monitoring Plan recommends a total of 46 monitoring well locations within 5 different geologic units including (**Table 16-2 and Figure 16-1, Appendix B**):

- Alluvium – 9 monitoring wells;
- Transition Zone – 17 monitoring wells;
- Saprolite – 8 monitoring wells;
- Bedrock – 12 monitoring wells.

The groundwater monitoring wells were also selected to include a combination of the above geologic units for groundwater monitoring in areas based on the following rationales:

- Determine background concentrations upland of basins – 9 monitoring wells;
- Downslope of the ash basin, both next to the French Broad River (13 monitoring wells) and southwest (8 monitoring wells) of the Site – 21 monitoring wells;
- Monitor contaminant migration south (2 monitoring wells), east (2 monitoring wells), and northwest (5 monitoring wells) of the basins – 9 monitoring wells;
- Next to 1964 basin, to monitor intersecting flow path to French Broad River – 7 monitoring wells.

The recommended parameter and constituent list includes a set of 6 field parameters, a suite of 21 inorganic constituents, major cations and anions, nitrate, total dissolved solids (TDS), total organic carbon (TOC), and total suspended solids (**Table 16-1, Appendix B**). Analytical methods and associated reporting limits are also provided for each parameter and constituent (**Table 16-1, Appendix B**).

The Interim Groundwater Monitoring Plan recommends a triannual groundwater sampling frequency intended to provide insight into potential seasonal trends, if any.

The Interim Groundwater Monitoring Plan presented in Section 16.0 of the CSA described above will be superseded by the updated Interim Monitoring Plan (IMP), and a post-closure Effectiveness Monitoring Program (EMP) described in Section 9.0 of Part 2 of the CAP, if and when the proposed remedial actions are accepted as proposed in Part 2 of the CAP. The IMP and EMP proposed in Part 2 of the CAP are described in further detail under **Section 11** of this document.

Additional characterization of the bedrock flow system beneath the ash basins and at a background location was requested by NCDEQ (SynTerra 2016b). Monitoring well ABMW-11BR was installed at a central location within the 1964 and 1982 Ash Basin waste boundary **(Figure 1-2, Appendix B)**. ABMW-11BR has been sampled twice since installation. Monitoring well CB-1BRL was also installed at a background location **(Figure 1-2, Appendix B)**.

4. RESULTS OF HYDROGEOLOGIC, GEOLOGIC, AND GEOTECHNICAL INVESTIGATIONS

The information in this section is a summary based on the Phase 2 Reconstitution Report (Amec Foster Wheeler 2015e), CSA report (SynTerra 2015a), and CSA Supplement 1 (SynTerra 2016b). More detailed descriptions can be found in the original reports.

4.1 Hydrogeology and Geologic Descriptions

4.1.1 Regional Geology

The Plant is within the Blue Ridge Physiographic Province of North Carolina. This province is characterized by a mountainous vegetated terrain with elevations ranging from 1,500 feet above mean sea level at the base of the escarpment to summit altitudes of over 6,000 feet.

The formations that underlie the Blue Ridge Physiographic Province primarily consist of complexly folded and faulted metamorphic and igneous rock with some sedimentary rock that make up the Blue Ridge geologic belt. The Blue Ridge geologic belt complexity is a result of extensive sheet thrusting, and is bounded to the southeast by the Brevard zone, a zone of major southwest–northeast faulting, and to the northwest by the Valley and Ridge Physiographic province in eastern Tennessee that are composed of low angle thrust faults. Within the Brevard zone, there are two major thrust faults approximately 1.3 miles southeast of the site (**Figure 6-1, Appendix B**). Since their deformation and Cenozoic uplift, this assemblage of metasedimentary and metavolcanic rock has been exposed and subjected to an extended period of erosion, and the erosion has produced a rugged terrain, consisting of steep mountains, intermittent basins, and trench valleys.

4.1.2 Regional Hydrogeology

Due to the geologic complexity of the Blue Ridge Physiographic Province, numerous studies have been conducted, including the USGS Regional Aquifer-System Analysis, which refers to hydrogeologic terranes instead of identifying specific aquifers and confining units for the province. Groundwater occurrence in the Blue Ridge Physiographic Province has been grouped into two hydrogeologic terranes identified by rock types and median well yields:

1. Gneiss-granite terrane having an interquartile well yield of approximately 8 to 32 gallons per minute (gal/min);
2. Schist-sandstone terrane having an interquartile well yield of approximately 10 to 61 gal/min.

Groundwater resides within the soil/saprolite regolith and is hydrologically connected with the underlying fractured bedrock forming a composite water-table aquifer system. Local groundwater flow is primarily influenced by 1) the soil/saprolite regolith thickness, and its existence, and 2) the nature of the parent bedrock. Typically, topographic highs exhibit thinner soil/saprolite zones, and topographic lows exhibit thicker soil/saprolite zones, with gneiss and schist rock sources having thicker soils and relatively higher fracture densities compared to unaltered igneous rocks, including granite. The higher fracture density and thicker soil zones of the gneiss and schist bedrock provide efficient transition zones with less clay, and may facilitate both rapid lateral groundwater movement along unweathered bedrock and vertical groundwater movement to underlying fractured rock.

Groundwater flow is also influenced in the area by precipitation serving as recharge, seasonal water table fluctuations with highs in the winter and lows in the fall, flow boundaries such as rivers, and topography where ridges can serve as groundwater divides. In general, groundwater flow in the area can be classified as a slope-aquifer system.

4.2 Stratigraphy of the Geologic Units Underlying Surface Impoundments

The stratigraphy of geologic units underlying the surface impoundments is similar in characteristics described for the local and regional geology. A comparison of preconstruction topography before installation of the ash basin to current elevations is consistent with measured ash thickness in core samples and indicates ash depth generally mimics the historical land surface. Borings drilled within the ash basins indicated a distinct contact between the ash and underlying soils without visible evidence of ash staining into underlying soils (Section 7 of CSA report).

In particular, the ash basins directly overly the local residual soils (Section 7 of CSA report). Toward the Lake Julian dam, ash overlies saprolite with increasing thickness (**Figure 6-3 and Figure 6-4, Appendix B**). The saprolite within the ash basin is underlain by transition zone media and a bedrock of mica gneiss, a member of the late Precambrian Ashe Metamorphic Suite. The Geologic Map of the Skyland Quadrangle (Dabbagh 1981) describes the underlying bedrock as being mainly composed of gray to dark gray, fine- to medium-grained gneiss. Of note is a shear zone trending northeast-southwest, which is mapped to underlie the approximate northwestern side of the 1982 Ash Basin.

4.3 Hydraulic Conductivity Information

The horizontal hydraulic conductivities of the site hydrogeologic zones were determined from in-situ field slug testing of wells in accordance with the Groundwater Assessment Work Plan (GAP) Section 7.1.4 (**Table 6-5, Appendix B**). The slug tests were performed in accordance with the documented standard ASTM D4044-96 (Appendix C of CSA report [SynTerra 2015a]). A total of 143 slug tests was performed at 47 well locations (**Table 4-1**). The tests were analyzed primarily by the Hvorslev analytical solution, with some well tests analyzed by the Bouwer-Rice analytical solution for wells that were not fully penetrating (Appendix G of CSA report [SynTerra 2015a]) according to the methodology described in Appendix C of the CSA report. Locations of tested wells are shown on **Figure 2-1 of Appendix B**.

The slug testing results listed in **Table 6-5 of Appendix B** includes individual well test hydraulic conductivity results, calculated geometric means for repeated testing of individual wells and for each hydrogeologic zone having multiple well results, and minimum and maximum values for individual wells and for each hydrogeologic zone. Testing results include testing of wells completed in hydrogeologic zones below the ash basins and in the surrounding area (**Figure 2-1, Appendix B**).

Table 4-1: Summary of Hydraulic Conductivity Geometric Mean Monitoring Well Slug Testing Results for Each Hydrogeologic Zone

Hydrogeologic Zone	Number of Wells Tested	Number of Slug Tests	Hydraulic Conductivity Geometric Mean (cm/sec)	Hydraulic Conductivity Geometric Mean (ft/day)
Ash Basins	3	7	1.52E-04	4.32E-01
Alluvium	2	15	3.21E-03	9.09E+00
Saprolite	7	25	2.83E-04	8.01E-01
Transition Zone	18	57	3.09E-04	8.76E-01
Bedrock	17	39	4.77E-04	1.35E+00

The results of slug testing indicate spatial variability throughout the site and between different hydrogeologic zones. Slug testing of alluvial deposits indicated approximately an order of magnitude higher hydraulic conductivity than other hydrogeologic zones (**Table 4-1**).

The hydraulic conductivity values for wells screened in the transition zone spanned three orders of magnitude from 1.1 × 10E-5 to 1.3 × 10E-2 centimeters per second (cm/sec), with a mean of 3.1 × 10E-4 cm/sec (**Table 6-5, Appendix B**). The large range in results reflects the degree of weathering which can be highly variable within the transition zone and related to the degree of infilling of fractures, varying amounts of clays, and other weathering products.

In addition to in-situ, horizontal hydraulic conductivity slug testing, three laboratory vertical hydraulic conductivity tests were performed on cores collected in Shelby tubes. These laboratory tests are reflective of site conditions because the ash basin is not lined (**Table 6-6, Appendix B**). A 2.5-foot core was collected from bore hole ABMW-02SB, and 2-foot cores were collected from both ABMW-07 and MW-16SB (**Table 6-6, Appendix B**). The intervals selected for testing the core represent three distinct zones: saprolite, ash, and alluvium, with values of 2.60E-06, 8.60E-06, and 4.80E-07 cm/sec, respectively. The vertical conductivity testing results are one to two orders of magnitude lower than horizontal conductivity values from in-situ slug testing, supporting a predominantly lateral groundwater flow in the Site area. In addition, the results support a predominantly lateral migration of COIs relative to vertical migration.

4.4 Geotechnical Properties

Subsurface investigations were performed as part of previous design and reconstitution projects at the Asheville Steam Electric Generating Plant. A summary of available boring, monitoring well, and piezometer locations involving the ash basins is shown on **Figure 4**. In these investigations, geotechnical properties were developed to characterize the soils and ash present at the site. As previously discussed, there is no liner underneath the ash basins. For this Removal Plan, the geotechnical properties listed below were gathered from the following previous reports:

- Amec Foster Wheeler, "Subsurface Exploration and Laboratory Testing Data Report, Landfill Development and Ash Basin Closure," August 2015;
- Amec Foster Wheeler, "Phase 2 Reconstitution of Ash Pond Designs, Final Report Submittal, Revision B, Asheville Steam Station," July 17, 2015;
- S&ME, Inc., "Subsurface Investigation and Slope Stability Analysis of 1964 Ash Basin Dike," December 28, 2009;
- S&ME, Inc. "1964 Ash Basin Dam Improvement Design – Appendix I – Slope Stability Analysis Discussion and Summary," December 28, 2009;
- MACTEC Engineering and Consulting, Inc., "Geotechnical Exploration Data Report, Asheville FGD Project, Constructed Wetlands System," October 18, 2004;
- MACTEC Engineering and Consulting, Inc., "Report of Geotechnical Exploration, 1982/1964 Ash Pond Drainage Modification Project," January 19, 2011;
- MACTEC Engineering and Consulting, Inc., "Final Report for Task ASH-1 Issue," August 2014;
- Law Engineering, Inc., "Stability Analysis of Downstream Slope, 1982 Ash Pond Dike," September 30, 1992;
- AMEC, "Asheville Steam Plant, Final Report for Task ASH-2 Issue," August 26, 2014.

1982 Ash Basin Dam

Design parameters for the 1982 Ash Basin Dam were developed from the analysis completed by Law Engineering (1992) and from the Phase 2 Reconstitution of Design report (Amec Foster Wheeler 2015e). The following material properties were developed from these analyses:

Table 4-2: Unit Weight and Shear Strength Parameters for the 1982 Ash Basin Dam

Material Description	Unit Weight	Shear Strength			
		Effective		R-Envelope	
	(pcf)	c' (psf)	Φ' (degree)	c' (psf)	Φ' (degree)
Embankment	120	400	33.9	0	32.8
Sand Drain	120	0	36	0	36
Foundation Soil	130	400	32	650	30
Partially Weathered Rock	135	10,000	45	10,000	45

*Note: Material Description information is included in the Phase 2 Reconstitution Report (Amec Foster Wheeler 2015e).

<u>1964 Ash Basin Dam</u>

The subsurface stratigraphy for the dam has been based on the stability analysis completed for the 1964 Ash Pond Dam (S&ME 2009) and on the Phase 2 Reconstitution of Design report (Amec Foster Wheeler 2015e). The following material properties were developed from this analysis:

Table 4-3: Unit Weight and Shear Strength Parameters for the 1964 Ash Basin Dam

Material Description	Unit Weight	Shear Strength			
		Effective		R-Envelope	
	(pcf)	c’ (psf)	Φ’ (degree)	c’ (psf)	Φ’ (degree)
Zone 1 - Core	120	200	32	600	17
Zone 2 - Rock Shell	120	0	47	0	47
Zone 3 – Mixed Fill	120	0	40	440	24
Zone 4 – Drainage Zone	120	0	36	0	36
Upstream Rockfill	120	0	40	0	40
Ash Fill	120	0	30	0	30
Ash (Above Water)	85	0	30	0	30
Ash (Below Water)	85	0	30	0	20
Ash Stack	85	0	30	0	30
Original 1964 Dike Fill	120	0	40	420	21
1971 Cofferdam Fill	120	0	30	300	20
Stilling Pond Embankment	120	140	33	400	20
Alluvium	120	50	28	50	24
Residual Soil	120	115	35	330	25
Partially Weathered Rock	120	1000	40	1000	40

*Note: Zone and Material Description information is included in the Phase 2 Reconstitution Report (Amec Foster Wheeler 2015e)

Separator Dike

The design parameters for the Separator Dike were developed from the Final Report for Task ASH-2 Issue (AMEC 2014b) and from the Phase 2 Reconstitution of Design report (Amec Foster Wheeler 2015e). The following material properties were developed from these analyses:

Table 4-4: Unit Weight and Shear Strength Parameters for the Separator Dike

Material Description	Unit Weight	Shear Strength			
		Effective		R-Envelope	
	(pcf)	c’ (psf)	Φ’ (degree)	c’ (psf)	Φ’ (degree)
Embankment	120	400	33.9	0	32.8
Zone 3	120	0	40	435	24.4
Ash	85	210	28.8	40	19.4
Zone 1	120	200	32	1000	16.9
Foundation Soil	130	400	32	650	30
Partially Weathered Rock	135	10,000	45	10,000	45

*Note: Zone and Material Description information is included in the Phase 2 Reconstitution Report (Amec Foster Wheeler 2015e).

<u>Residual Materials in 1982 Ash Basin</u>

Amec Foster Wheeler drilled an additional 30 borings within the limits of the 1982 Ash Basin. Laboratory tests were performed on samples collected from these borings. The samples generally consisted of ash fill within the basin, and residual materials from the original ground underlying the basin. Since ash removal was completed on September 30, 2016, **Table 4-5** only lists the material properties that were developed for the residual materials from these analyses.

TABLE 4-5
Index Property Test Results of Materials in 1982 Ash Basin

Boring	Sample Type	Sample Depth (Feet bgs)	Visual Identification	Natural Moisture Content, %	Dry Unit Weight, pcf	Atterberg Limits			Percent Finer Than No. 200 Sieve	Other Test
						Liquid Limit	Plastic Limit	Plasticity Index		
BL-1A	UD-1	15-17	Yellowish Brown Silt with Sand (ML)-RESIDUUM	74.8* 81.6*		NP	NP	NP	82.8	S.G. = 3.00 k
BL-8	Bulk-1	0-10	Brown Silty Sand (SM) - RESIDUUM	22.7*		NP	NP	NP	41.1	S.G. = 2.72 P
BL-14	Bulk-1	0-8.9	Brown Silty Sand (SM) - RESIDUUM	12.9 12.7*		NP	NP	NP	27.7	S.G. = 2.78 P
BL-19	Bulk-1	0-10	Brown Silty Sand (SM) - RESIDUUM	17.8		NP	NP	NP	36.2	S.G. = 2.73 P

SPT-Standard Penetration Test/Split-Spoon; UD-Undisturbed Sample;
P - Moisture-Density Relationship Test; NP-Non Plastic;
k – Hydraulic Conductivity Test; S.G.-Specific Gravity Test
*Result obtained from a different laboratory test method (i.e., Hydraulic Conductivity, Atterberg limit test, etc.)

Prepared/Date: H. Benkhayal/7-29-2015
Checked/Date: C. Tockstein/7-29-2015

CCR and Residual Materials in 1964 Ash Basin

A subsurface investigation was performed by Amec Foster Wheeler in 2015 with the intent of providing additional information for the development of closure and/or landfill options for the ash basins. As part of this investigation, 10 borings were drilled within the limits of the 1964 Ash Basin. Laboratory tests were performed on samples collected from these borings. The samples generally consisted of ash fill within the basin, and residual materials from the original ground underlying the basin. The following material properties were developed from these analyses:

TABLE 4-6
Index Property Test Results of Materials in 1964 Ash Basin

Boring	Sample Type	Sample Depth (Feet bgs)	Visual Identification	Natural Moisture Content, %	Dry Unit Weight, pcf	Atterberg Limits			Percent Finer Than No. 200 Sieve	Other Test
						Liquid Limit	Plastic Limit	Plasticity Index		
BC-2	UD-1	21-23	Dark Gray Sandy Silt (ML) - Fly Ash - FILL	26.7*		NP	NP	NP	55.4	S.G. = 2.15
BC-2	UD-2	51-53	Brown Micaceous Silty Sand (SM) - RESIDUUM	18.5* 20.5*		NP	NP	NP	13.7	S.G. = 2.81 k
BC-4	SPT-1	3.5-5	Light to Dark Gray Sandy Silt - Fly Ash - FILL	35.5						
BC-4	SPT-2	8.5-10	Light to Dark Gray Sandy Silt - Fly Ash - FILL	35.4						
BC-4	SPT-3	13.5-15	Dark Gray Sandy Silt - Fly Ash - FILL	34.3						
BC-4	SPT-4	18.5-20	Dark Gray Sandy Silt - Fly Ash - FILL	40.9						
BC-4	SPT-6	28.5-30	Dark Gray Sandy Silt - Fly Ash - FILL	47.0						
BC-4	SPT-8	40-41.5	Dark Gray Sandy Silt - Fly Ash - FILL	46.8						
BC-4	SPT-10	48.5-50	Dark Gray Sandy Silt - Fly Ash - FILL	45.5						
BC-4	SPT-12	58.5-60	Dark Gray Silty Sand with Gravel - Fly Ash - FILL	38.4						
BC-4	SPT-14A	68.5-69.2	Light to Dark Gray Sandy Silt - Fly Ash - FILL	37.7						
BC-4	SPT-14A	69.2-70	Reddish Brown Sandy Lean Clay - RESIDUUM	24.8						
BC-4	SPT-16	78.5-79	Dark Gray and Brown Silty Sand - RESIDUUM	29.8						

SPT-Standard Penetration Test/Split-Spoon; UD-Undisturbed Sample;
P – Moisture-Density Relationship Test; NP-Non Plastic; k – Hydraulic Conductivity Test;
S.G.-Specific Gravity Test *Result obtained from a different laboratory test method (i.e. Hydraulic Conductivity, Atterberg limit test, etc.)

Prepared/Date: H. Benkhayal/7-29-2015
Checked/Date: C. Tockstein/7-29-2015

TABLE 4-6 (Continued)
Index Property Test Results of Materials in 1964 Ash Basin

Boring	Sample Type	Sample Depth (Feet bgs)	Visual Identification	Natural Moisture Content, %	Dry Unit Weight, pcf	Atterberg Limits			Percent Finer Than No. 200 Sieve	Other Test
						Liquid Limit	Plastic Limit	Plasticity Index		
BC-4	UD-1	20-22	Dark Gray Silty Sand (SM) - Fly Ash - FILL	18.0*		NP	NP	NP	43.8	S.G. = 2.34
BC-5	Bulk-1	28.5-38.5	Dark Gray Silt with Sand (ML) -Fly Ash - FILL	31.3*		NP	NP	NP	80.5	S.G. = 2.26 P
BC-7	Bulk-1	5-15	Dark Gray Silt (ML) - Fly Ash - FILL	25.6*		NP	NP	NP	84.8	S.G. = 2.34 P
BC-8	UD-1	26-28	Reddish Brown Silty Sand (SM) - RESIDUUM	14.8*		NP	NP	NP	30.1	S.G. = 2.73 k
BC-8	UD-2	55.5-57.5	Gray Micaceous Silty Sand (SM) - RESIDUUM	27.5* 32.5*		NP	NP	NP	25.3	S.G. = 2.80 k
BC-9	SPT-1	5-6.5	Very Dark Gray Sandy Silt – Fly Ash - FILL	32.4						
BC-9	SPT-2	8.5-10	Very Dark Gray Sandy Silt – Fly Ash - FILL	42.2						
BC-9	SPT-3	13.5-15	Very Dark Gray Sandy Silt – Fly Ash - FILL	39.3						
BC-9	SPT-4	18.5-20	Very Dark Gray Sandy Silt – Fly Ash - FILL	32.5						
BC-9	SPT-5	23.5-25	Very Dark Gray Sandy Silt – Fly Ash - FILL	51.9						
BC-9	SPT-6	28.5-30	Very Dark Gray Sandy Silt – Fly Ash - FILL	43.6						
BC-9	SPT-7	33.5-35	Very Dark Gray Sandy Silt – Fly Ash - FILL	58.1						

SPT-Standard Penetration Test/Split-Spoon; UD-Undisturbed Sample;
P - Moisture-Density Relationship Test; NP-Non Plastic; k – Hydraulic Conductivity Test;
S.G.-Specific Gravity Test *Result obtained from a different laboratory test method (i.e. Hydraulic Conductivity, Atterberg limit test, etc.

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Checked/Date: C. Tockstein/7-29-2015

TABLE 4-6 (Continued)
Index Property Test Results of Materials in 1964 Ash Basin

Boring	Sample Type	Sample Depth (Feet bgs)	Visual Identification	Natural Moisture Content, %	Dry Unit Weight, pcf	Atterberg Limits			Percent Finer Than No. 200 Sieve	Other Test
BC-9	SPT-9	43.5-45	Very Dark Gray Sandy Silt – Fly Ash - FILL	78.5						
BC-9	SPT-11	53.5-55	Strong Brown, Yellow, and Dark Reddish Brown Sandy Silt - RESIDUUM	23.4						
BC-9	SPT-13	63.5-65	White, Strong Brown, and Very Dark Gray Sandy Silt - RESIDUUM	40.7						
BC-10	Bulk-1	13.5-23.5	Dark Gray Silt (ML) - Fly Ash - FILL	27.9*		NP	NP	NP	86.1	S.G. = 2.30 P
BC-10	UD-1	35-37	Gray Silt (ML) - Fly Ash - FILL	26.8*		NP	NP	NP	97.8	S.G. = 2.31

SPT-Standard Penetration Test/Split-Spoon; UD-Undisturbed Sample;
P - Moisture-Density Relationship Test; NP-Non Plastic; k – Hydraulic Conductivity Test;
S.G.-Specific Gravity Test *Result obtained from a different laboratory test method (i.e. Hydraulic Conductivity, Atterberg limit test, etc.)

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Checked/Date: C. Tockstein/7-29-2015

4.5 Chemical Analysis of Impoundment Water, CCR Materials and CCR Affected Soil

Source area characterization of the site is described in the CSA (SynTerra 2015a) and supplemented by the CAP Part 1 (SynTerra 2015b). The characterization includes the collection and analysis of soil, groundwater, surface water, and sediment samples from the ash basins and surrounding area to identify provisional background concentrations and the extent of impacts. Sample locations are identified on **Figure 2-1, Appendix B**. Development of groundwater provisional background concentrations for key constituents is an ongoing process that primarily entails collection of sufficient groundwater samples to provide statistically meaningful results. The long-term goal is to calculate upper prediction limits for the pool of background data to be used for comparison to samples collected from monitoring wells located hydraulically downgradient of the ash basins. EPA guidance documents indicate that eight to 10 rounds of background sample data are necessary to develop meaningful provisional background concentrations. Six rounds of background sample data are included in the CSA Supplement 1 (SynTerra 2016b), and results are tabulated in **Tables 4-1 through 4-8 (Appendix B)**.The analysis of CCR ash and pore water from the ash basins resulted in the identification of Site-specific constituents of interest (COIs). The COIs are constituents that are associated with the ash basin and are elevated above background values. Some COIs are also identified in water quality samples collected from background monitoring wells, and they require careful examination to determine their origin and source. The COIs identified from the Asheville Plant ash material and pore water sample analyses include antimony, arsenic, boron, chromium, cobalt, iron, manganese, sulfate, thallium, TDS, vanadium, and pH. These COIs are identified as exceeding either the 2L or Interim Maximum Allowable Concentrations (IMAC) in at least one ash pore water monitoring well (CSA report [SynTerra 2015a]).

4.5.1 Source Area(s) Characterization

Included in this section are the results of the ash basin and seep source area characterization, as presented in the CSA Report (SynTerra 2015a). Media sampled by SynTerra included ash matrix, ash porewater, settling basin surface water, and seep water.

CCR Ash Materials Chemical Analyses Results

A total of 10 borings and 13 monitoring wells were drilled and installed using rotary sonic drilling with continuous sample recovery (Section 7 of CSA report [SynTerra 2015a]). The drilling locations were divided between the 1964 (borings AB-01 and AB-03 and monitoring wells ABMW-02, ABMW-02S, ABMW-04, ABMW-04D, and ABMW-04BR) and the 1982 (borings AB-09 and AB-10 and monitoring wells ABMW-05S, ABMW-05D, ABMW-05BR, ABMW-06BR, ABMW-07, ABMW-07S, ABMW-07BR and ABMW-08) ash basins (Appendix E of the CSA report). During this drilling program, ash samples were collected from the basin in accordance with GAP Section 7.1.1 for analysis of total metals, U.S. Environmental Protection Agency (USEPA) Synthetic Precipitation Leaching Procedure (SPLP), and Energy Dispersive X-Ray

Fluorescence (EDXRF) with documented methodologies in Appendix C of the CSA report (SynTerra 2015a).

Results from 16 ash samples were analyzed for total metals, and results identified 14 constituents (aluminum, antimony, arsenic, barium, beryllium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, selenium, and vanadium) at levels exceeding one or more of the USEPA Soil Regional Screening Level (**Table 7-4, Appendix B**). Ash samples from the basin were also analyzed for TOC content and resulted in values from 9,630 to 87,800 milligrams per kilogram.

Results from eight ash samples tested using the SPLP method were compared to the 2L for informational purposes and values of antimony, arsenic, chromium, cobalt, iron, manganese, nitrate, selenium, thallium, and vanadium were typically in exceedance of the 2L reference values. However, boron in ash SPLP leachate was not in exceedance of the 2L value. These results were also compared to background soil values. The comparison of ash SPLP leachate results to background soil values indicates the following:

- Antimony, arsenic, selenium, and vanadium values in SPLP leachate from ash are higher than background soils. However, these metals are typically not detected in background soils, with the exception of vanadium and sporadic selenium.
- Boron, chromium, cobalt, iron, lead, manganese, nitrate, and thallium leachate results indicate similar ranges of concentrations from soils and ash.

While the above metals are identified as being elevated in the SPLP leachate of ash samples, SPLP concentrations in soil samples collected from below the ash basins do not suggest migration of these metals from the source material.

Results from three ash samples analyzed by EDXRF indicate whole rock metal oxide (**Table 7-6, Appendix B**) and elemental content (**Table 7-7, Appendix B**). The results indicate the ash primarily consists of oxides of silicon (SiO_2), aluminum (Al_2O_3), and iron (Fe_2O_3) (**Figure 7-1, Appendix B**).

Results from chemical analyses of ash samples collected throughout the ash basins indicate aluminum, arsenic, barium, cobalt, iron, lead, manganese, mercury, selenium, and vanadium are above either the USEPA Regional Screening Level (RSL) for Protection of Groundwater or Residential Health.

<u>CCR Ash Impoundment Pore Water Chemical Analyses Results</u>

Ash pore water quality samples were collected for analysis of the expanded analyte list, metals speciation, and radiological parameters. The samples were collected from ash basin monitoring wells ABMW-02 and ABMW-04 in the 1964 Ash Basin (**Table 7-8, Appendix B**), and from monitoring wells ABMW-08, P-100, P-101, and P-103 in the 1982 Ash Basin. The results indicate that antimony, arsenic, boron, chromium, cobalt, iron, manganese, sulfate, thallium, TDS, vanadium, and pH are above the 2L or IMAC in ash pore water (**Table 7-9, Appendix B**).

Analysis of the analytical results using published methods referenced in the CSA also indicate that the redox state of pore water within both the ash basins is anoxic, with some mixed anoxic processes identified at well ABMW-04 in the 1964 basin (**Table 7-8, Appendix B**).

Speciation results of arsenic, chromium, iron, manganese, and selenium are provided for wells ABMW-02 and ABMW-04 (**Table 7-10, Appendix B**). The results indicate that trivalent iron is the predominant species of iron in both well pore water samples, and hexavalent chromium is below the USEPA tapwater screening level of 0.035 microgram per liter (µg/L) in ash pore water.

Settling Basin Surface Water Characteristics

One surface water sample was collected from the settling basin located within the 1964 Ash Basin, SW-05 (**Table 9-3, Appendix B**) [SynTerra 2015a]. Most of the constituent detections above the 2L or 2B values were from this sample. SynTerra noted no corrective action is necessary because the wastewater from this basin is under a NPDES permit.

Summary of CCR Waste Boundary Seep Water Sediment Characteristics

Seeps have been documented and sampled by SynTerra (**Figure 2-1, Appendix B**). Seep data includes results from the June 2014 Asheville Seep Monitoring Report (SynTerra 2014c) with samples from 17 representative seeps below (downgradient of) the ash basins, NCDENR seep sampling in 2014 (**Table 9-4, Appendix B**), and seep results from 11 seeps that confirm the extent of impacted groundwater with COI values above the 2L or IMAC (**Table 9-2, Appendix B**). Concentrations from seep P-01 are consistent with background surface waters (**Figures 9-1 and 9-2, Appendix B**). SynTerra also compared the results of the 11 seep samples in **Table 9-2, Appendix B**, to North Carolina Administrative Code (NCAC) Surface Water (2B) values.

4.5.2 Surface Water and Sediment Assessment

Summary of Surface Water Characteristics

Samples of sediment, surface water, and seeps were collected in August 2015 and analyzed for water quality (**Figure 2-1, Appendix B**). Sediment samples were collected from the same locations of surface water and seep sample water quality collection (**Figure 2-1, Appendix B**).

Sediment sample results from background locations exceed one or more RSLs for a few COIs including aluminum, cobalt, iron, and manganese (**Table 9-1, Appendix B**). The sediment samples collected from seeps below (downgradient of) the ash basins exceeded the RSL for COIs including aluminum, antimony, arsenic, barium, cobalt, copper, iron, manganese, mercury, molybdenum, nickel, selenium, and thallium in at least one sample. The side-gradient sediment sample results from SW-01 are generally similar to background values except for elevated aluminum and barium.

SynTerra provided results for surface water samples collected from the French Broad River (upstream and downstream from the Site), Lake Julian, and areas within the French Broad River floodplain. Two samples, one from upstream of the French Broad River (FB-01) and the other from Lake Julian (SW-06), serve as background locations for comparison. Surface water sample results to seep sample results are compared in Piper diagrams (**Figures 9-1 and 9-2, Appendix**

B). The upstream and downstream French Broad River samples did not vary. However, thallium was detected only at the upstream site (0.202 µg/L), which may indicate other potential sources of thallium outside the ash basins. The surface water samples that have concentrations greater than 2B values are listed in **Table 9-5, Appendix B**. Surface water sample results for constituents that are elevated compared to background and lack a 2B value include boron, iron, manganese, sulfate, TDS, and vanadium.

In part 2 of the CAP, Section 2.5, SynTerra reports that additional seep, surface water, and sediment data was collected in November 2015 with a seep inspection performed on November 19, 2015. The results of an initial screening of the data indicates no substantial variation from August 2015 with no newly identified seeps.

To further refine knowledge of hydrogeologic conditions, ten stream gauges were installed in March 2016. Gauges were co-located with CSA surface water sample locations A-01, A-02, B-01, C-01, and D-01, spanning the eastern side of the French Broad River along the western stretch of the property boundary. Gauges were also co-located at SD-01 and N-01, representing the western portion of Powell Creek below the Lake Julian dam. A gauge was placed in the outfall area of the 1964 dam, correlating to surface water sample location C-02. Stream gauge survey information is provided in **Table 1-1 (Appendix B)**. Four surface water features (two springs and two surface water drainages) were sampled as part of the additional assessment west of the French Broad River (SynTerra 2016b). The purpose of collecting surface water samples is to evaluate the contribution of agricultural and domestic activities to observed concentrations of boron in water supply wells. The primary area targeted for investigation is located on the same parcel as AS-14 (115 Justin Trail). In May 2016, four surface water samples were collected in upgradient, sidegradient, and downgradient areas to agricultural fields. Data is presented in **Table 3-1 (Appendix B)**.

4.6 Historical Groundwater Sampling Results

A detailed description of groundwater characterization from the installation and sampling of 47 new monitoring wells and 36 existing monitoring wells is provided in Section 10 of CSA report (SynTerra 2015a). A summary of those findings is provided in this section.

The sampling locations and dates are listed in **Table 10-1 of Appendix B**, and the full parameter list with analytical methods and reporting limits are listed in **Table 10-2 of Appendix B**. Analytical results are listed in **Table 10-3 of Appendix B**.

The results of groundwater sampling indicate that 18 analytes exceed the 2L or IMAC in groundwater at the Site (**Table 10-4, Appendix B**). The area of groundwater concentrations exceeding 2L is identified under the ash basins and to the west along groundwater flow lines up to the French Broad River (**Figure ES-1, Appendix B**). Five of the 18 parameters (pH, cobalt, iron, manganese, and vanadium) exceed the 2L or IMAC in one or more background wells. In 2013, chromium was sporadically detected above the 2L limit at background monitoring well CB-01. While concentrations for 18 parameters are in exceedance of 2L or IMAC values, no private or public wells are within the impacted area (**Figures ES-1, and 10-5 to 10-56, Appendix B**).

The speciation data results are presented in **Table 10-3 of Appendix B** and indicate the following:

- Background groundwater is oxic, with oxic and mixed conditions in groundwater upgradient of the ash basins.
- Groundwater beneath the ash basins is anoxic and mixed anoxic.
- Downgradient and side gradient groundwater is variable.

Part 2 of the CAP, Section 2.6, discusses additional characterization of the bedrock flow system beneath the ash basins at a background location is included within data gap activities as requested by NCDEQ. The information collected during the data gap activities is not expected to substantially alter the groundwater corrective action plans proposed in Part 2 of the CAP. The data gap activities include confirmation sampling on a private water supply well located on the west side of the French Broad River, and confirmed initial results of iron, manganese, and TDS at levels greater than the 2L standard, and boron elevated above background but below the 2L standard. Additionally, a third and fourth set of CSA groundwater data was collected in December 2015 and January 2016 for comparison to the initial two sets of data and to supplement background data. Six rounds of monitoring for CSA parameters have been completed through July 2016 and **Tables 1-2 through 1-5 (Appendix B)** provide a summary of groundwater from all sampling events completed to date (*e.g.*, CSA and NPDES programs) that exceed 2L or IMAC for each of the primary hydrogeologic flow zones (surficial transition zone, and bedrock). Additional sampling is scheduled in September and November of 2016 from select Asheville wells (**Table 1-8, Appendix B**). Additional data from sampling results and results of analysis are included in the CSA Supplement 1 (SynTerra, 2016b). CAMA sampling locations are summarized in **Table 1-8 (Appendix B)** with locations and rationale for inclusion. Background wells CB-09 (saprolite), CB-09SL (lower saprolite), CB-09BR (bedrock), CB-01 (surficial), CB-01D (transition zone), AMW-03B (bedrock), and MW-10 (alluvial) are planned to be monitored to provide a more robust data set for provisional background concentration evaluation. Groundwater data reported from previous rounds of monitoring from the majority of wells across the site is consistent and confirms the current understanding of site conditions, specifically the extent of impact to groundwater from ash basin-sourced constituents (*e.g.*, boron). However, monitoring of select wells along the east side of the French Broad River and west of the ash basins is anticipated to be ongoing in 2016. Data gap wells installed in 2016 (ABMW-11BR, MW-18BRL) are also included in the 2016 sampling program.

4.6.1 Summary of Surficial Aquifer Results

Surficial aquifer samples were collected from 27 saprolite monitoring wells and 9 alluvial monitoring wells. The results indicate that impacts downgradient of the ash basins and wastewater treatment constructed wetlands from leaching of the source areas are migrating toward the French Broad River resulting in 17 parameters in the saprolite, and 11 parameters in the alluvium that exceed 2L or IMAC (**Table 10-4, Appendix B**). SynTerra reports that the wells completed within the surficial zone downgradient of the ash basin and the wastewater treatment constructed wetlands are the most impacted by leaching from the source areas. The CSA Supplement 1 reports the following results for background data. Surficial groundwater is represented by alluvial well MW-10 and saprolite wells CB-1, CB-09, CB-9SL, and MW-24S, and provisional background concentrations were calculated for those wells. Exceedances above 2L and IMAC values were noted for pH (all wells), hexavalent chromium (MW-10, CB-9, CB-9SL, and MW-24S); chromium (CB-1), cobalt (MW-10, CB-1, CB-9. MW-24S), iron (all wells), manganese (MW-10, CB-1, CB-9, MW-24S), and vanadium (CB-9).

The CSA Supplement 1 reports the following results for downgradient wells. Concentrations of boron, cadmium, chloride, cobalt, iron, manganese, hexavalent chromium, selenium, strontium, sulfate, thallium, TDS, and vanadium have been detected in alluvial monitoring wells in excess of the 2L, IMAC values. In general, concentrations within the floodplain area of the French Broad River have remained relatively stable, with one exception at CB-6. Concentrations of cobalt, manganese, sulfate and TDS increased substantially between July and November 2015, January 2016, and April 2016. These increases can be correlated to a decrease in pH from 5.9 to 3.4. The pH at CB-6 was 4.7 in July 2016. Concentrations of antimony, boron, cobalt, hexavalent chromium, iron, manganese, nitrate, sulfate, TDS, thallium, and vanadium have been detected in saprolite monitoring wells in excess of the 2L and IMAC values; however, none of these constituents exceeded corresponding provisional background concentrations beyond the compliance boundary. In general, concentrations within saprolite wells have remained stable with slight increases of boron noted in wells MW-8S and MW-9S and slight increases of boron, sulfate, and TDS in GW-3. **Figure 1-81 (Appendix B)** presents a piper diagram that indicates samples from the alluvial and saprolite flow zones appear to be divided into two sub-groups, sulfate and chloride type. Samples collected downgradient of the 1964 Ash Basin are dominated by chloride, while those collected downgradient from the 1982 Ash Basin are more associated with sulfate type water. This difference is attributed to the former wetland treatment areas recently removed from the 1964 Ash Basin.

4.6.2 Summary of Transitional Zone Aquifer Results

In general, the distribution of parameters in exceedance of the 2L or IMAC in the transition zone samples mimics those identified in the surficial aquifer, but at reduced concentrations. Twenty-four wells within the transition zone were sampled, and boron, chromium, cobalt, iron, manganese, nickel, nitrate, selenium, sulfate, thallium, TDS, and vanadium were detected at concentrations greater than the 2L or IMAC. One well, MW-09D, showed concentrations of chloride and selenium greater than the 2L.

The CSA Supplement 1 reports transition zone groundwater is represented by one monitoring well, CB-1, and provisional background concentrations were determined for this well. Exceedances above 2L or IMAC are noted for pH, cobalt, iron, manganese, and vanadium. Downgradient results indicate concentrations of boron, chloride, chromium, cobalt, hexavalent chromium, iron, manganese, nitrate, nickel, selenium, sulfate, TDS, thallium, and vanadium have been detected in transition zone monitoring wells in excess of 2L and IMAC values. Of these constituents, cobalt, iron, manganese, and vanadium are detected greater than provisional background concentrations (which are greater that the 2L or IMAC values) downgradient of the 1964 and 1982 Ash Basins beyond the compliance boundary in transition zone wells. Concentrations of boron, chloride, sulfate, and TDS beyond the compliance boundary are greater than provisional background concentrations, but less than 2L. In general, concentrations within transition zone wells have remained stable. **Figure 1-82 (Appendix B)** presents a piper diagram that indicates samples from the transitional flow zone associated with the 1982 Ash Basin tend to show sulfate type characteristics, while those associated with the 1964 Ash Basin tend to be associated with chloride type water. Groundwater from background locations and unaffected areas near each ash basin are characterized by calcium bicarbonate type groundwater, typical of shallow fresh groundwater.

4.6.3 Summary of Bedrock Aquifer Results

Bedrock groundwater samples were collected from 20 wells and indicated exceedances of 2L or IMAC for 9 parameters, and most have exceedances of cobalt, iron, manganese, and vanadium (**Table 10-4, Appendix B**). Boron was only detected in a quarter of the bedrock wells sampled, and sulfate was detected above the 2L at MW-18BR.

The CSA Supplement 1 presents data from two background monitoring wells, CB-9BR and AMW-3B, and provisional background concentrations were determined for these wells. Exceedances above 2L and IMAC values were noted for pH (both wells); hexavalent chromium (both wells), iron (both wells); manganese (both wells); and vanadium (both wells).

Concentrations of boron, chloride, chromium, cobalt, hexavalent chromium, iron, manganese, selenium, sulfate, TDS, thallium, and vanadium have been detected in bedrock monitoring wells in excess of 2L or IMAC values. Iron and manganese have been detected in exceedance of 2L and provisional background concentrations beyond the compliance boundary to the south of the 1982 Ash Basin. Chloride, strontium, and TDS are found at levels greater than the provisional background concentration beyond the compliance boundary west of the 1964 Ash Basin and south of the 1982 Ash Basin. In general, concentrations within bedrock wells have remained stable with a few exceptions. Initial monitoring indicates increasing concentrations are noted in downgradient monitoring wells of the 1964 Ash Basin: MW-9BR (boron, chloride, iron, manganese, sulfate, strontium, and TDS) and GW-2 (boron chromium, iron, manganese, sulfate, and strontium). However, these data sets are limited, and further monitoring will determine if these increases are trends. Similar to the transition zone, bedrock groundwater is consistent with calcium-bicarbonate type water. The distinction of the 1964 Ash Basin groundwater (chloride-type) and the 1982 Ash Basin groundwater (sulfate type) is evident and most clearly defined in this flow zone. Groundwater downgradient of the ash basins is characteristic of calcium – sulfate type water (**Figure 1-83, Appendix B**).

4.7 Groundwater Potentiometric Contour Maps

Existing site wells and piezometers have been used to monitor groundwater levels in and around the 1982 and 1964 Ash Basins. During monthly site visits, the wells and piezometers are gauged using a water-level meter to measure the depth to water to the nearest 0.01 foot. All measurements are referenced to the top of riser casing and recorded on a well gauging form. Groundwater gauging data from June 2015 were used to develop surficial (alluvium, saprolite, and transition zone) and bedrock water-level maps (**Figure 6-10 and Figure 6-11, respectively, Appendix B**). And groundwater gauging data from December 2015 were used to develop an updated surficial (alluvium, saprolite, and transition zone) and bedrock water-level maps provided in Part 2 of the CAP (**Figure 2-1 and Figure 2-2, respectively, Appendix C**). The surficial potentiometric data was combined with the transition zone data because the aquifers do not appear to be isolated.

Groundwater flow remains consistently to the west and southwest toward the French Broad River. During the April to July 2015 data collection period, the groundwater hydraulic gradient calculated from the northeast edge of the 1982 Ash Basin to the dam wall along the southwest edge of the basin averaged 0.03 foot/foot. During this same four-month period, the hydraulic gradient calculated from the dam wall along the southwest edge of the 1982 Ash Basin to the wells along the French Broad River averaged 0.06 foot/foot.

For the June 2015 contour figures, water levels in a combined 107 wells and piezometers were gauged within a 24-hour period on June 29, 2015. This provided a snapshot in time of the groundwater elevation data for the multiple flow systems observed at the Site (**Table 6-2, Appendix B**).

The potentiometric surfaces developed from the June 2015 water level measurements for the combined surficial/transition zone and bedrock hydrogeologic zones indicate a substantial variability in the Site horizontal gradients (**Table 6-2, Figures 6-10 and 6-11, and Appendix B**). The horizontal gradients were used with Site-specific slug test hydraulic conductivity values and average porosities to calculate groundwater flow velocities at the Site (Appendix G of CSA report). The resulting groundwater flow velocities range from 0.61 foot to 3,266 feet per year. The highest values are observed near the ash basins due to the increased hydraulic gradients that are related to the location of the basins at topographic highs.

Vertical groundwater gradients were also calculated using select well pairs (**Table 6-4, Appendix B**). The wells in upland areas indicate downward vertical gradients of 0.9 foot, and the remaining well clusters show vertical gradients near equilibrium (Section 6, CSA report [SynTerra 2015a]).

The CSA Supplement 1 presents the following additional information. A comprehensive, site-wide round of water level measurements from all site monitoring wells was collected during a 24-hour period on December 17, 2015 for comparison to previous measurements collected during June 2015 for the CSA. The water level data are presented in **Table 1-6 (Appendix B)**. No significant changes in water levels or groundwater flow directions were noted in December 2015 as compared to the June 2015 water level map included in the CSA Report (SynTerra, 2015a). However, it was also noted that the recent ash excavation and dewatering of the 1982 Ash Basin has effectively lowered the potentiometric surface in adjacent downgradient compliance wells (CB-2, CB-3R) that have had significant decreases in water elevation since the basin dewatering began in 2012. Hydrograph data is shown on **Figure 1-80 (Appendix B)**, and is summarized in the CSA Supplement 1.

4.8 Figures: Cross Sections Vertical and Horizontal Extent of CCR within the Impoundments

As previously discussed, groundwater at the site generally flows from east to west, from the ash basins toward the French Broad River, following topography. Similarly, the COIs are expected to be highest near the ash basins with transport toward the west. The area of groundwater concentrations exceeding 2L are identified under the ash basins and to the west along groundwater flow lines up to the French Broad River (**Figure ES-1, Appendix B**).

The vertical and horizontal extent of ash at the Site is illustrated in relation to local hydrogeologic zones underlying and surrounding the ash basins, including the vertical extent of areas where groundwater quality standards exceed the 2L or IMAC standards in plan layout view and in cross-sections developed form the drilling and monitoring program (CSA report [SynTerra 2015a]). Relevant available figures from the CSA report (**Appendix B**) are listed below.

- Plan Layout Figures (**Appendix B**):
    - General Site map with cross-section lines, well locations, and boundaries, **Figure 2-1;**
    - Geologic map with ash basin delineations, **Figure 6-1;**
    - Surficial soil exceedances of COIs, **Figure 8-3;**
    - Groundwater 2L exceedances for ash pore water, surficial, transition zone, and bedrock wells, **Figures 10-1 to 10-4;**
    - Ash pore water well isoconcentration maps of antimony, arsenic, boron, chloride, chromium, cobalt, iron, manganese, pH, sulfate, thallium, TDS, and vanadium, **Figures 10-5 to 10-17;**
    - Surficial groundwater well isoconcentration maps of antimony, arsenic, boron, chloride, chromium, cobalt, iron, manganese, pH, sulfate, thallium, TDS, and vanadium, **Figures 10-18 to 10-30;**
    - Transition zone groundwater well isoconcentration maps of antimony, arsenic, boron, chloride, chromium, cobalt, iron, manganese, pH, sulfate, thallium, TDS, and vanadium, **Figures 10-31 to 10-43;**
    - Bedrock groundwater well isoconcentration maps of antimony, arsenic, boron, chloride, chromium, cobalt, iron, manganese, pH, sulfate, thallium, TDS, and vanadium, **Figures 10-44 to 10-56;**
    - Detection monitoring results for ash, surficial, transition zone, and bedrock wells, **Figures 10-57 to 10-60;**
    - Assessment monitoring results for ash, surficial, transition zone, and bedrock wells, **Figures 10-61 to 10-64.**

- Cross-section Figures (Section line locations depicted in **Figure 2-1, Appendix B**):
    - Geology and water level, **Figures 6-3 and 6-4;**
    - Geology and water level with photographs of core, **Figures 6-5 to 6-9;**
    - Conceptual Site model with area of COIs greater than 2L and IMAC, **Figure 6-12;**
    - Geology and water level with groundwater and soil analytical results for sampled monitoring wells and borings, **Figures 8-1 and 8-2;**
    - Geology and water level with individual COIs (antimony, arsenic, boron, chromium, chloride, cobalt, iron, manganese, sulfate, TDS, thallium, vanadium, **Figures 11-1 to 11-12.**

The CSA Supplement 1 contains updated geologic cross sections for various COI’s.

5. GROUNDWATER MODELING ANALYSIS

As previously discussed in **Section 2.2**, NCDEQ granted permission for Duke to submit the CAP in two phases. Part 1 of the CAP was submitted on November 20, 2015. Part 1 includes background information, a brief summary of the CSA findings, a brief description of site geology and hydrogeology, a summary of the previously completed receptor survey, a description of 2L and 2B exceedances, proposed site-specific groundwater background concentrations, a detailed description of the site conceptual model, geochemical assessment and modeling, and numerical groundwater flow and transport modeling used to evaluate the effects of various potential closure options on groundwater and surface water quality.

The second part of the CAP was submitted on February 19, 2016, and identifies updated numerical modeling results, alternative corrective actions, the proposed corrective action, conceptual plans for recommended corrective actions, implementation schedule, and a plan for future monitoring and reporting.

The groundwater modeling analysis prepared by SynTerra is presented as a combination of assessments including the following:

- SCM development;
- Geochemical assessment and modeling;
- Numerical flow and transport modeling.

The information from each of the above assessments was successively used to develop the next in order to develop a complete model of the system.

Modeling in Part 1 of the CAP was used to assess source handling and control options with the following scenarios:

- Existing Conditions;
- Capping Ash Basins;
- Removal of Ash.

Ash removal by excavation with lowering of the dams, and installation of drains was proposed as the recommended source control option and modeling in Part 2 of the CAP addresses alternative remedial alternatives to restore groundwater after ash removal including:

- Monitored Natural Attenuation;
- Groundwater Extraction;
- In-Situ Chemical Immobilization;
- Permeable Reactive Barrier.

The modeling results were then used to select the final combined recommended remedial approach following specific alternative evaluation criteria described in detail in Section 6.0 of the CAP Part 2:

- Effectiveness;
- Implementability/Feasibility;
- Environmental Sustainability;
- Cost; and
- Community Acceptance.

Modeling applied with the above alternative evaluation criteria, resulted in selection of monitored natural attenuation as the proposed groundwater restoration alternative. After initial selection of Monitored Natural Attenuation, the modeling results were used to assess the effectiveness against the EPA guidance methods for monitored natural attenuation using a tiered approach. The four tiered objectives from EPA cited by SynTerra are:

I. *Demonstration that the ground-water plume is not expanding and that sorption of the contaminant onto aquifer solids is occurring where immobilization is the predominant attenuation process;*
II. *Determination of the mechanism and rate of the attenuation process;*
III. *Determination of the capacity of the aquifer to attenuate the mass of the contaminant within the plume and the stability of the immobilized contaminant to resist re-mobilization, and;*
IV. *Design performance monitoring program based on the mechanistic understanding developed for the attenuation process, and establish a contingency plan tailored to the site-specific characteristics.*

The final result of the modeling efforts by SynTerra is the recommendation for ash removal, dam lowering, and installation of drains, followed by monitored natural attenuation.

The following section presents the SCM. Predictions for post-closure groundwater elevations are included in the figure, "**Predicted Post-Closure Groundwater Elevation, Asheville Steam Electric Plant, Arden, North Carolina**," included in **Appendix B**.

Each assessment detailed in Part 1 and 2 of the CAP is summarized in the following sections.

5.1 Site Conceptual Model

SynTerra developed and summarized the components of a SCM for the Asheville Plant area in Section 11 of the CSA report, and Section 3 of the CAP Part 1 (SynTerra 2015b), and used it as the basis for the development of the numerical groundwater transport model presented in Part 1 of the CAP. The SCM was developed from data (discussed in Section 4) generated during previous assessments and existing groundwater monitoring data. The SCM was modified based on the results of the 2015 groundwater assessment activities and included geochemical testing and analysis described in Part 1 of the CAP and further refined in Part 2 of the CAP.

The SCM identifies the following key aspects for model development and predictions of potential impacts:

- The two ash basins, designated as the 1964 and 1982 ash basins, and a constructed wetlands used for FGD treatment within a portion of the 1964 ash basin, are identified as the source of potential COIs;
- Groundwater wells immediately downgradient of the constructed wetlands indicate potential impact from FGD blowdown wastewater;
- The subsurface geology at the Asheville Plant is composed of alluvium in the French Broad River valley, saprolite, a transition zone, and fractured shallow bedrock;
- Groundwater flow is unconfined and generally follows topography;
- Groundwater flow is from the east and dominated by Lake Julian at higher elevation (2160.7 feet mean sea level [MSL]), and discharges to the French Broad River in the west at lower elevation (2030 feet MSL), that then flows north;
- The primary factor in constituent transport across the site is hydraulic control, with the hydraulic head at Lake Julian and significant topographic relief driving groundwater flow through the system from the ash basin to the French Broad River;
- Groundwater flow from the Lake Julian area to the French Broad River occurs over less than half a mile;
- Groundwater is significantly influenced by the unlined, secondary settling basin at the northeastern corner of the 1964 ash basin with an average water level of 2137 feet MSL;
- Groundwater is recharged by Lake Julian and aerial precipitation that also occurs within the ash basins;
- Coal ash is primarily above the existing water table, but historically would have been below the water table during sluicing operations;
- The ash basin source areas discharge pore water to the subsurface beneath the basins and via seeps through the embankments;
- Forty-one private water wells have been identified within one-half mile of the site, with more than half on the west side of the French Broad River, and a large number south of the site;
- The primary site-specific COIs identified as being above 2L or IMAC standards in ash pore water are: antimony, arsenic, boron, chromium, cobalt, iron, manganese, sulfate, thallium, TDS, vanadium, and pH;

- Boron and cobalt are the most prevalent COIs in downgradient groundwater. The identified boron plume extends to saprolite, the transition zone and bedrock groundwater, and to wells west of the French Broad River;
- Boron concentrations are elevated in a localized area downgradient from the northwest corner of the constructed wetlands, but are typically significantly below 2L standards and generally less than the detection limit in background wells;
- Cobalt is identified in groundwater throughout the site at concentrations above the IMAC without a distinct plume, having similar values identified in background wells and ash pore water, and transition concentrations that often exceed ash pore water values;
- Boron, chloride, cobalt, sulfate, and TDS were selected as a subset of site-specific COIs to represent the extent of contamination for further modeling because values of other COIs either do not significantly exceed background levels, and/or no discernable existing associated plume is downgradient from the ash basins.

5.2 Geochemical Modeling

The geochemical modeling detailed in Part 1 of the CAP (SynTerra 2015b) provides qualitative and quantitative estimations of key COIs behavior in the Site environment. The geochemical modeling and assessment results were performed to address site-specific processes and characteristics identified in the SCM. Part 1 of the CAP presents a detailed discussion of the geochemical properties of the COIs in relation to site-specific materials and how these properties relate to the retention and mobility of these constituents. The mobility of the COIs is addressed in a detailed soil sorption evaluation provided in Part 1 of the CAP, (Appendix B) that had the objective of providing site-specific sorption coefficients (K_d) for each COI for use in numerical modeling and incorporates effects related to oxidation/reduction potential (E_H) and pH. In Part 2 of the CAP, geochemical modeling was used to assess alternative groundwater restoration scenarios and to assess site specific monitored natural attenuation against the EPA tiered approach for monitored natural attenuation.

5.2.1 Soil Sorption Evaluation

SynTerra contracted the University of North Carolina at Charlotte (UNCC) to perform and analyze soil sorption characteristics. UNCC developed K_d values for COIs using 12 soil samples collected during the geotechnical and environmental exploration program at the site between March 13 and January 2, 2015 (**Table 1 of Appendix C**). The 12 soil samples were selected to represent the saturated zone beneath and downgradient of the ash basin. The solutions used in both the batch and column sorption testing were generated in the laboratory as synthetic groundwater with targeted COI concentrations (**Table 2 of Appendix C**). The leachates of the batch and column testing were analyzed for 13 analytes (arsenic, beryllium, boron, cadmium, chromium, cobalt, antimony, iron, manganese, nickel, selenium, thallium, and vanadium). Desorption assessment was subsequently performed on column tests by application of six pore volumes of laboratory-grade water to assess the potential for COI mobilization after sorption.

Leaching analysis of two ash samples from each basin, 1982 and 1964, was also conducted using standard Methods 1313 and 1316 to assess the source of COIs.

The soil sorption evaluation by UNCC assumed that metal oxy-hydroxide phases of iron, manganese, and aluminum in the soil samples are the most important phases in terms of sorption of COIs, and provided quantitative analysis of these phases in the soil samples.

UNCC identified general concerns with applying batch and column testing results to the field results, and key findings of the soil sorption evaluation.

Soil Sorption Evaluation General Comments:

- The synthetic groundwater used differs from in-situ groundwater chemistry, and the soil samples were originally exposed to different geochemical conditions before testing;
- The geochemical interaction of COIs with the soils in the same testing solution may result in different sorption characteristics;
- Tests were performed at atmospheric conditions, and redox conditions were not adjusted to represent field conditions. The sorption results are reflective of the redox conditions in the lab and may not be representative of other redox conditions;
- The soil samples were sieved to less than 0.30 millimeter before testing, which could affect the laboratory-determined K_d value.

Soil Sorption Evaluation Key Findings:

- The batch and column testing for most COIs yielded results that were typically within one order of magnitude difference for each COI, with the exception of cadmium, chromium, cobalt, nickel and vanadium, which spanned two orders of magnitude;
- The batch test for boron was inconclusive. A K_d value could not be determined due to non-linear behavior, negligible sorption, and/or leaching of boron from the soil sample. The column experiment for boron produced a K_d range from less than 10 to 75 milliliters per gram (mL/g);
- Iron and manganese were not included in the synthetic groundwater solution, but their presence in leachates provide insight into their potential for leaching;
- Ash leaching tests indicated negligible (close to the detection limit of 1 part per billion) leaching of beryllium, cadmium, cobalt, copper, nickel, lead, thallium and zinc;
- Ash leaching tests indicated increased concentrations of arsenic, boron, chromium, iron, molybdenum, selenium, and vanadium in the leachate solution, and the leachate concentrations of these COIs were higher for the 1982 basin test compared to the 1964 basin test.

An addendum to the initial UNCC soil sorption evaluation study was provided in Part 2 of the CAP to include calculation of three sorption isotherm equations for the batch testing data provided in Part 1 of the CAP. Isotherm equations are presented in Appendix D of Part 2 of the

CAP. Linear, linear with irreversible sorption fraction, and Freundlich sorption isotherms equations for antimony, arsenic, beryllium, boron, cadmium, chromium, cobalt, nickel, selenium, thallium, and vanadium are included in tabular and graphical format.

5.2.2 Geochemical Numerical Modeling Analysis

In addition to the geochemical sorption testing and analysis performed by UNCC, SynTerra contracted Brian Powell, Ph.D., to perform a geochemical assessment and modeling of the overall mobility of COIs at the site. The results of this testing and analysis are presented in detail in Appendix C of Part 1 of the CAP and updated with modeling results using additional site specific data in Appendix C of Part 2 of the CAP. The geochemical assessment and modeling includes the sorption processes performed by UNCC and precipitation/coprecipitation reactions involving COIs and mineral phases. This assessment also accounted for geochemical reactions and COI speciation influenced by the pH and E_H of the pore water at the site. The geochemical modeling was performed using the USGS program PHREEQC and the results were compared to the UNCC Soil sorption evaluation study results (**Table 5.1 of Appendix C**). In Part 1 of the CAP sorption was modeled as being associated only with hydrous ferric oxide (HFO) using values based on the measured extractable iron content of the aquifer solids in site samples. In Part 2 of the CAP additional data, including extractable iron and aluminum concentrations, was used in the numerical modeling of COIs to account for HFO, gibbsite (HAO), and potential variations in site specific pH and E_H, using averages, minimums and maximums to bracket values, that could occur due to system changes associated with remediation. The CAP Part 2 assessment compares K_d values obtained from PHREEQC simulations of sorption with sorption identified in Part 1 of the CAP from UNCC laboratory batch testing.

In summary, the geochemical modeling identified the following results:

- Boron as borate, barium, and zinc were identified as being relatively mobile with low K_d values;
- Boron has the lowest experimentally and simulated K_d, and therefore is assumed to be a conservative representation of known areas of groundwater impact;
- Arsenic, iron, manganese, selenium, and vanadium also were identified as having low K_d values, but were predicted for the “worst case” scenario. The modeled E_H and pH conditions similar to those during the UNCC laboratory testing produced generally similar results as the UNCC tests for these COIs;
- The modeled and the experimental boron sorption were significantly different (1000x), where boron sorption was underpredicted by the modeling. In either case, boron is considered highly mobile under site conditions;
- Sorption processes were identified as a dominant removal mechanism, and the number of sorption sites required for complete removal of the total of all constituents in solution is calculated as less than 1% of the available sorption sites. It is concluded that sufficient

sorption capacity exists for removal of high concentrations of all COIs (**Table 6.2 Appendix C**).

Recommendations and limitations of the geochemical modeling from Part 1 of the CAP include:

- Consideration of aluminum oxide surface for sorption should be included to improve predictions, and may in part be related to the observed differences between experimental and modeled K_d values for boron;
- Additional studies to identify sorption site density of solid phases for soils are needed to verify assumptions on site densities used in modeling;
- Additional speciation data is needed to verify predicted oxidation states of arsenic, selenium, vanadium, and other redox-sensitive COIs under site conditions;
- Predictive geochemical modeling using fixed E_H and pH site-specific conditions could be used to verify observed field data for model verification;
- A statistical analysis of the correlation between dissolved COIs and dissolved organic carbon in pore waters is recommended to identify potentially associated sorption relationship to COI mobility.

Part 2 of the CAP addressed some of the above recommendations and limitations including:

- Assessment of aluminum oxide surface sorption;
- Incorporation of additional data to support sorption site density;
- Incorporation of pH and E_H data to support predicted oxidation states for redox-sensitive COIs under site conditions.

5.3 Numerical Groundwater and Transport Modeling

SynTerra provided a detailed numerical groundwater flow and transport model report in Appendix D of Part 1 of the CAP (SynTerra 2015b) and updated modeling results in Part 2 of the CAP (SynTerra 2016a). The model was based on the SCM and geochemical modeling and assessment using MODFLOW to simulate hydrologic flow, and MT3DMS to simulate COI transport. The numerical flow and transport models were developed such that the key site-specific geological and hydrogeological features identified in the SCM and geochemical assessment influencing the migration, chemical, and physical characteristics of contaminants are represented.

The described numerical groundwater model is a three-dimensional groundwater flow and contaminant fate and transport model having the objective of predicting the following in support of the CAP:

- Predict concentrations of the COIs at the compliance boundary or other locations of interest over time;
- Estimate the groundwater flow and constituent loading to surface water discharge areas;

- Predict approximate groundwater elevations in the ash for the proposed corrective action;
- Predict fate and transport of COIs for the different remedial alternatives for groundwater restoration.

The model and model report were developed in general accordance with the guidelines found in the memorandum Groundwater Modeling Policy, issued by NCDEQ DWQ on May 31, 2007 (DEQ modeling guidelines).

5.3.1 Numerical Groundwater Flow Model Description

The MODFLOW model includes the following features:

- The model covers an area of approximately 802.5 acres centered on the site, and includes Lake Julian and the French Broad River as constant-head boundary conditions to the east and west, respectively;
- Surface topography was interpolated from NCDOT LIDAR data;
- Ash basin top elevations, for both the 1964 and 1982 ash basins, came from site-specific survey data;
- Geologic grids developed from interpolation between well boring logs and represented by 16 model layers were discretized horizontally at a 40-foot by 40-foot spacing, resulting in 240,202 active cells;
- Hydraulic conductivities were determined through calibration;
- Recharge was set as 6 inches per year for upland areas, and 1 inch per year historically at the Plant site for the dams of Lake Julian and the two ash basins to represent the impervious nature of the facility and compacted soils. The ash basins during current conditions had infiltration rates of 6 and 12 inches per year for the 1982 and 1964 basins, respectively. Final basin recharge rates ranged from 12 to 24 inches per year;
- The settling pond in the 1964 basin and dewatering basin in the 1982 basin were also set as constant-head boundaries within the model;
- Creeks and drains determined from LIDAR elevations were assigned in the model using the MODFLOW DRAIN feature;
- Steady-state flow calibration targets included 97 water level measurements taken in June 2015.

Sensitivity analysis of the flow model was performed after calibration. The results indicated that the numeric flow model is insensitive to small changes in the main hydraulic conductivity parameters, the model is more sensitive to changes in the bedrock hydraulic conductivity value compared to shallow layers, and the uncertainty is likely a factor of 2 or more, but less than an order of magnitude.

5.3.2 Numerical Groundwater Transport Model Description

Transport was assessed using MT3DMS with the MODFLOW-generated transient flow velocity fields representing the time from January 1964 to July 2015. The transient flow field began with steady-state conditions, followed by development history of the 1964 and 1982 ash basins broken into three successive periods:

1. High infiltration rate in the 1964 basin representing ash sluicing from 1964 to 1982;
2. Increased infiltration rate in the 1982 basin from 1982 to 2013;
3. Current basin infiltration rates from 2013 to 2015.

The combined CAP Part 1 and 2 transport modeling took into account the following characteristics:

- Boron, chloride, cobalt, manganese, sulfate, and TDS selected as a subset of site-specific COIs to represent the extent of contamination for modeling;
- Source concentrations in the ash basins identified in ash pore water samples;
- Soil-water distribution coefficients (K_d) for the lowest UNCC cobalt value (2.5 mL/g), and a default low value of 0.1 mL/g to represent boron and sulfate retardation consistent with other sites;
- Longitudinal, transverse and vertical dispersivity of 20 feet, 2 feet, and 0.2 feet, respectively;
- Effective porosity of 0.2 in unconsolidated layers and 0.001 in bedrock layers;
- Soil dry bulk density of 1.6 g/mL.

Initial background COI concentrations were set as zero concentration to represent no impacts in 1964. The saturated cells within layers 3–7 underlying the ash basins were assigned constant concentrations to represent the source of COIs. The report notes that the placement of constant concentrations several feet deeper than the ash basins potentially results in an overestimate of the COIs in groundwater below the basins. The transport of COIs was then calibrated to concentrations measured in samples from 98 monitoring wells in June 2015.

The calibrated model comparison of simulated to measured boron, chloride, cobalt, sulfate, and TDS concentrations is listed in **Tables 6, 7, 8, 9, and 10 of Appendix C**, respectively.

5.4 Groundwater Chemistry Effects

Predictions of groundwater chemistry effects were modeled for three possible source control scenarios presented in Part 1 of the CAP:

1. Closure Model Scenario #1 (CMS1) – no further action;

2. Closure Model Scenario #2 (CMS2) – complete ash removal from the 1982 and 1964 Ash Basins, installation of drains along the bottom of the former ash basins, and backfilling and regrading of the former ash basins with clean fill to 2110 feet and 2120 feet MSL based on the Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) ash basin closure design (2015) (**Figure 29 of Appendix C**);
3. Closure Model Scenario #3 (CMS3) – adds an impermeable surface cap to CMS1.

All source control scenario predictions were used to provide simulated results through year 2045, and results in Appendix D of the CAP Part 1 are presented at 5 years (2020), 15 years (2030), and 30 years (2045). Results provided in the CAP Part 1 are only presented for boron under the assumption that it provides the most conservative estimate of widespread transport. Boron is considered the most conservative COI based on laboratory sorption evaluation and geochemical modeling. However, updated modeling results are provided in the CAP Part 2 to address potential source contribution of manganese, sulfate and TDS concentrations by applying observed concentrations to model simulations for these constituents. A manganese concentrations of 7000 µg/L in the western parts of the 1964 and 1982 basins, and a manganese concentration of 1000 µg/L for the eastern parts of the basins.

The model report results for the CMS1 scenario indicate that the boron plume is stabilized after 30 years, and little change occurs. This is because the boron plume has already reached the French Broad River from the 1964 ash basin, while the boron plume from the 1984 basin recedes due to reduced infiltration through the ash basin.

The model results for the CMS2 scenario indicate little effect on the boron plume within the first 2 years, but by 2030 the simulation predicts that the boron plume in the shallower part of the system will be significantly reduced (**Figure 39 of Appendix C**), as will the southern area of the deeper part of the system (**Figure 40 of Appendix C**). By year 2045, the simulation predicts that the extent of boron will be greatly reduced, both horizontally and vertically (**Figures 41 and 42 of Appendix C**). The dominant concentration reduction mechanism is dilution by flushing of groundwater from upgradient toward the French Broad River. The remaining boron is identified in lower conductivity zones which receive less flushing.

The model results for CMS3 are relatively similar to those identified for CMS1 with the exception that the boron plume is slightly reduced for CMS3 compared to CMS1.

While predictions are based on the conservative nature of boron, Part 1 of the CAP identified that the pH and oxidation/reduction potential has a fundamental influence on the extent of contaminant mobility for redox sensitive COIs.

Part 2 of the CAP addressed alternative corrective action measures for groundwater restoration which required additional numerical transport modeling of fate and transport of COPCs to evaluate the effectiveness of the different remedial alternatives.

The alternative corrective action measures evaluated are:

- Monitored Natural Attenuation (MNA);

- Groundwater Extraction (recovery wells or trenches) with fracture enhancement option;
- In-Situ Chemical Immobilization;
- Permeable Reactive Barrier.

Each alternative was evaluated and discussed in Section 6.0 of Part 2 of the CAP including model simulations to support the final recommended approach.

The groundwater extraction simulation included a line of 10 bedrock pumping wells covering 800 feet located beyond the northwest corner of the 1964 ash basin along the access road near the toe of the 1964 dam, and eighty feet into the saturated bedrock. The simulation indicated that each of the 10 wells was able to sustain a pumping rate of 0.3 gpm for a combined total of 3 gpm resulting in drawdown of 10 to 20 feet in each well. The boron transport simulation with source excavation. MNA, and groundwater extraction indicates that the bulk of the boron plume mass is removed by the year 2030 with some smaller areas of boron mass remaining through 2045. A comparison of simulated boron concentrations over time resulting from source excavation with monitored natural attenuation (MNA), and with groundwater extraction is provided in Figure 3-1 in Part 2 of the CAP.

Section 7.0 of Part 2 of the CAP provides the final proposed corrective actions based on data and numerical modeling assessment from both Parts 1 and 2 of the CAP, with subsequent evaluation of each piece to assure compliance in a timely manner, and includes the following:

- Source Control – ash basin closure and source removal. Soils left on site after ash removal will be sampled and analyzed, and results will be incorporated into fate and transport modeling to assess the potential for modification to the corrective actions;
- Elimination of Potential Receptors – installation of the Bear Leah Trail public water supply line has resulted in replacing five private water wells that are planned for subsequent geophysical survey and abandonment;
- Monitored Natural Attenuation – SynTerra identified that the groundwater impacted by the ash basin does not pose unacceptable risks to either human health or ecological receptors further discussed in Section 5 of Part 2 of the CAP. And as supported by groundwater flow and geochemical modeling, attenuation of COPCs will be achieved by a combination of dilution, dispersion, and limited sorption.

Simulated manganese concentrations, and updated simulations of sulfate and TDS are provided in Appendix B of Part 2 of the CAP.

The results of modeling the monitored natural attenuation alternative are presented in Figure 3-1 of Part 2 of the CAP for predictions at years 2020, 2030, and 2045.

5.5 Groundwater Trend Analysis Methods

The CSA Report indicates that historical analytical results from compliance and voluntary groundwater monitoring wells were used to assess background groundwater quality and assess results against existing IMAC and 2L values. Compliance groundwater monitoring wells were sampled as part of the CSA Report to supplement the expanded groundwater assessment. Time series plots of existing data comparing compliance, background wells, and 2L standards, where applicable, were shown on **Figures H1 through H21 of Appendix B**.

Groundwater monitoring data collected from the four compliance monitoring wells were evaluated by SynTerra using interwell prediction limits (parametric, nonparametric, and Poisson) to compare background well data (CB-01 and CB-09) to the results for the most recently available sample data from compliance wells collected in April 2015. The detailed description is in Section 10.0 of the CSA (SynTerra 2015a).

Before statistical assessment, the dataset was assessed and treated using guidance from ASTM D6312-98 and USEPA 2007. COIs with exceedances of the 2L or IMAC are identified in all compliance boundary wells at statistically elevated values over concentrations observed in designated background wells CB-01 and CB-09 (**Table 2-2, Appendix B**).

6. BENEFICIAL REUSE AND FUTURE USE

6.1 CCR Material Reuse

From 2007 through summer 2015, a portion of the CCR materials from the 1982 Ash Basin was excavated and transported to the Asheville Regional Airport for beneficial use. The airport extended its runway/taxiway network by using the CCR as permitted structural fill in compliance with existing permits. Ash transport to the Asheville Regional Airport ended in summer 2015.

Duke considers CCR beneficial use in an environmentally responsible manner for ash that is produced at its plants or is removed from existing ash basins. Ash basin closure by removal presents the opportunity for CCR beneficial use. Duke has a team dedicated to identifying beneficial use opportunities and evaluating their feasibility. Consistent with North Carolina CAMA requirements, Part III, Section 4(e), Duke issued a request for proposals to conduct a beneficial use market analysis, study the feasibility and advisability of installing existing beneficiation technologies, and examine innovative technologies.

At this time, no CCR beneficial use opportunities have been identified for the remaining CCR materials. Findings indicate that large-scale beneficiation technologies are not feasible to install at this time.

6.2 Site Future Use

The anticipated future use of the 1964 Ash Basin is undetermined at this time. Possibilities for this Ash Basin include but are not limited to a permitted structural fill, a solar farm, or simply being reseeded with grass. The closure design of the 1964 Ash Basin is planned to include a balanced breach, in which the impoundment will be excavated to a design elevation. The basin will be backfilled to promote drainage, resulting in a non-impounding structure. The backfill will also be graded in a way to allow stormwater flows from the basin to pass through an existing culvert under I-26.

In contrast to the 1964 Ash Basin, the closure plans for the 1982 Ash Basin were developed to facilitate the construction of the proposed Combined Cycle Plant. This Plant will be located within the footprint of the 1982 Ash Basin. The closure design of the 1982 Ash Basin includes a dam breach to an elevation of 2106 feet, with an engineered fill to this same minimum elevation within the existing Ash Basin. After completion of the balanced breach, additional fill will be placed to facilitate construction of the Combined Cycle Plant to design grades.

After the completion of the Combined Cycle Plant, the existing coal-fired generating plant will be decommissioned. Duke intends to cease operation of the coal-fired units in accordance with CAMA, but specific details of future decommissioning and demolition have not been developed at this time. The property deed will be recorded to document the site conditions at the time of closure.

7. CLOSURE DESIGN DOCUMENTS

7.1 Engineering Evaluations and Analyses

As part of the closure design process, engineering evaluations and analyses (calculations) were developed for the 1982 Ash Basin and are included in **Appendix D**. Engineering evaluations and analyses will be developed in the future for the 1964 Ash Basin. The basins are required to be closed by 2022, and each basin must be closed such that it will not impound water. Ash has been removed from the 1982 Ash Basin, and dam decommissioning is currently underway.

Excavation of the 1982 Ash Basin was completed on September 30, 2016. The ash basin was then turned over for dam decommissioning and construction of the natural gas combined cycle plant. The proposed decommissioning of this ash basin dam is shown on the drawings referenced in Section 7.2. Additional fill will be placed to support a combined cycle plant. To construct the fill, the existing embankment will be breached to create a non-impounding structure, and this material will be placed in the existing ash basin. Borrow material will also be obtained from onsite borrow areas to support the combined cycle plant construction. This borrow material will be placed and compacted in accordance with the CQA Plan referenced in Section 7.3. Drainage ditches are also incorporated into the final configuration to route the 100 year – 24 hour flow to an existing culvert under I-26.

7.2 Site Analysis and Removal Plan Drawings

The design drawings associated with the dam decommissioning of the 1982 Ash Basin are included in **Appendix E**. These drawings were developed for three separate submittals and resulting approvals from NCDEQ: 1) Decommissioning and Ash Removal Closure Plan drawings, 2) Erosion and Sediment Control Plan drawings, and 3) Stormwater Management Plan drawings.

Design drawings for the dam decommissioning of the 1964 Ash Basin will be prepared and submitted to NCDEQ at a later date.

7.3 Construction Quality Assurance Plan

The purpose of the CQA Plan is to identify the quality assurance procedures, standards, and methods that will be employed during the project to provide assurance that the requirements of the drawings, specifications, and regulatory permits are met. The CQA Plan is specific to the Asheville 1982 and 1964 Ash Basins Closure Design, and is prepared in compliance with CAMA. The CQA Plan is included and attached to this document in **Appendix F**.

8. MANAGEMENT OF WASTEWATER AND STORMWATER

8.1 Stormwater Management

Ash removal within the 1982 Ash Basin is complete, and dam decommissioning activities are currently underway to prepare the site for construction of a natural gas combined cycle plant. At the conclusion of dam decommissioning activities, stormwater flows will exit the basin through permitted stormwater channels along the toe of the dam breach. Stormwater management for the 1982 Ash Basin is detailed on the drawings in **Appendix E**.

Duke Energy is authorized to discharge stormwater and industrial effluent to the French Broad River through Outfall 001 in accordance with NPDES Permit NC0000396. Stormwater from the 1964 Ash Basin currently drains to the Duck Pond within the ash basin, and is conveyed to the lined Rim Ditch system. Stormwater runoff from the plant area, parking lots, existing combustion turbine area, oil storage and handling facility, and the plant’s substations is also routed to the lined Rim Ditch for treatment. During maintenance activities, sludge removed from catch basins, sumps, etc., may be transported to the 1964 Ash Basin, and/or lined Rim Ditch for treatment and further handling. Runoff from the coal, limestone, and gypsum piles are collected in their respective drainage ditches. The drainage ditches are routed to the 1964 Ash Basin or lined Rim Ditch for treatment. Additional information is contained in the 2016 Permit Renewal Supplemental Information Package (Duke Energy 2016a, **Appendix I**). Characteristics of discharges are included in **Table 8-1** in the following section.

The goal of the 1964 Ash Basin decommissioning is to return the former ash basin to a natural state where stormwater is discharged via sheet flow to the receiving water(s), such as the French Broad River, and eliminate the requirement for an NPDES stormwater permit, concurrent with ash removal activities. To accomplish this, multiple phases of decommissioning work are required. Subsequent work activities will include the following:

- Evaluate, design, and construct water treatment system(s) and/or water retention for utilization after plant and rim ditch retirement;
- Maintain the lowered water state of the Duck Pond;
- Decommission and demolish the 1964 Ash Basin Rim Ditch system.

8.2 Wastewater Management

The Rim Ditch system receives the sluiced ash and water from the Plant. Water from the Rim Ditch is pumped through a center pond filter system to the stilling basin located to the north of the 1964 Ash Basin, and then out through NPDES Outfall 001. Characteristics of wastewater discharges to the 1964 Ash Basin are listed in **Table 8-1** and are described as follows. Ash sluice water consists of fly and bottom ash from both units, is hydraulically conveyed via pipeline to the lined Rim Ditch system, and is treated with sulfuric acid for pH adjustment. As needed, chemical flocculants may be added to aid settling. The Plant operates a Selective Catalytic Reduction system, which may introduce ammonia into the combustion process. Various wastewater boiler sediments and ash accumulations from wastewater processes collected during maintenance activities may also be physically transported the lined Rim Ditch. The 1964 Ash Basin and lined Rim Ditch discharge into the secondary settling pond prior to discharging to the French Broad River through Outfall 001.

Low volume waste sources discharged to the lined Rim Ditch system include: boiler water treated with ammonia, hydrazine, and sodium hydroxide; boiler blowdown and drainage; thus, the waste streams may contain small quantities of these chemicals. Effluent from other sources and treatment systems include the following: reject stream from reverse osmosis, molybdate waste from the closed cooling water system, overflow from the hopper seal treated with sodium hydroxide solution for pH adjustment, chemicals used for coal dust suppression, small amounts of urea from bulk area unloading operations, plant floor drains and equipment drainage and wash down. In many cases, added chemicals are consumed or chemically altered during the plant processes. Only trace amounts might be recoverable in water entering the lined Rim Ditch. Detectable levels of these chemicals would not be expected to occur in Rim Ditch discharges.

Operation of the combustion turbine generating facility may produce turbine blade wash water, inlet filter cooling water, various condensate waters, and water from equipment and tank drains. These wastewaters are collected in the stormwater collection system of the combustion turbine site and are routed to the lined Rim Ditch system.

The boilers are chemically cleaned every five-to-eight years using tetraammonia ethylate diamine tetraaccetic acid solution. The cleaning solution is stored on-site for disposal by evaporation in an operating system’s furnace. Should evaporation not be used, the wastewater can be treated by neutralization and precipitation prior to being conveyed to the lined Rim Ditch system, or other means of disposal. Dam seepage is addressed in Appendix F of the 2016 Permit Renewal Supplemental Information Package (Duke Energy 2016a, **Appendix I**).

The wastewater treatment system will continue to be operated in this manner until such time that the coal fired plant is retired, and ash and effluent discharges from the plant to the 1964 Ash Basin cease.

Subsequent to plant and Rim Ditch retirement, additional water management and treatment systems will be required in accordance with the DEQ letter from Jeff Poupart, Water Quality Permitting Section Chief, to Duke Energy on July 20, 2016 regarding decanting of coal ash impoundments. Management of wastewater will also be addressed as the coal operations become inactive.

Table 8-1: Flow Characteristics of Discharges into the 1964 Ash Basin[1]

Stream	Name	Average Flow	Comments
E	Low Volume Wastes • Ash Hopper Seals • Sandbed Filter Backwash • Boiler Blowdown • Truck Wash • Water purification process waste streams	 0.05 MGD 2600 Gal/event 0.006 MGD Variable variable	 Rare Usage Startup - Estimated
G	Ash Sluice Water	3.03 MGD	Estimated
H	Dam Seepage	~ 0.09 MGD	Calculated
J	Coal Pile Runoff	0.01 MGD	Based on Average Annual Rainfall of 47” and 50 % Runoff
K	Storm Water	0.07 MGD	Estimated
L	Chemical Metal Cleaning Wastes	0 - 90,000 Gallons (0 gallons anticipated)	Normal Practice is Evaporation
M	Water From Combustion Turbine Facility Operation (Blade wash activities)	0 - 0.02 MGD	Intermittent
Q	Fire Protection Water	0.010 MGD	Estimated
R	Air Preheater Cleaning	10,000 gallons/event	Estimated

[1] Information taken from Duke Energy, July 30, 2014

9. DESCRIPTION OF FINAL DISPOSITION OF CCR MATERIALS

From early 2007 through summer 2015, the CCR materials from the 1982 Ash Basin were excavated and transported by truck to the Asheville Regional Airport and beneficially reused as structural fill. The airport used the ash for projects aimed at extending the runway/taxiway network. The off-site removal details for the Asheville Regional Airport are presented below:

- Facility location and name: Asheville Regional Airport, 61 Terminal Drive, Fletcher, NC 28732;
- Facility permit number: Structural Fill Permit # WQ0000020;
- Facility type: Permitted structural fill for runway/taxiway construction.

Beginning in fall 2015, Duke started transporting the remaining CCR in the 1982 Ash Basin to an off-site fully lined landfill near Homer, Georgia. From February 2016 through October 2016, ash was transported to an additional landfill located in Mooresboro, North Carolina. Currently, ash from the 1964 Ash Basin is being transported to the landfill near Homer, Georgia. The off-site removal details for the Georgia landfill are presented below:

- Facility location and name: R&B Landfill, 610 Bennett Road, Homer, GA 30547;
- Facility permit number: Permit 006-009D(MSWL);
- Facility type: Solid Waste Handling - Permitted landfill.

The off-site removal details for the North Carolina landfill are presented below:

- Facility location and name: Duke Energy Rogers CCP Landfill, 573 Duke Power Rd, Mooresboro, NC 28114;
- Facility permit number: Solid Waste Management Facility Permit No. 8106;
- Facility type: Solid Waste Management Facility.

Duke continues to consider future disposal and/or beneficial reuse opportunities.

10. APPLICABLE PERMITS FOR CLOSURE

Implementation of the Ash Basin closure at the Asheville Steam Electric Generating Plant will require permits issued by regulatory authorities. A list of the anticipated permits required for closure is below:

- Dam Breach Certificate of Approval to Repair/Modify for Decommissioning Dam Structures;
- Discharge Permits for Wastewater and Stormwater;
- Solid Waste Permits for Landfills and Structural Fills (by others); and
- Erosion and Sedimentation Control Permits.

11. POST CLOSURE MONITORING AND CARE

The Post-Closure Operations Maintenance and Monitoring (OM&M) Plan is provided as **Appendix G**. The default post-closure period is 30 years; however, opportunities to modify and reduce the post-closure period for various requirements including groundwater and surface water monitoring are possible. The Post-Closure OM&M Plan addresses the following:

- Description of the closure components;
- Regular inspections and maintenance of the stormwater and erosion control measures;
- Post-closure inspection checklist to guide post-closure inspections;
- Continuation of the groundwater and surface water monitoring and assessment program;
- Provide means and methods of managing affected groundwater and stormwater;
- Maintaining the groundwater monitoring system;
- Facility contact information;
- Description of planned post-closure uses.

11.1 Groundwater Monitoring Program

The (CSA report [SynTerra 2015a]) provides an interim groundwater monitoring plan to bridge the gap between completion of CSA Report activities and implementation of the pending Groundwater Monitoring Plan and CAP. The interim groundwater monitoring plan provided in the CSA is also summarized in **Section 3.3.2** of this document. The proposed constituents, parameters, and sampling locations for the interim groundwater monitoring plan were presented in Section 16.0 of the CSA report (SynTerra 2015a) and is updated in Part 2 of the CAP in relation to proposed remedial actions.

With the submittal of part 2 of the CAP SynTerra has provided a proposed updated Interim Monitoring Plan (IMP), and a post-closure Effectiveness Monitoring Program (EMP) as required by CAMA in Section 9.0 of Part 2 of the CAP. The EMP is to begin after implementation of the basin closure groundwater Corrective Action Plan, with the IMP being implemented within 30 days of CAP approval by CAMA.

The proposed updated IMP consists of sampling groundwater and surface water for the constituents listed in Part 2 of the CAP (**Table 9-1 of Appendix C**) on a semi-annual basis, with the sampling frequency of background wells being modified to achieve a minimum of eight sets of data prior to implementation of the EMP. Reporting will be annually. The IMP will also be periodically evaluated and modified as needed. The proposed IMP sampling locations for groundwater are provided in **Table 9-2 of Appendix C**, and surface water and seep sampling locations are provided in **Table 9-3 of Appendix C**. Groundwater, surface water, and seep sample locations are presented spatially in **Figure 9-1 of Appendix C**.

The proposed EMP program also consists of sampling groundwater and surface water for the constituents listed in **Table 9-1 of Appendix C** on a semi-annual basis, and is intended to support triannual NPDES compliance monitoring with a reduced frequency if monitoring results are consistent with modeling results provided in Section 6.0 of Part 2 of the CAP. Reporting will be annually. The EMP will also be evaluated periodically and modified as needed. The proposed EMP sampling locations for groundwater are provided in **Table 9-2 of Appendix C**, and surface water and seep sampling locations are provided in **Table 9-3 of Appendix C**. Groundwater, surface water, and seep sample locations are presented spatially in **Figure 9-1 of Appendix C**. Additional monitoring locations may be required once the final corrective action plan is selected and implemented. Additionally, the EMP is designed to meet the requirements of the Tier 4 monitoring and the USEPA established eight objectives for performance. However, additional analysis is required to achieve all the objectives and the EMP reports will include two phases to address these.

A Sampling and Analysis Plan (SAP) will be developed and adhered to once approved and prior to implementation of both the IMP and EMP. Currently, groundwater samples are planned to be collected using low-flow sampling techniques in accordance with the NCDEQ conditionally approved June 10, 2015, low flow sampling program provided in Appendix G of Part 2 of the CAP.

Implementation of the IMP or EMP is scheduled to begin in the month April or November following the CAP approval. Subsequent sampling events will then follow on subsequent April and November months. The data will be reviewed annually to confirm the corrective actions are effective at protecting human health and the environment.

12. PROJECT MILESTONES AND COST ESTIMATES

12.1 Project Schedule

CAMA deems the Asheville Plant a “high-priority” site, which specifically requires closure of the ash basins pursuant to Part II, Section 3(c). The CAMA closure definition of dewatering to the maximum extent practicable and removing and transferring CCR to a landfill or structural fill is demonstrated in the proposed schedule. Groundwater assessment and corrective action is ongoing, and the requirements and time for restoring groundwater quality are currently unknown.

The anticipated milestones are defined and shown below. The Dam Decommissioning Plan for the1982 Ash Basin has been approved by NCDEQ, and ash removal is complete. Note that the milestones are subject to change when not required by regulations.

The Anticipated Activities and milestone dates are listed in **Table 12-1**.

Table 12-1: Project Schedule

Milestones	**Dates**	
	1982 Ash Basin	**1964 Ash Basin**
Removal Plan Submittal	December 21, 2016 (Actual)	December 21, 2016 (Actual)
Start Date of Ash Removal	2007 (Actual)	August 26, 2016 (Actual)
Completion of Ash Removal	September 30, 2016 (Actual)	August 2022
Cease operation of coal-fired units at the Plant	January 2020	January 2020
Impoundments Closed Pursuant to PART II, Section 3.(c) of CAMA and Section 2.(a) of the Mountain Energy Act	August 2022	August 2022
Beginning of Post-Closure Care Period	March 2023	March 2023

12.2 Closure and Post-Closure Cost Estimate

The estimated cost associated with the assessment, corrective action, closure and post-closure care, and water line connection of the site was prepared internally by Duke Energy to support the Duke Energy Carolinas and Duke Energy Progress December 31, 2016 CCR asset retirement obligations within balance sheets of the audited financial statements on Form 10-K submitted to the Securities and Exchange Commission. The cost estimate is provided in **Appendix H**.

13. REFERENCED DOCUMENTS

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Dewberry & Davis, Inc., “Final Coal Combustion Waste Impoundment Dam Assessment Report, Site 7, 1982 Pond & 1964 Pond, Progress Energy Carolinas, Asheville, North Carolina”, Revised Final September 11, 2009.

Duke Energy, “2016 Permit Renewal Supplemental Information Package,” December 1, 2016 (2016a).

Duke Energy, “Asheville Steam Electric Generating Plant, Coal Ash Excavation Plan,” December 2016.

Duke Energy, “Update of Renewal Application Originally Submitted on June 16, 2010,” July 30, 2014.

Law Engineering, Inc. (Amec Foster Wheeler), “Stability Analysis of Downstream Slope, 1982 Ash Pond Dike,” September 30, 1992.

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MACTEC Engineering and Consulting, Inc. (Amec Foster Wheeler), “Report of Geotechnical Exploration, 1982/1964 Ash Pond Drainage Modification Project,” January 19, 2011.

NCDENR Notice of Inspection Reports for 1964 Ash Pond Dam (BUNCO-097) dated April 30, 2010; May 6, 2011; February 22, 2012; April 19, 2013; and April1, 2014.

NCDENR Notice of Inspection Reports for 1982 Ash Pond Dam (BUNCO-089) dated May 5, 2010; May 6, 2011; February 22, 2012; April 19, 2013; and, April1, 2014.

S&ME, Inc. “1964 Ash Basin Dam Improvement Design – Appendix I – Slope Stability Analysis Discussion and Summary,” December 28, 2009.

S&ME Inc., “Construction Repair Certification Report, 1964 Ash Basin Dam Improvements (Phase II), Progress Energy Asheville Plant”, December 18, 2012.

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TABLES

Table 2-1: Federal CCR Rule Closure Plan Requirements
Summary and Cross Reference Table
Ash Basin Site Analysis and Removal Plan - Asheville Steam Electric Generating Plant
Duke Energy

No.	**Description**	**Corresponding Closure Plan Section**
Federal Register Vol. 80 No. 74 Part 2 (April 17, 2015)/40 CFR Part 257: Environmental Protection, Beneficial Use, Coal Combustion Products, CCRs, Coal Combustion Waste, Disposal, Hazardous Waste, Landfill, Surface Impoundments		
40 CFR §257.102 (b)(1) (i. - vi) Closure Plans for all impoundments shall include all of the following:		
i.	**Narrative description of how CCR unit will be closed (in accordance with this section)**	**All Chapters**
ii.	**If closure is through the removal of CCR from the unit, description of procedures to remove CCR and decontaminate CCR unit (in accordance with (c))**	**7**
iii.	**If closure by leaving CCR in place, description of final cover system (in accordance with (d)), methods & procedures used to install final cover, and also discussion of how final cover will achieve performance standards (in accordance with (d))**	**NA**
iv.	**Estimate of maximum inventory of CCR ever on site over active life of CCR unit**	**3.1.2**
v.	**Estimate of largest area of CCR unit ever requiring a final cover (in accordance with (d)) at any time during active life of CCR unit**	**NA**
vi.	**Schedule for completion of all activities necessary to satisfy closure, including estimate of year in which all closure activities will be completed. Sufficient information to describe sequential steps of closure, including:**	**12.1**
a.	Obtaining approvals and permits	10
b.	Dewatering and stabilization phases	7
c.	Installation of final cover system	7
d.	Estimated timeframes to complete each step/phase	10
Note:	If closure exceeds timeframes in (f)(1), closure plan must include site specific info./factors/considerations to support time extension.	

Table 2-2: NC CAMA Closure Plan Requirements
Summary and Cross Reference Table
Ash Basin Site Analysis and Removal Plan - Asheville Steam Electric Generating Plant
Duke Energy

No.	Description	Corresponding Closure Plan Section
Part II. Provisions for Comprehensive Management of Coal Combustion Residuals		
§ 130A-309.214(a)(4) Closure Plans for all impoundments shall include all of the following:		
a. Facility and coal combustion residuals surface impoundment description. – A description of the operation of the site that shall include, at a minimum, all of the following:		
1	Site history and history of site operations, including details on the manner in which coal combustion residuals have been stored and disposed of historically.	3.1.1
2	Estimated volume of material contained in the impoundment.	3.1.2
3	Analysis of the structural integrity of dikes or dams associated with impoundment.	3.1.3
4	All sources of discharge into the impoundment, including volume and characteristics of each discharge.	3.1.4
5	Whether the impoundment is lined, and, if so, the composition thereof.	3.1.5
6	A summary of all information available concerning the impoundment as a result of inspections and monitoring conducted pursuant to this Part and otherwise available.	3.1.6
b. Site maps, which, at a minimum, illustrate all of the following:		
1	All structures associated with the operation of any coal combustion residuals surface impoundment located on the site. For purposes of this sub-subdivision, the term "site" means the land or waters within the property boundary of the applicable electric generating station.	3.2.1
2	All current and former coal combustion residuals disposal and storage areas on the site, including details concerning coal combustion residuals produced historically by the electric generating station and disposed of through transfer to structural fills.	3.2.1
3	The property boundary for the applicable site, including established compliance boundaries within the site.	3.3
4	All potential receptors within 2,640 feet from established compliance boundaries.	3.2.2
5	Topographic contour intervals of the site shall be selected to enable an accurate representation of site features and terrain and in most cases should be less than 20-foot intervals.	3.3
6	Locations of all sanitary landfills permitted pursuant to this Article on the site that are actively receiving waste or are closed, as well as the established compliance boundaries and components of associated groundwater and surface water monitoring systems.	3.2.3
7	All existing and proposed groundwater monitoring wells associated with any coal combustion residuals surface impoundment on the site.	3.3
8	All existing and proposed surface water sample collection locations associated with any coal combustion residuals surface impoundment on the site.	3.3
c. The results of a hydrogeologic, geologic, and geotechnical investigation of the site, including, at a minimum, all of the following:		
1	A description of the hydrogeology and geology of the site.	4.1
2	A description of the stratigraphy of the geologic units underlying each coal combustion residuals surface impoundment located on the site.	4.2
3	The saturated hydraulic conductivity for (i) the coal combustion residuals within any coal combustion residuals surface impoundment located on the site and (ii) the saturated hydraulic conductivity of any existing liner installed at an impoundment, if any.	4.3
4	The geotechnical properties for (i) the coal combustion residuals within any coal combustion residuals surface impoundment located on the site, (ii) the geotechnical properties of any existing liner installed at an impoundment, if any, and (iii) the uppermost identified stratigraphic unit underlying the impoundment, including the soil classification based upon the Unified Soil Classification System, in-place moisture content, particle size distribution, Atterberg limits, specific gravity, effective friction angle, maximum dry density, optimum moisture content, and permeability.	4.4
5	A chemical analysis of the coal combustion residuals surface impoundment, including water, coal combustion residuals, and coal combustion residuals-affected soil.	4.5
6	Identification of all substances with concentrations determined to be in excess of the groundwater quality standards for the substance established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code, including all laboratory results for these analyses.	4.6
7	Summary tables of historical records of groundwater sampling results.	4.6
8	A map that illustrates the potentiometric contours and flow directions for all identified aquifers underlying impoundments (shallow, intermediate, and deep) and the horizontal extent of areas where groundwater quality standards established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code for a substance are exceeded.	4.7
9	Cross-sections that illustrate the following: the vertical and horizontal extent of the coal combustion residuals within an impoundment; stratigraphy of the geologic units underlying an impoundment; and the vertical extent of areas where groundwater quality standards established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code for a substance are exceeded.	4.8
d.	**The results of groundwater modeling of the site that shall include, at a minimum, all of the following:**	
1	An account of the design of the proposed Closure Plan that is based on the site hydrogeologic conceptual model developed and includes (i) predictions on post-closure groundwater elevations and groundwater flow directions and velocities, including the effects on and from the potential receptors and (ii) predictions at the compliance boundary for substances with concentrations determined to be in excess of the groundwater quality standards for the substance established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code.	5.1
2	Predictions that include the effects on the groundwater chemistry and should describe migration, concentration, mobilization, and fate for substances with concentrations determined to be in excess of the groundwater quality standards for the substance established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code pre- and post-closure, including the effects on and from potential receptors.	5.2
3	A description of the groundwater trend analysis methods used to demonstrate compliance with groundwater quality standards for the substance established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code and requirements for corrective action of groundwater contamination established by Subchapter L of Chapter 2 of Title 15A of the North Carolina Administrative Code.	5.3

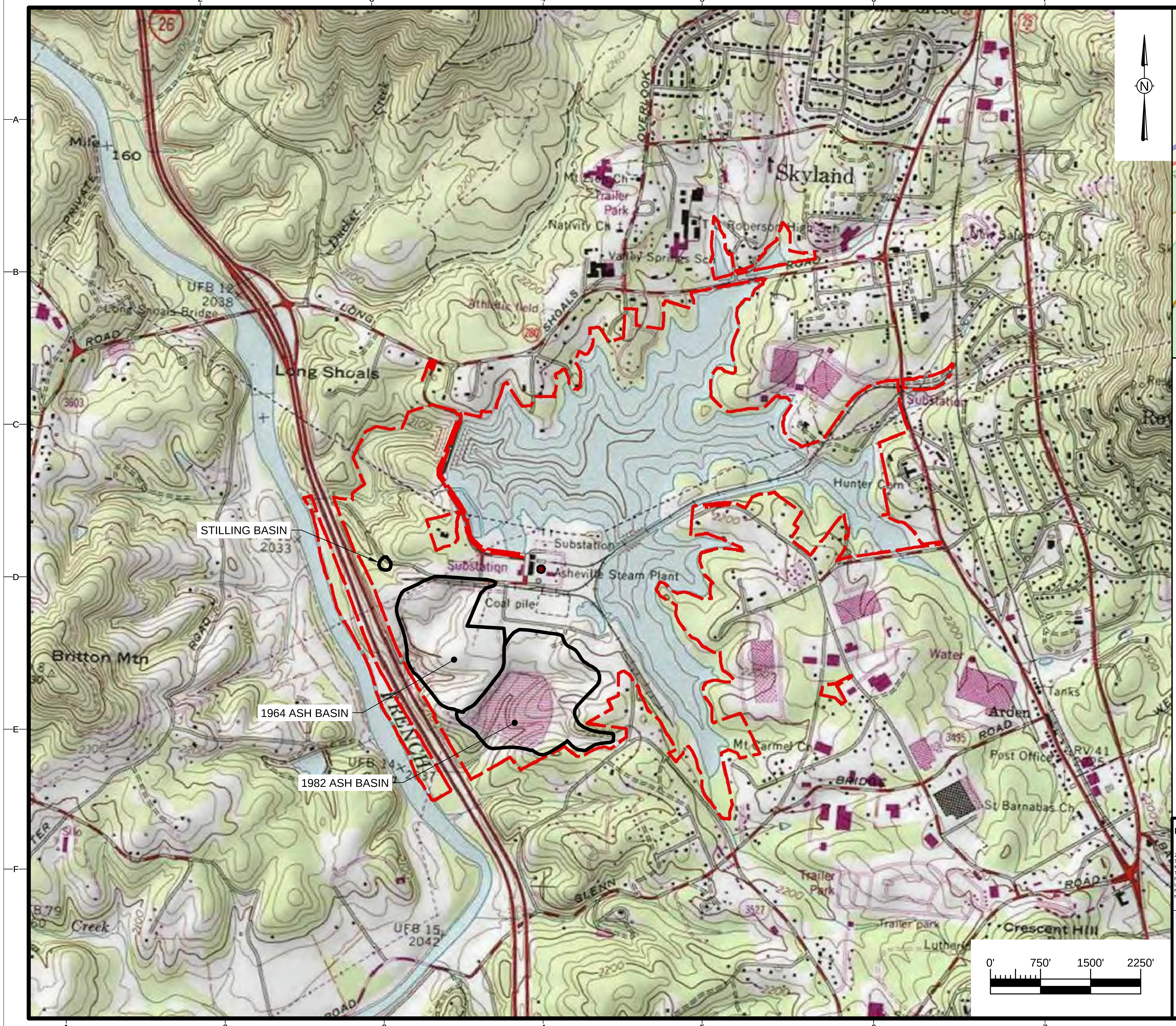
Table 2-2: NC CAMA Closure Plan Requirements
Summary and Cross Reference Table
Ash Basin Site Analysis and Removal Plan - Asheville Steam Electric Generating Plant
Duke Energy

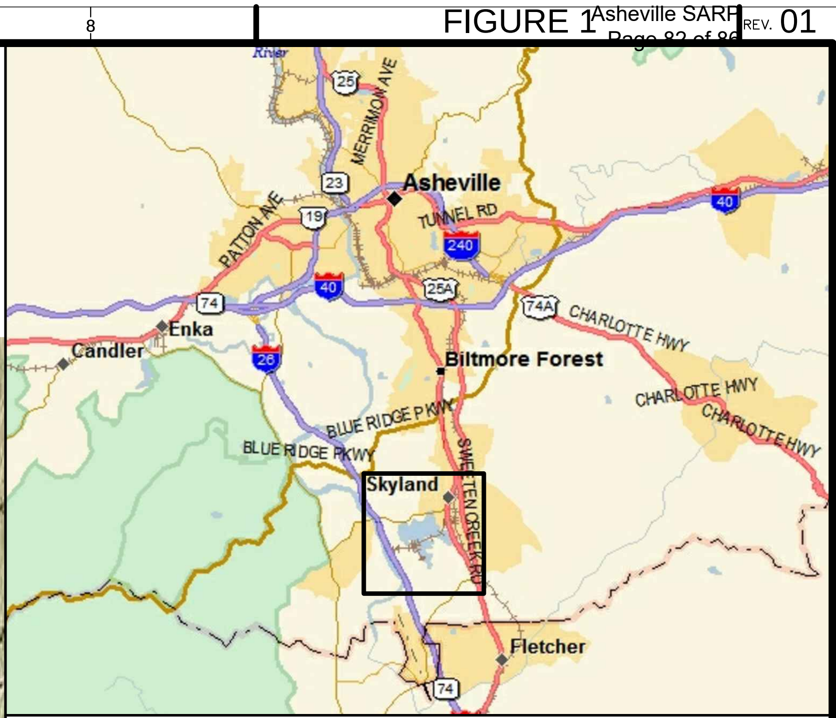
No.	Description	Corresponding Closure Plan Section
e.	**A description of any plans for beneficial use of the coal combustion residuals in compliance with the requirements of Section .1700 of Subchapter B of Chapter 13 of Title 15A of the North Carolina Administrative Code (Requirements for Beneficial Use of Coal Combustion By-Products) and Section .1205 of Subchapter T of Chapter 2 of Title 15A of the North Carolina Administrative Code (Coal Combustion Products Management).**	6.1
f.	**All engineering drawings, schematics, and specifications for the proposed Closure Plan. If required by Chapter 89C of the General Statutes, engineering design documents should be prepared, signed, and sealed by a professional engineer.**	7.1, 7.2
g.	**A description of the construction quality assurance and quality control program to be implemented in conjunction with the Closure Plan, including the responsibilities and authorities for monitoring and testing activities, sampling strategies, and reporting requirements.**	7.3
h.	**A description of the provisions for disposal of wastewater and management of stormwater and the plan for obtaining all required permits.**	8
i.	**A description of the provisions for the final disposition of the coal combustion residuals. If the coal combustion residuals are to be removed, the owner must identify (i) the location and permit number for the coal combustion residuals landfills, industrial landfills, or municipal solid waste landfills in which the coal combustion residuals will be disposed and (ii) in the case where the coal combustion residuals are planned for beneficial use, the location and manner in which the residuals will be temporarily stored. If the coal combustion residuals are to be left in the impoundment, the owner must (i) in the case of closure pursuant to sub-subdivision (a)(1)a. of this section, provide a description of how the ash will be stabilized prior to completion of closure in accordance with closure and post-closure requirements established by Section .1627 of Subchapter B of Chapter 13 of Title 15A of the North Carolina Administrative Code and (ii) in the case of closure pursuant to sub-subdivision (a)(1)b. of this section, provide a description of how the ash will be stabilized pre- and post-closure. If the coal combustion residuals are to be left in the impoundment, the owner must provide an estimate of the volume of coal combustion residuals remaining.**	9
j.	**A list of all permits that will need to be acquired or modified to complete closure activities.**	10
k.	**A description of the plan for post-closure monitoring and care for an impoundment for a minimum of 30 years. The length of the post-closure care period may be (i) proposed to be decreased or the frequency and parameter list modified if the owner demonstrates that the reduced period or modifications are sufficient to protect public health, safety, and welfare; the environment; and natural resources and (ii) increased by the Department at the end of the post-closure monitoring and care period if there are statistically significant increasing groundwater quality trends or if contaminant concentrations have not decreased to a level protective of public health, safety, and welfare; the environment; and natural resources. If the owner determines that the post-closure care monitoring and care period is no longer needed and the Department agrees, the owner shall provide a certification, signed and sealed by a professional engineer, verifying that post-closure monitoring and care has been completed in accordance with the post-closure plan. If required by Chapter 89C of the General Statutes, the proposed plan for post-closure monitoring and care should be signed and sealed by a professional engineer. The plan shall include, at a minimum, all of the following:**	11
1	A demonstration of the long-term control of all leachate, affected groundwater, and stormwater.	11
2	A description of a groundwater monitoring program that includes (i) post-closure groundwater monitoring, including parameters to be sampled and sampling schedules; (ii) any additional monitoring well installations, including a map with the proposed locations and well construction details; and (iii) the actions proposed to mitigate statistically significant increasing groundwater quality trends.	11.1
l.	**An estimate of the milestone dates for all activities related to closure and post-closure.**	12.1
m.	**Projected costs of assessment, corrective action, closure, and post-closure care for each coal combustion residuals surface impoundment.**	12.2
n.	**A description of the anticipated future use of the site and the necessity for the implementation of institutional controls following closure, including property use restrictions, and requirements for recordation of notices documenting the presence of contamination, if applicable, or historical site use.**	6.2
§ 130A-309.212(b)(3) No later than 60 days after receipt of a proposed Closure Plan, the Department shall conduct a public meeting in the county or counties proposed Closure Plan and alternatives to the public.		
§ 130A-309.212(d) Within 30 days of its approval of a Coal Combustion Residuals Surface Impoundment Closure Plan, the Department shall submit the Closure Plan to the Coal Ash Management Commission.		

Note: Although it is not mandated by CAMA, Duke Energy is submitting this Closure Plan to the North Carolina Department of Environmental Quality (formerly NCDENR) to assist the department with identifying areas where its permitting actions will be crucial in allowing Duke Energy to meet its statutory deadlines. Securing the required permit approvals by March 31, 2016, will allow Duke Energy to achieve closure of the 1982 Ash Basin and meet the requirements of the Mountain Energy Act of 2015 (Session Law 2015-110, Signed June 24, 2015), which requires that the ash basins be closed by August 1, 2022.

FIGURES

FIGURE 1 REV. 01





SERVICE LAYER: CREDITS: DELORME STREET ATLAS, ESRI ARCMAP, © : 2013 NATIONAL GEOGRAPHIC SOCIETY.

LEGEND

🟥 – – –	APPROXIMATE DUKE ENERGY PROPERTY BOUNDARY
▬	APPROXIMATE BASIN BOUNDARIES

FIGURE 1

REV. 01

Environment & Infrastructure
2030 FALLING WATERS
SUITE 300
KNOXVILLE, TN 37922
TEL: (865) 671-6774
FAX: (865) 671-6254
LICENSURE:
NC ENG: F-1253
NC GEOLOGY: C-247

amec foster wheeler

SEAL

TITLE
SITE LOCATION MAP
DUKE ENERGY ASHEVILLE PLANT
SKYLAND, NORTH CAROLINA

FOR
ASHEVILLE PLANT

DUKE ENERGY®

SCALE:	AS SHOWN	DES:	APT
DWG TYPE:	DWG	DFTR:	APT
JOB NO:	7810160620	CHKD:	MB
DATE:	12-12-2016	ENGR:	DS
FILENAME:	Figure 1 Site Location Map.dwg	APPD:	

DWG SIZE	DRAWING NO.	REVISION
ANSI C 11"x17"	FIGURE 1	01

Plotted By: Troxel, Paul Sheet Set: New Sheet Set (3) Layout: 01 December 13, 2016 08:31:38am P:\CADD\Projects\7810\7810160620 Asheville\Site Analysis & Removal Plan\Plansheets\Figure 1 Site Location Map.dwg

LEGEND

- — — — ASH POND LIMITS
- —·—·— PROPERTY BOUNDARY
- ——— FORMER WETLAND AREA

NOTE:

1. AERIAL PHOTO DATED 10-2015 SOURCE BY GOOGLE EARTH PRO.
2. PROPERTY BOUNDARY OBTAINED FROM BUNCOMBE COUNTY GIS DATA AT HTTP://BUNCOMBECOUNTY.ORG/MAP_ALL.HTML.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

DUKE ENERGY

CLIENT:

DUKE ENERGY PROGRESS
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec foster wheeler

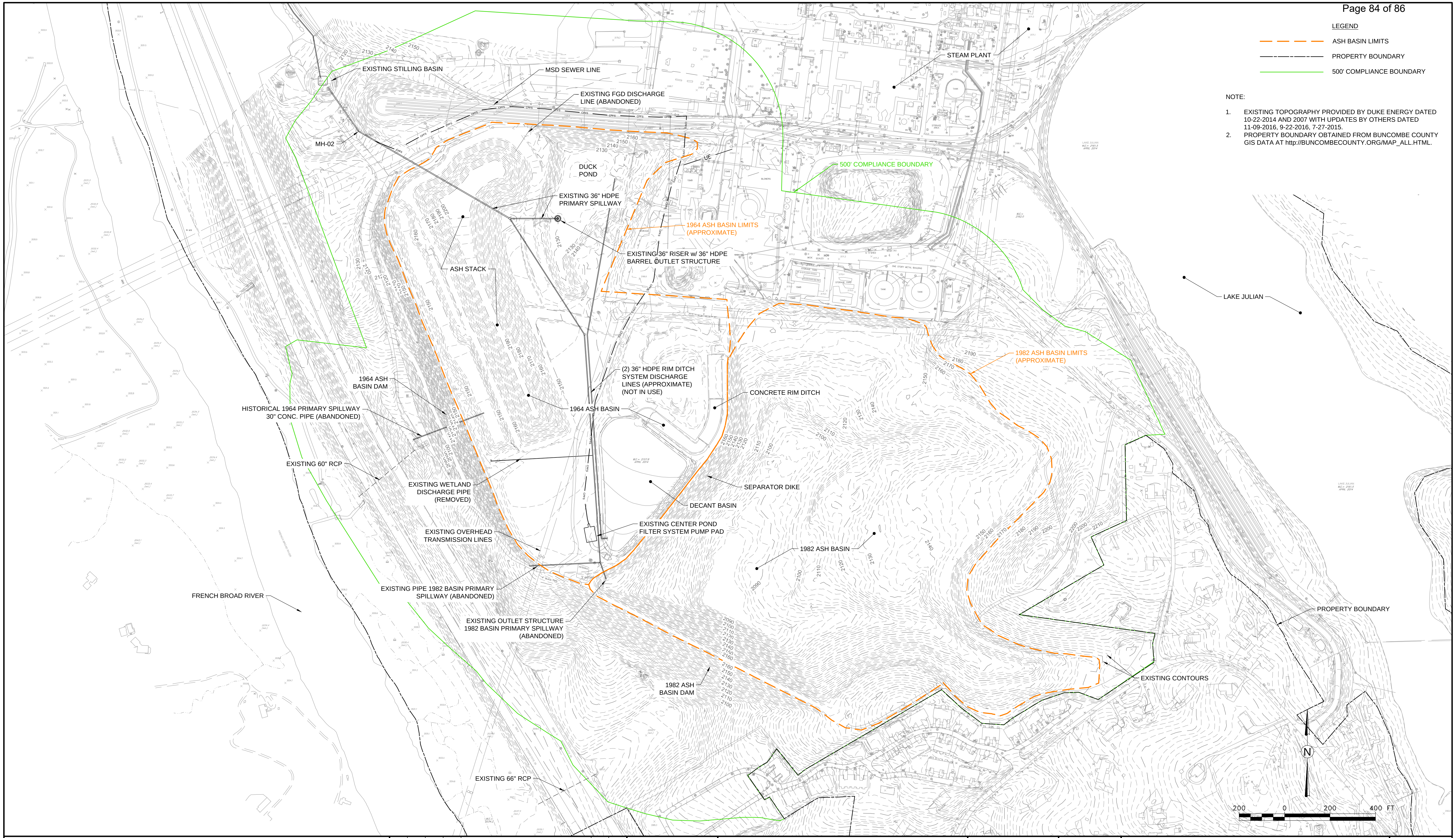
DATUM: WGS84
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: MB
SCALE: AS NOTED

PROJECT:
SITE ANALYSIS AND REMOVAL PLAN
DUKE ENERGY - ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE:
SITE OVERVIEW AERIAL PLAN

PROJECT NO.: 7810160620
REVISION NO. NA
DATE: 12/12/2016
FIGURE NO. 2

Plotted By: Troxel, Paul Sheet Set: N/A Layout: 01 December 13, 2016 08:28:46am P:\CADD\Projects\7810\7810160620 Asheville\Site Analysis & Removal Plan\Plansheets\Figure 2 Site Overview Aerial.dwg



LEGEND

— — — —	ASH BASIN LIMITS
—-—-—-—	PROPERTY BOUNDARY
———	500' COMPLIANCE BOUNDARY

NOTE:

1. EXISTING TOPOGRAPHY PROVIDED BY DUKE ENERGY DATED 10-22-2014 AND 2007 WITH UPDATES BY OTHERS DATED 11-09-2016, 9-22-2016, 7-27-2015.
2. PROPERTY BOUNDARY OBTAINED FROM BUNCOMBE COUNTY GIS DATA AT http://BUNCOMBECOUNTY.ORG/MAP_ALL.HTML.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

DUKE ENERGY

CLIENT:

DUKE ENERGY PROGRESS
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec foster wheeler

DATUM: WGS84
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: MB
SCALE: AS NOTED

PROJECT:
SITE ANALYSIS AND REMOVAL PLAN
DUKE ENERGY - ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

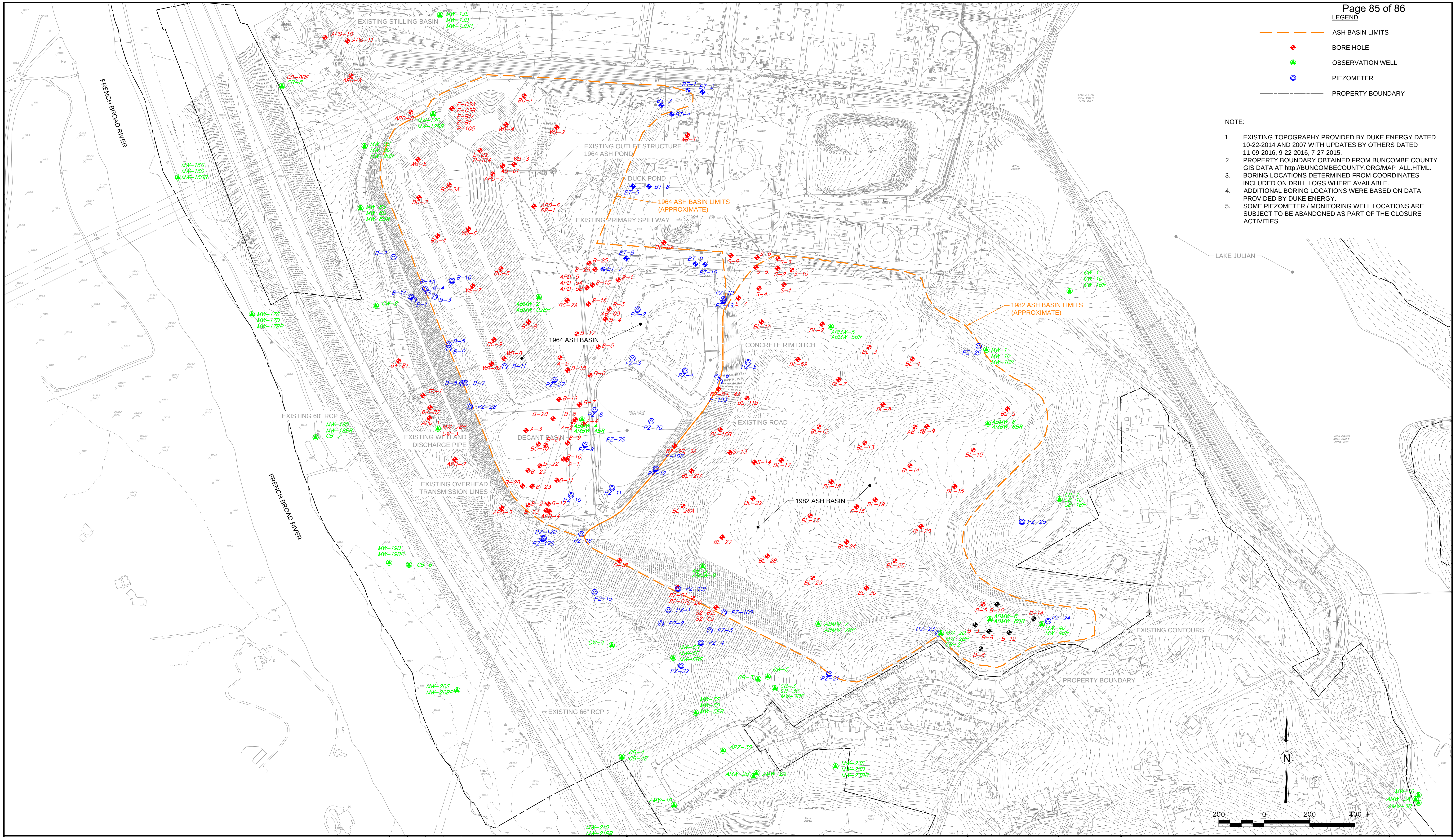
TITLE:
CCR IMPOUNDMENT RELATED STRUCTURES

PROJECT NO.: 7810160620
REVISION NO. NA
DATE: 12/12/2016
FIGURE NO. 3

Plotted By: Troxel, Paul Sheet Set: N/A Layout: 01 December 13, 2016 08:33:14am P:\CADD\Projects\7810\7810160620 Asheville\Site Analysis & Removal Plan\Plansheets\Figure 3 CCR Impoundment Related Structures.dwg

OFFICIAL COPY

Oct 30 2019



LEGEND

— — — —	ASH BASIN LIMITS
⊕	BORE HOLE
▲	OBSERVATION WELL
△	PIEZOMETER
—-—-—-—	PROPERTY BOUNDARY

NOTE:

1. EXISTING TOPOGRAPHY PROVIDED BY DUKE ENERGY DATED 10-22-2014 AND 2007 WITH UPDATES BY OTHERS DATED 11-09-2016, 9-22-2016, 7-27-2015.
2. PROPERTY BOUNDARY OBTAINED FROM BUNCOMBE COUNTY GIS DATA AT http://BUNCOMBECOUNTY.ORG/MAP_ALL.HTML.
3. BORING LOCATIONS DETERMINED FROM COORDINATES INCLUDED ON DRILL LOGS WHERE AVAILABLE.
4. ADDITIONAL BORING LOCATIONS WERE BASED ON DATA PROVIDED BY DUKE ENERGY.
5. SOME PIEZOMETER / MONITORING WELL LOCATIONS ARE SUBJECT TO BE ABANDONED AS PART OF THE CLOSURE ACTIVITIES.

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

CLIENT:

DUKE ENERGY PROGRESS
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM:	WGS84
PROJECTION:	STATE PLANE 83
DRAWN BY:	APT
REVIEWED BY:	MB
SCALE:	AS NOTED

PROJECT:
SITE ANALYSIS AND REMOVAL PLAN
DUKE ENERGY - ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE:

BORING LOCATION MAP 1982 & 1964 ASH BASINS

PROJECT NO.:	7810160620
REVISION NO.	NA
DATE:	12/12/2016
FIGURE NO.	4

Plotted By: Troxel, Paul Sheet Set: N/A Layout: 01 December 13, 2016 08:34:50am P:\CADD\Projects\7810\7810160620 Asheville\Site Analysis & Removal Plan\Plansheets\Figure 4 Boring Location Map.dwg

APPENDICES

APPENDIX A: WASTE INVENTORY ANALYSIS (1964 ASH BASIN)

amec
foster
wheeler

CALCULATION COVER SHEET

Project Asheville Steam Station – Waste Strategy Analysis	**Calc/Analysis No.** WBS 2	**AMEC Project No.** 7810-14-0162.02
Title Estimate of Coal Combustion Residuals (CCR) Quantity	**Client Contract** NA **Discipline** Civil	**Sheet No. 1 of 5**
Computer Program AutoDesk Civil 3D 2013	**Version / Release No.** N/A	
Purpose and Objective Estimate the quantity of CCR located on Asheville Steam Station property (excluding material that is currently being removed).	**Quality Assurance Conditions (e.g. safety classification)** NA	

Summary of Conclusion

Based on the assumptions described in this calculation, the quantity of CCR on the Asheville Steam Station site (excluding material that is currently being removed) was estimated to be approximately 2,113,000 cubic yards (2.1 million dry tons).

Revision Log

Rev. No.	**Revision Description**
00	Initial issue.
1A	Refined volume calculations. Separated from landfill size calculations.

Sign Off

Rev. No.	**Originator (Print)** **Sign / Date**	**Verification Method**	**Verifier (Print)** **Sign / Date**	**Technical Lead (Print)** **Sign / Date**
00	Chris Jordan	**Design Review**	Thomas B. Maier	Kenneth R. Daly
	Chris Jordan, EI		**Thomas B. Maier, PE**	**Ken Daly, PE**
1A	**1/12/2015**		**1/12/2015**	**1/14/2015**

Additional Reviewer (Print)	**Signature**	**Date**
NA		

RECORD OF REVISION

Revision No.	Date	Revisions Made
00	11/05/2014	Initial issue
1A	1/12/2015	Refined volume calculations. Separated from landfill size calculations.

TABLE OF CONTENTS

LIST OF TABLES

1.0 OBJECTIVE

The objective of this calculation is to estimate the quantity of coal combustion residuals (CCR) located on Asheville Steam Station property (excluding material that is currently being removed). The areas containing CCR are shown on the attached **Figure 1**.

2.0 ASSUMPTIONS

The following assumptions and limitations are noted.

- Based on data gathered from several coal burning plants, the following typical CCR properties are assumed:

Material	Dry Unit Weight (tons/cy)	Moisture Content (%)	Moist Unit Weight (%)
CCR in Wet Ponds	0.8	50%	1.2
CCR in Ash Fills	1.0	20%	1.2

- Since the 1964 Ash Pond has not impounded water for many years and there has been significant dry stacking/filling on the pond, it is assumed to have properties closer to those in the second row of the above table.

3.0 APPROACH

Material quantities were estimated using a method that consists of utilizing historical ground surface topographic information from historic design drawings or USGS mapping, and using AutoCAD Civil 3D software to compare the historic ground surface with current conditions.

Quantity of Material Within the 1964 Ash Basin
(see attached Figures 2.1 through 2.5)

The area of the 1964 Ash Basin is approximately 41 acres (**See Table 1**). The quantity of material within the 1964 Ash Basin was estimated using AutoCAD Civil 3D software. An approximate pre-fill ground surface was generated based on the approximate topographic information shown in Brown and Root Drawing G-221-B Rev. B dated 7/29/1971 (topography dated 12/30/1969). The pre-fill grades were compared to 4/3/2012 topography obtained from the North Carolina Flood Plain Mapping LIDAR geodatabase. In addition, a surface was generated to approximate the 2013 settling basin excavation by Charah based on the drawing entitled, " '64 Rim Ditch & Settling Basin Improvements – Layout/Grading Plan" revised 1/29/13. The estimated quantity of material within the 1964 Ash Basin is provided in **Table 1**.

Data Limitations
The following data limitations, which are potential sources of inaccuracies in the calculated volumes, have been identified: Drawing G-221-B used for the 1964 basin bottom topography shows standing water which decreases the calculated pond volume, and the volume of FGD wastewater pond material that may need to be disposed separately is not known.

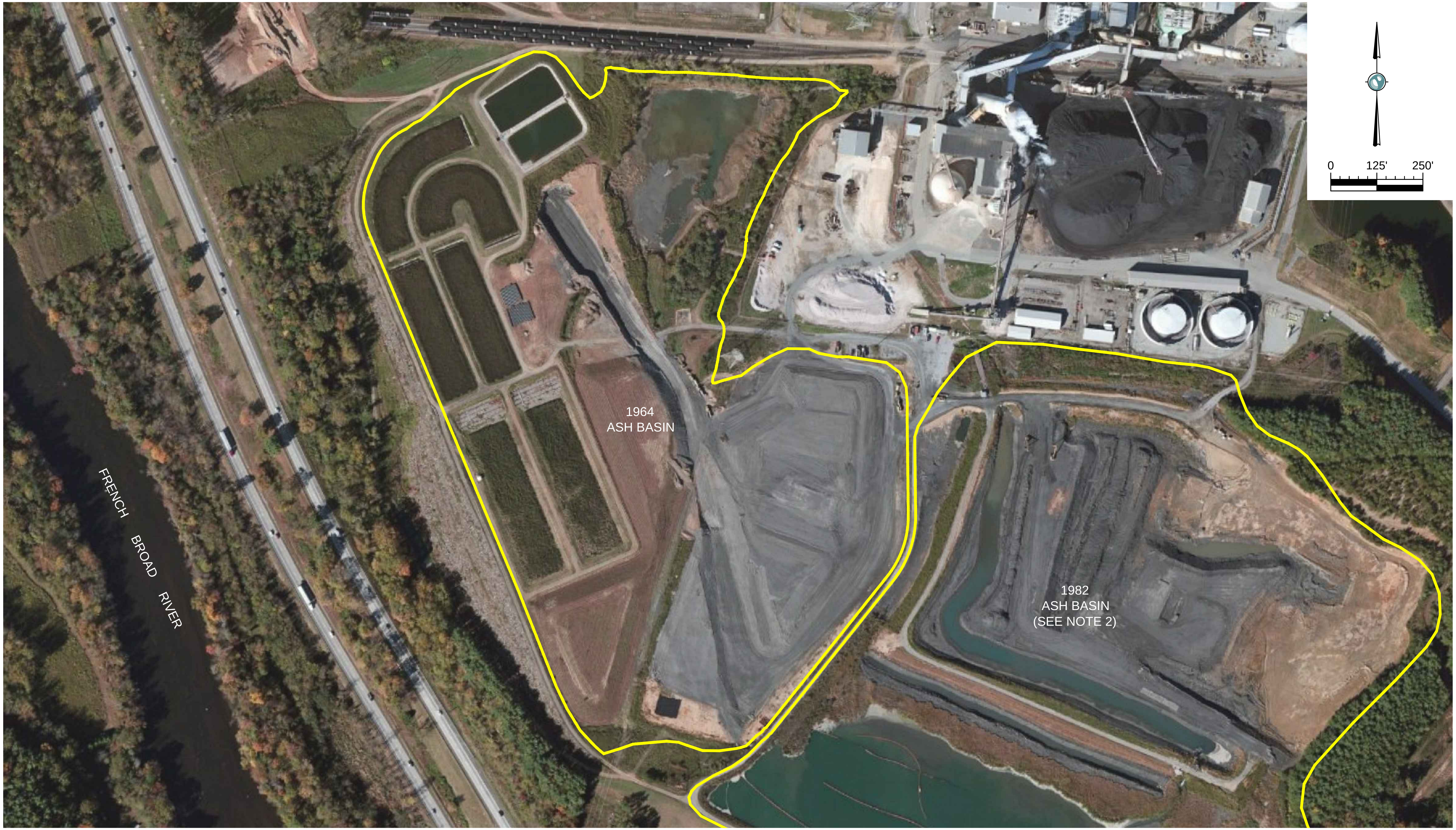
4.0 CONCLUSIONS

Based on the assumptions described in this calculation, the quantity of CCR in the Asheville Steam Station 1964 Ash Basin was estimated to be approximately 2,113,000 cubic yards (2,113,000 dry tons). The estimated moist weight of CCR is also reported in **Table 1** because it is a more realistic representation of the weight of material to be handled during removal and construction activities. Moist unit weight is calculated based on the assumed dry unit weight and moisture content noted herein.

Table 1: Summary of Areas Containing Ash Included in this Analysis

Description	Surface Area (ac)	Volume (cy)	Estimated Dry Unit Weight (ton/cy)	Estimated Dry Weight (tons)	Estimated Moisture Content (%)	Estimated Moist Unit Weight (ton/cy)	Estimated Moist Weight* (tons)
1964 Ash Basin	41.4	2,113,000	1.0	2,113,000	20%	1.2	2,535,600
TOTAL	41.4	2,113,000		2,113,000			2,536,000

*Moist unit weight is used for construction cost estimating purposes.



NOTES:
1. ASH BOUNDARIES ARE APPROXIMATE.
2. THE 1982 ASH BASIN IS NOT INCLUDED IN THIS INVENTORY. ASH IS CURRENTLY BEING REMOVED FROM THIS BASIN FOR BENEFICIAL USE.

REFERENCES
1. HIGH RESOLUTION 2010 AERIAL IMAGERY WAS OBTAINED FROM WWW.ESRI.COM.

CLIENT:
DUKE ENERGY.

AMEC Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec

DATUM (HOR - VER): NAD83 - NAVD88
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

PROJECT:
WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE:
ASH AREAS
AERIAL IMAGERY
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO. 0
DATE: DEC. 2014
FIGURE NO. 1

Q:\Ash Inventory\Asheville\Asheville 2.x Set.dwg

NOTES:
1. BOXED CONTOUR LABELS HAVE BEEN ADDED FOR CLARITY.
2. CONTOUR ELEVATIONS ARE ASSUMED TO REFERENCE NGVD29 VERTICAL DATUM.

REFERENCES
1. DRAWING NO. G-221-B ENTITLED, "ASH DISPOSAL POND & DAM, GENERAL LAYOUT" PREPARED BY CAROLINA POWER & LIGHT COMPANY, REV. B, DATED 7/29/71. VERTICAL DATUM NOT INDICATED.

CLIENT: DUKE ENERGY

AMEC Environment & Infrastructure, Inc.
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CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec

DATUM (HOR - VER): NAD83 - NGVD29
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

PROJECT: WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE: 1964 ASH BASIN
ORIGINAL TOPOGRAPHY
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO.: 0
DATE: DEC. 2014
FIGURE NO. 2.1

Q:\Ash Inventory\Asheville\Asheville 2.x Set.dwg

NOTES:
1. (2FT) CONTOURS WERE DIGITIZED FROM HISTORICAL TOPO SHOWN IN FIGURE 2.1 (REFERENCE 1). INTERPOLATED (5FT) CONTOURS ARE SHOWN HERE FOR CLARITY PURPOSE.
2. A DATUM SHIFT OF -0.13 FT WAS APPLIED TO CONVERT ELEVATIONS FROM NGVD29 TO NAVD88.
3. THIS IS AN ACCURATE REPRESENTATION OF THE CONTOURS SHOWN IN REFERENCE 1 AND IS AN APPROXIMATION OF THE BOTTOM OF ASH BASIN CONTOURS BASED ON THE BEST INFORMATION AVAILABLE TO AMEC IN DECEMBER 2014.

REFERENCES
1. DRAWING NO. G-221-B ENTITLED, "ASH DISPOSAL POND & DAM, GENERAL LAYOUT" PREPARED BY CAROLINA POWER & LIGHT COMPANY, REV. B, DATED 7/29/71. VERTICAL DATUM CONVERTED FROM NGVD29 TO NAVD88.

CLIENT:
DUKE ENERGY

AMEC Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec

DATUM (HOR - VER): NAD83 - NAVD88
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

PROJECT:
WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE:
1964 ASH BASIN
DIGITIZED BASE CONTOURS
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO.: 0
DATE: DEC. 2014
FIGURE NO.: 2.2

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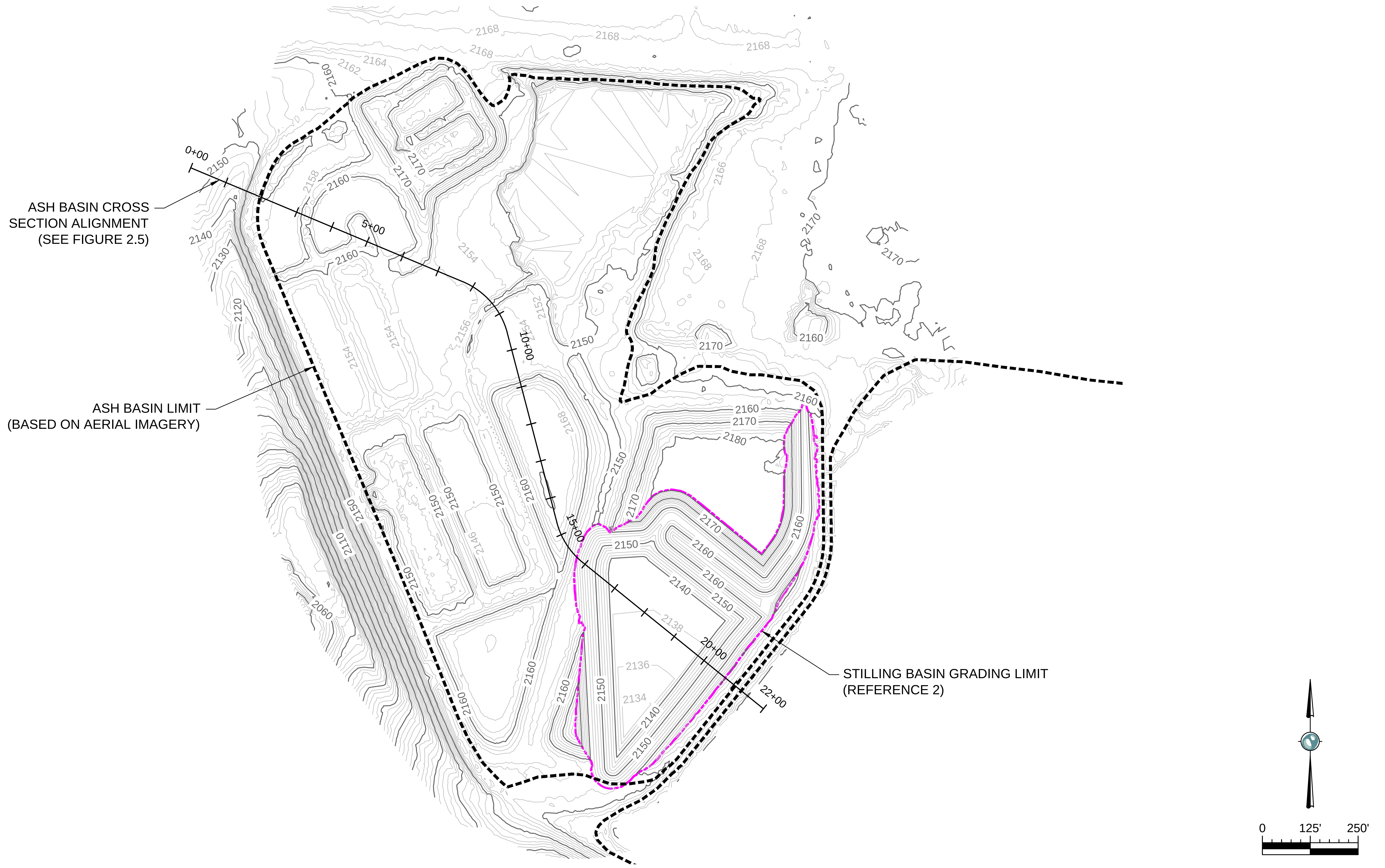

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NOTES

1. ASH BOUNDARIES ARE APPROXIMATE.

REFERENCES

1. NORTH CAROLINA FLOODPLAIN MAPPING PROGRAM (NCFMP) LIDAR BARE EARTH MASS POINTS PUBLISHED IN APRIL 2006. VERTICAL DATUM NAVD88.
2. DRAWING NO. 1.0 ENTITLED, " '64 RIM DITCH & STILLING BASIN IMPROVEMENTS LAYOUT/GRADING PLAN" REV. 2 PREPARED BY FRANKLIN S. CRAIG, PE, DATED 1/29/13.VERTICAL DATUM NAVD88.

CLIENT:
DUKE ENERGY.

AMEC Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

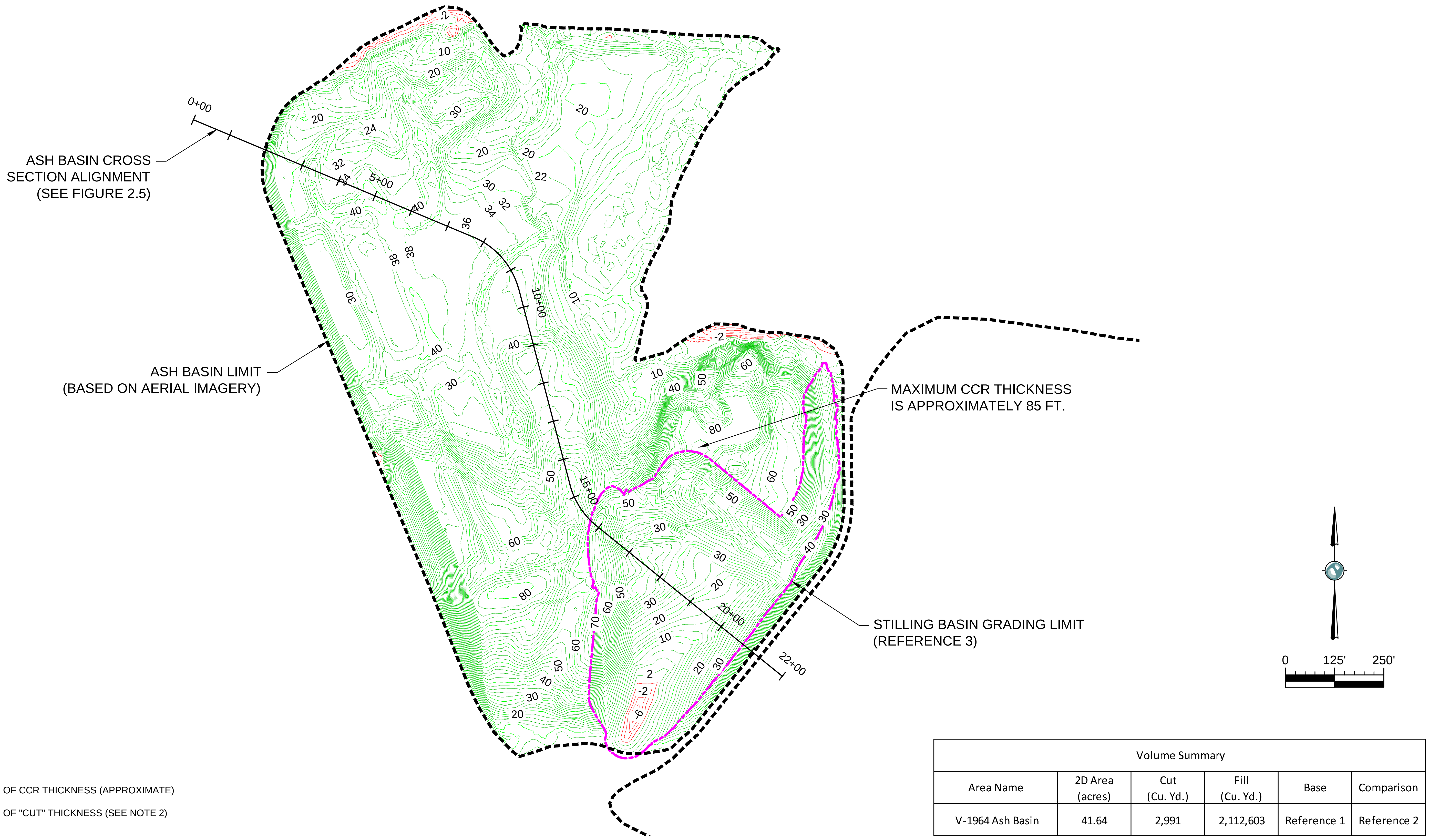
amec

DATUM (HOR - VER): NAD83 - NAVD88
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

PROJECT: WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE:
1964 ASH BASIN
RECENT TOPOGRAPHY
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO.: 0
DATE: DEC. 2014
FIGURE NO.: 2.3



LEGEND

🟩 CONTOUR OF CCR THICKNESS (APPROXIMATE)

🟥 CONTOUR OF "CUT" THICKNESS (SEE NOTE 2)

Volume Summary					
Area Name	2D Area (acres)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Base	Comparison
V-1964 Ash Basin	41.64	2,991	2,112,603	Reference 1	Reference 2

Q:\Ash Inventory\Asheville\Asheville 2.x Set.dwg

NOTES:
1. COAL COMBUSTION RESIDUALS (CCR) VOLUME WAS CALCULATED USING AUTOCAD CIVIL 3D SOFTWARE.
2. RED CONTOURS, IF PRESENT, INDICATE THAT THE BASE SURFACE IS AT HIGHER ELEVATION THAN THE COMPARISON SURFACE. THIS MAY BE DUE TO REGRADING AND/OR LIMITATIONS OF DATA QUALITY.

REFERENCES:
1. DRAWING NO. G-221-B ENTITLED, "ASH DISPOSAL POND & DAM, GENERAL LAYOUT" PREPARED BY CAROLINA POWER & LIGHT COMPANY, REV. B, DATED 7/29/71. VERTICAL DATUM CONVERTED FROM NGVD29 TO NAVD88.
2. NORTH CAROLINA FLOODPLAIN MAPPING PROGRAM (NCFMP) LIDAR BARE EARTH MASS POINTS PUBLISHED IN APRIL 2006. VERTICAL DATUM NAVD88.
3. DRAWING NO. 1.0 ENTITLED, " '64 RIM DITCH & STILLING BASIN IMPROVEMENTS LAYOUT/GRADING PLAN" REV. 2 PREPARED BY FRANKLIN S. CRAIG, PE, DATED 1/29/13.VERTICAL DATUM NAVD88.

CLIENT: DUKE ENERGY

AMEC Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

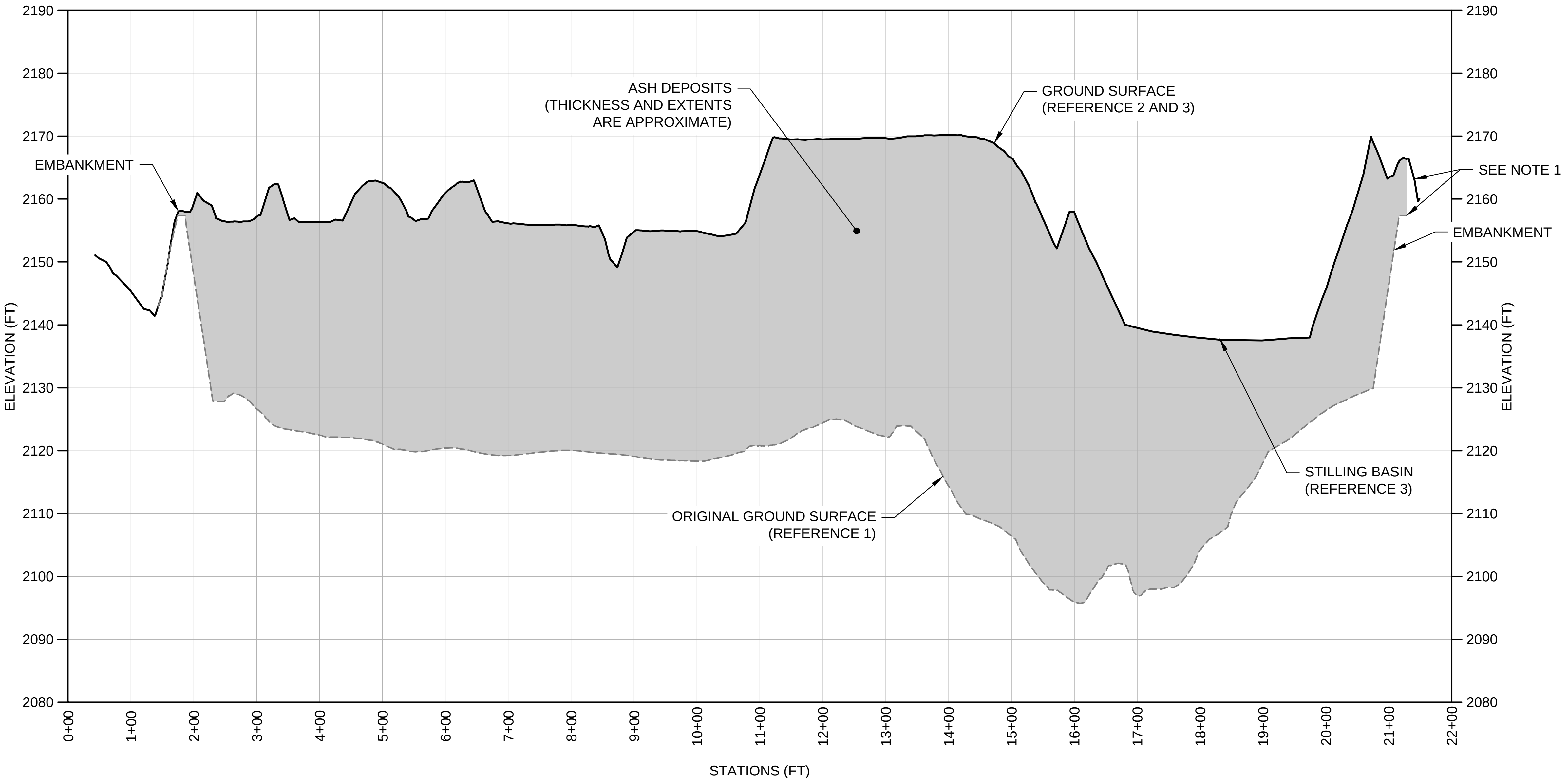
DATUM (HOR - VER): NAD83 - NAVD88
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

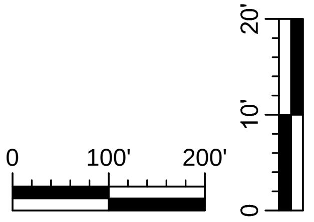
PROJECT:
WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE:
1964 ASH BASIN
ISOPACH
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO.: 0
DATE: DEC. 2014
FIGURE NO. 2.4

ASHEVILLE STEAM STATION 1964 ASH BASIN





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NOTES:
1. AT THE DESIGNATED LIMIT OF ASH BASIN, THE ORIGINAL GROUND SURFACE ELEVATION MAY NOT EQUAL THE "EXISTING" GROUND SURFACE ELEVATION DUE TO REGRADING AND/OR LIMITATIONS OF DATA QUALITY.

REFERENCES:
1. DRAWING NO. G-221-B ENTITLED, "ASH DISPOSAL POND & DAM, GENERAL LAYOUT" PREPARED BY CAROLINA POWER & LIGHT COMPANY, REV. B, DATED 7/29/71. VERTICAL DATUM CONVERTED FROM NGVD29 TO NAVD88.
2. NORTH CAROLINA FLOODPLAIN MAPPING PROGRAM (NCFMP) LIDAR BARE EARTH MASS POINTS PUBLISHED IN APRIL 2006. VERTICAL DATUM NAVD88.
3. DRAWING NO. 1.0 ENTITLED, " '64 RIM DITCH & STILLING BASIN IMPROVEMENTS LAYOUT/GRADING PLAN" REV. 2 PREPARED BY FRANKLIN S. CRAIG, PE, DATED 1/29/13.VERTICAL DATUM NAVD88.

CLIENT:
DUKE ENERGY®

AMEC Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

amec

DATUM (HOR - VER): NAD83 - NAVD88
PROJECTION: NC83F
DRAWN BY: MA
REVIEWED BY: TM
SCALE: AS NOTED

PROJECT:
WASTE STRATEGY ANALYSIS
ASHEVILLE - ASH INVENTORY

TITLE:
1964 ASH BASIN
CROSS SECTION
ASHEVILLE STEAM STATION, BUNCOMBE CO., NC

PROJECT NO.: 7810140162.02
REVISION NO.: 0
DATE: DEC. 2014
FIGURE NO.: 2.5

Bednarcik Exhibit 8
Docket No. E-2 Sub 1219
Asheville SARP Appendix B
Page 1 of 2

APPENDIX B: COMPREHENSIVE SITE ASSESSMENT (CSA) REPORT, AUGUST 23, 2015 (SYNTERRA 2015a); CSA REPORT SUPPLEMENT 1, AUGUST 31, 2016 (SYNTERRA 2016b)

Reports are presented herein in electronic format on the enclosed CD.

APPENDIX C: CORRECTIVE ACTION PLAN (CAP) PART 1, NOVEMBER 20, 2016 (SYNTERRA 2015b); CAP PART 2, FEBRUARY 19, 2016 (SYNTERRA, 2016a); UPDATED GROUNDWATER FLOW AND TRANSPORT MODELING REPORT, MARCH 17, 2017 (Falta, et al 2017)

Reports are presented herein in electronic format on the enclosed CD.

APPENDIX D: ENGINEERING EVALUATIONS AND ANALYSES OF CLOSURE DESIGN GRADING PLANS FOR THE 1982 ASH BASIN

Decommissioning Plan Calculations

Calculation Title:
PMP Containment Calculations

Summary:
This calculation determines the minimum crest elevation required for the existing 1982 Ash Basin Dam to contain the design PMP storm event. Stage-storage curves were developed during the decommissioning design for the ash basin dam and the storage volumes within the existing ash basin. Those stage-storage curves were compared with the PMP stormwater volume, and an elevation of 2126' was determined as the minimum required crest elevation for the dam to contain the storm.

Once this elevation is reached the dam will be breached along the left abutment to the active fill area (or lower to facilitate underdrain construction) so that the dam will no longer impound significant volumes of water.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	Luke C. Williams, PE 041903 Luke C. Williams 1-14-16	Daniel R. Smith 1/14/16

OBJECTIVE:

The objective of this calculation is to determine the minimum crest elevation of the 1982 Ash Basin dam that is required to store the PMP design storm event without overtopping. The results of this calculation will be used in the construction sequencing design to determine the point in which the dam should be breached.

METHOD:

Calculations for the PMP storm event are based on stage-storage information associated with the balanced breach design presented in the drawings. Two stage-storage curves were developed for the balanced breach: 1. Volume of dam material generated during excavation, and 2. Impoundment volume present within the existing ash basin after ash removal. The design storm volume was compared to the stage-storage curves to determine the minimum crest elevation required.

CALCULATIONS:

1.0 Volume of Dam Material Generated During Excavation

A stage-volume curve was developed for the material in the current 1982 Ash Basin Dam that will be used as fill material. The volumes were determined using the computer program AutoCAD Civil 3D. AutoCAD calculates these volumes based on triangulation methods. The volumes were calculated between the crest elevation of approximately 2166’ to an elevation of 2090’. As shown on **Figure 1**, the cumulative volume present within the 1982 Ash Basin Dam between these elevations is approximately 208 acre-feet. The AutoCAD output of these volumes is included with this calculation as **Attachment 1**.

2.0 Impoundment Volume within the Existing Ash Basin

Storage volumes that will be present within the existing 1982 Ash Basin were also calculated. As part of the decommissioning process, ash that is currently present within the basin will be removed and transported offsite. Therefore, post ash excavation grades were developed for the 1982 Ash Basin, which will represent the configuration of the basin before dam decommissioning activities commence. Using the post ash excavation grades, a stage-storage curve was developed for the storage volume available.

The stage-storage curve was calculated using AutoCAD Civil 3D’s triangulation methods. The storage volumes were calculated between the basin elevations of 2074’ and 2130’. As shown on **Figure 1**, the cumulative storage volume present within the 1982 Ash Basin between these elevations is approximately 492 acre-feet. The AutoCAD output of these volumes is included with this calculation as **Attachment 2**.

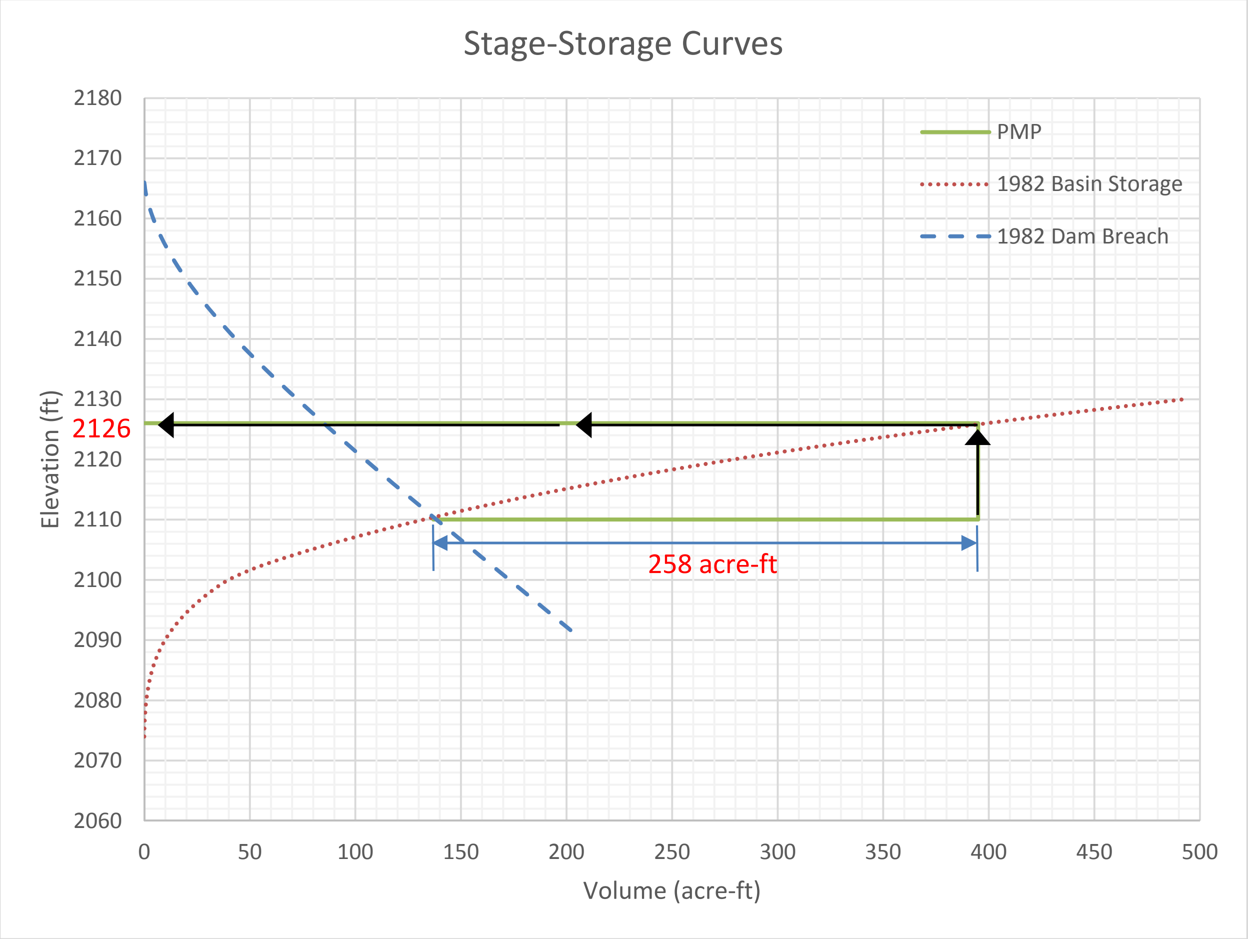


Figure 1: Stage-Storage Curves for the 1982 Ash Basin

3.0 PMP Storage Volume Calculations

The design storm volumes for the 1982 Ash Basin was modeled using a Full PMP storm event. These calculations were performed as part of the Phase 2 Reconstitution for the site. As determined from the "Asheville 1964 and 1982 Ash Ponds – Hydrologic and Hydraulic (H&H) Analysis," the design storm volume under a Full PMP storm event is 258 acre-feet.

To calculate the minimum required crest elevation to contain the design storm event, the design storm volume of 258 acre-feet was also plotted with the stage-storage curves presented on **Figure 1**. As part of the balanced breach activities, excavated materials from the dam will be used as fill materials within the basin. The intersection of the two curves is at 2110' and 138 acre-feet, thus representing the idealized balanced breach elevation and volume, respectively.

It should be noted that the design drawings [Ref. 4] show a balanced breach at elevation 2106'. The final design reflects a lower breach elevation, as more material is necessary to slope the proposed backfill to allow for stormwater drainage. However, the calculation herein presents the idealized balanced breach, which is applicable for interim construction conditions.

The design storm volume of 258 acre-feet was drawn at the idealized intersection at elevation 2110’, and new line intersects were drawn to determine the required dam crest elevation to contain the storm volume. As shown on **Figure 1**, a minimum dam elevation of 2126’ is required during balanced breach activities to contain the design storm event.

DISCUSSION:

During the decommissioning activities, the PMP design storm volume will initially be contained within the existing 1982 Ash Basin at the site. However, as construction of the dam breach progresses, storage volume within the existing basin will be decreased as the dam is lowered and backfill is placed within the basin. Once the basin is no longer able to contain the PMP storm event, a breach through the dam is necessary to safely convey the stormwater runoff away from the basin and prevent overtopping of the dam. Using stage-storage curves for both the dam excavation and the storage volume within the basin, it was determined that the PMP storm event could be contained with a minimum dam elevation of 2126’.

REFERENCES:

1. “Asheville 1964 and 1982 Ash Ponds – Hydrologic and Hydraulic (H&H) Analysis,” Phase 2 Reconstitution of Design, December 30, 2014.

2. Microsoft Excel 2013, Microsoft Corporation.

3. AutoCAD Civil 3D 2015, AutoDesk Inc.

4. Amec Foster Wheeler, “Decommissioning and Ash Removal Plan, 1982 Ash Basin,” January 14, 2016.

ATTACHMENTS:

Attachment 1 – 1982 Ash Basin Dam Breach Volumes AutoCAD Output

Attachment 2 – 1982 Ash Basin Storage Volumes AutoCAD Output

Attachment 1

1982 Ash Basin Dam Breach Volumes AutoCAD Output

```
                  1982 Dam Breech-Volumes by Triangulation (Prisms).txt
Volumes by Triangulation (Prisms)                      Wed Jan 06 12:03:24 2016
Existing Surface: P:\CADD\Projects\7810\7810150250 Asheville Pond\100% Design
Package Pond 1982 & 1964 Closure\Work\APT\1982 Dam Breech Base.tin
Final Surface:   P:\CADD\Projects\7810\7810150250 Asheville Pond\100% Design Package
Pond 1982 & 1964 Closure\Work\APT\1982 Dam Breech.tin

Cut volume: 9,042,998.3 C.F., 334,925.86 C.Y.
Fill volume: 565.7 C.F., 20.95 C.Y.

Area in Cut : 285,518.5 S.F., 6.55 Acres
Area in Fill: 477.4 S.F., 0.01 Acres
Total inclusion area: 286,004.9 S.F., 6.57 Acres

Average Cut Depth: 31.67 feet
Cut to Fill ratio: 15984.50
Export Volume: 334,904.9 C.Y.
Elevation Change To Reach Balance: 31.616
Volume Change Per .1 ft: 1,059.3 C.Y.

Cut (C.Y.) / Area (acres): 51010.91
Fill (C.Y.) / Area (acres): 3.19

Max Cut: 76.000 at 944892.414,642851.901
Max Fill: 2.915 at 944500.922,643111.262

Elevation Zone Volumes

Zone: 2166.000 to 2168.000
Cut Volume : 314.49 C.F., 11.65 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.

Zone: 2164.000 to 2166.000
Cut Volume : 35,794.31 C.F., 1,325.72 C.Y.
Fill Volume : 1.47 C.F., 0.05 C.Y.
Running Totals:
Cut Volume : 36,108.80 C.F., 1,337.36 C.Y.
Fill Volume : 1.47 C.F., 0.05 C.Y.

Zone: 2162.000 to 2164.000
Cut Volume : 64,747.36 C.F., 2,398.05 C.Y.
Fill Volume : 0.32 C.F., 0.01 C.Y.
Running Totals:
Cut Volume : 100,856.16 C.F., 3,735.41 C.Y.
Fill Volume : 1.79 C.F., 0.07 C.Y.

Zone: 2160.000 to 2162.000
Cut Volume : 83,739.29 C.F., 3,101.46 C.Y.
Fill Volume : 0.07 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 184,595.45 C.F., 6,836.87 C.Y.
Fill Volume : 1.86 C.F., 0.07 C.Y.

Zone: 2158.000 to 2160.000
Cut Volume : 102,073.34 C.F., 3,780.49 C.Y.
Fill Volume : 0.10 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 286,668.79 C.F., 10,617.36 C.Y.
Fill Volume : 1.95 C.F., 0.07 C.Y.

Zone: 2156.000 to 2158.000
Cut Volume : 119,667.30 C.F., 4,432.12 C.Y.
Fill Volume : 0.02 C.F., 0.00 C.Y.
Running Totals:
```

```
Cut Volume : 406,336.10 C.F., 15,049.49 C.Y.
Fill Volume : 1.97 C.F., 0.07 C.Y.

Zone: 2154.000 to 2156.000
Cut Volume : 136,460.10 C.F., 5,054.08 C.Y.
Fill Volume : 0.01 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 542,796.20 C.F., 20,103.56 C.Y.
Fill Volume : 1.98 C.F., 0.07 C.Y.

Zone: 2152.000 to 2154.000
Cut Volume : 152,439.02 C.F., 5,645.89 C.Y.
Fill Volume : 0.07 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 695,235.23 C.F., 25,749.45 C.Y.
Fill Volume : 2.05 C.F., 0.08 C.Y.

Zone: 2150.000 to 2152.000
Cut Volume : 167,634.39 C.F., 6,208.68 C.Y.
Fill Volume : 7.53 C.F., 0.28 C.Y.
Running Totals:
Cut Volume : 862,869.61 C.F., 31,958.13 C.Y.
Fill Volume : 9.58 C.F., 0.35 C.Y.

Zone: 2148.000 to 2150.000
Cut Volume : 181,338.47 C.F., 6,716.24 C.Y.
Fill Volume : 366.78 C.F., 13.58 C.Y.
Running Totals:
Cut Volume : 1,044,208.08 C.F., 38,674.37 C.Y.
Fill Volume : 376.36 C.F., 13.94 C.Y.

Zone: 2146.000 to 2148.000
Cut Volume : 193,633.69 C.F., 7,171.62 C.Y.
Fill Volume : 187.75 C.F., 6.95 C.Y.
Running Totals:
Cut Volume : 1,237,841.77 C.F., 45,845.99 C.Y.
Fill Volume : 564.11 C.F., 20.89 C.Y.

Zone: 2144.000 to 2146.000
Cut Volume : 205,482.72 C.F., 7,610.47 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 1,443,324.49 C.F., 53,456.46 C.Y.
Fill Volume : 564.11 C.F., 20.89 C.Y.

Zone: 2142.000 to 2144.000
Cut Volume : 216,571.67 C.F., 8,021.17 C.Y.
Fill Volume : 0.10 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 1,659,896.16 C.F., 61,477.64 C.Y.
Fill Volume : 564.21 C.F., 20.90 C.Y.

Zone: 2140.000 to 2142.000
Cut Volume : 227,265.20 C.F., 8,417.23 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 1,887,161.36 C.F., 69,894.87 C.Y.
Fill Volume : 564.21 C.F., 20.90 C.Y.

Zone: 2138.000 to 2140.000
Cut Volume : 237,438.41 C.F., 8,794.02 C.Y.
Fill Volume : 0.22 C.F., 0.01 C.Y.
Running Totals:
```

```
Cut Volume : 2,124,599.77 C.F., 78,688.88 C.Y.
Fill Volume : 564.43 C.F., 20.90 C.Y.

Zone: 2136.000 to 2138.000
Cut Volume : 246,970.04 C.F., 9,147.04 C.Y.
Fill Volume : 0.08 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 2,371,569.82 C.F., 87,835.92 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2134.000 to 2136.000
Cut Volume : 255,418.40 C.F., 9,459.94 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 2,626,988.22 C.F., 97,295.86 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2132.000 to 2134.000
Cut Volume : 262,753.18 C.F., 9,731.60 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 2,889,741.40 C.F., 107,027.46 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2130.000 to 2132.000
Cut Volume : 267,889.22 C.F., 9,921.82 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 3,157,630.62 C.F., 116,949.28 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2128.000 to 2130.000
Cut Volume : 271,568.38 C.F., 10,058.09 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 3,429,199.00 C.F., 127,007.37 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2126.000 to 2128.000
Cut Volume : 275,646.87 C.F., 10,209.14 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 3,704,845.87 C.F., 137,216.51 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2124.000 to 2126.000
Cut Volume : 279,366.71 C.F., 10,346.92 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 3,984,212.58 C.F., 147,563.43 C.Y.
Fill Volume : 564.51 C.F., 20.91 C.Y.

Zone: 2122.000 to 2124.000
Cut Volume : 282,625.92 C.F., 10,467.63 C.Y.
Fill Volume : 0.09 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 4,266,838.50 C.F., 158,031.06 C.Y.
Fill Volume : 564.60 C.F., 20.91 C.Y.

Zone: 2120.000 to 2122.000
Cut Volume : 285,514.94 C.F., 10,574.63 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
```

```
Cut Volume : 4,552,353.43 C.F., 168,605.68 C.Y.
Fill Volume : 564.60 C.F., 20.91 C.Y.

Zone: 2118.000 to 2120.000
Cut Volume : 289,722.86 C.F., 10,730.48 C.Y.
Fill Volume : 0.06 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 4,842,076.30 C.F., 179,336.16 C.Y.
Fill Volume : 564.66 C.F., 20.91 C.Y.

Zone: 2116.000 to 2118.000
Cut Volume : 294,265.15 C.F., 10,898.71 C.Y.
Fill Volume : 0.21 C.F., 0.01 C.Y.
Running Totals:
Cut Volume : 5,136,341.44 C.F., 190,234.87 C.Y.
Fill Volume : 564.87 C.F., 20.92 C.Y.

Zone: 2114.000 to 2116.000
Cut Volume : 297,227.92 C.F., 11,008.44 C.Y.
Fill Volume : 0.23 C.F., 0.01 C.Y.
Running Totals:
Cut Volume : 5,433,569.36 C.F., 201,243.31 C.Y.
Fill Volume : 565.10 C.F., 20.93 C.Y.

Zone: 2112.000 to 2114.000
Cut Volume : 298,522.04 C.F., 11,056.37 C.Y.
Fill Volume : 0.13 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 5,732,091.41 C.F., 212,299.68 C.Y.
Fill Volume : 565.23 C.F., 20.93 C.Y.

Zone: 2110.000 to 2112.000
Cut Volume : 298,002.05 C.F., 11,037.11 C.Y.
Fill Volume : 0.04 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 6,030,093.46 C.F., 223,336.79 C.Y.
Fill Volume : 565.27 C.F., 20.94 C.Y.

Zone: 2108.000 to 2110.000
Cut Volume : 297,974.54 C.F., 11,036.09 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 6,328,068.00 C.F., 234,372.89 C.Y.
Fill Volume : 565.27 C.F., 20.94 C.Y.

Zone: 2106.000 to 2108.000
Cut Volume : 299,642.95 C.F., 11,097.89 C.Y.
Fill Volume : 0.17 C.F., 0.01 C.Y.
Running Totals:
Cut Volume : 6,627,710.95 C.F., 245,470.78 C.Y.
Fill Volume : 565.44 C.F., 20.94 C.Y.

Zone: 2104.000 to 2106.000
Cut Volume : 301,147.46 C.F., 11,153.61 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 6,928,858.41 C.F., 256,624.39 C.Y.
Fill Volume : 565.44 C.F., 20.94 C.Y.

Zone: 2102.000 to 2104.000
Cut Volume : 302,469.88 C.F., 11,202.59 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
```

```
Cut Volume : 7,231,328.28 C.F., 267,826.97 C.Y.
Fill Volume : 565.44 C.F., 20.94 C.Y.

Zone: 2100.000 to 2102.000
Cut Volume : 303,159.42 C.F., 11,228.13 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 7,534,487.70 C.F., 279,055.10 C.Y.
Fill Volume : 565.44 C.F., 20.94 C.Y.

Zone: 2098.000 to 2100.000
Cut Volume : 302,756.31 C.F., 11,213.20 C.Y.
Fill Volume : 0.31 C.F., 0.01 C.Y.
Running Totals:
Cut Volume : 7,837,244.01 C.F., 290,268.30 C.Y.
Fill Volume : 565.74 C.F., 20.95 C.Y.

Zone: 2096.000 to 2098.000
Cut Volume : 301,936.72 C.F., 11,182.84 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 8,139,180.72 C.F., 301,451.14 C.Y.
Fill Volume : 565.75 C.F., 20.95 C.Y.

Zone: 2094.000 to 2096.000
Cut Volume : 301,296.97 C.F., 11,159.15 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 8,440,477.70 C.F., 312,610.29 C.Y.
Fill Volume : 565.75 C.F., 20.95 C.Y.

Zone: 2092.000 to 2094.000
Cut Volume : 301,078.88 C.F., 11,151.07 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 8,741,556.58 C.F., 323,761.35 C.Y.
Fill Volume : 565.75 C.F., 20.95 C.Y.

Zone: 2090.000 to 2092.000
Cut Volume : 301,433.49 C.F., 11,164.20 C.Y.
Fill Volume : 0.00 C.F., 0.00 C.Y.
Running Totals:
Cut Volume : 9,042,990.07 C.F., 334,925.56 C.Y.
Fill Volume : 565.75 C.F., 20.95 C.Y.
```

Attachment 2

1982 Ash Basin Storage Volumes AutoCAD Output

1982 Ash Removal-Pond Storage Volumes.txt

```
Pond Storage Volumes                                     Wed Jan 06 10:05:48 2016

Water Elev    Storage(AcreFt)  (C.Y.)    (C.F.)     Area(Acre)
2074.00       0.00122          2.0       53.0       0.005
2076.00       0.09708          156.6     4228.7     0.108
2078.00       0.43280          698.3     18852.9    0.203
2080.00       0.96722          1560.4    42131.9    0.319
2082.00       1.78284          2876.3    77660.3    0.463
2084.00       2.93112          4728.9    127679.4   0.662
2086.00       4.57653          7383.5    199353.6   0.960
2088.00       6.82646          11013.4   297360.6   1.270
2090.00       9.78460          15785.8   426217.2   1.664
2092.00       13.63750         22001.8   594049.5   2.140
2094.00       18.41436         29708.5   802129.5   2.632
2096.00       24.23012         39091.3   1055464.1  3.167
2098.00       31.25953         50432.0   1361665.0  3.797
2100.00       39.79823         64207.8   1733611.1  4.741
2102.00       52.63097         84911.3   2292605.0  7.809
2104.00       69.45406         112052.5  3025418.8  8.982
2106.00       88.42905         142665.5  3851969.6  9.956
2108.00       109.27234        176292.7  4759902.9  10.880
2110.00       132.05249        213044.7  5752206.3  11.872
2112.00       156.86645        253077.9  6833102.5  12.925
2114.00       183.69336        296358.6  8001682.7  13.918
2116.00       212.95642        343569.7  9276381.6  15.183
2118.00       244.59829        394618.6  10654701.7 16.421
2120.00       278.85199        449881.2  12146792.5 17.770
2122.00       315.93646        509710.8  13762192.0 19.286
2124.00       355.91596        574211.1  15503699.3 20.646
2126.00       398.63035        643123.6  17364338.2 22.027
2128.00       444.17086        716595.7  19348082.7 23.446
2130.00       492.47209        794521.6  21452084.1 24.826
```

Calculation Title:
Slope Stability of Dam Breach Calculations

Summary:
This calculation determines the stability of the existing 1982 Ash Basin Dam after dam decommissioning and final grading activities are completed. In this analysis, seepage modeling was performed using SEEP/W, and slope stability modeling was performed using SLOPE/W. Both steady-state and pseudo-static scenarios were analyzed using both circular and block failure surfaces. The slope stability modeling resulted in factors of safety greater than the minimum required values accepted under current geotechnical engineering standards of practice.

Notes:

Revision Log:

No.	**Description**	**Originator / Date**	**Technical Reviewer / Date**
0	Initial Submittal	**Luke Williams, PE** SEAL 041903 LUKE C. WILLIAMS 1-14-16	**Carl Tockstein, PE** 1-14-16

OBJECTIVE:

The objective of this calculation is to evaluate the stability of the existing 1982 Ash Basin Dam after dam decommissioning and final grading activities are completed. Seepage and slope stability modeling were performed through the section of the embankment with the highest existing embankment height using the proposed final grading as shown on the project drawings.

METHOD:

Seepage and slope stability modeling were performed using GeoStudio 2012 computer software. The seepage analysis was performed using SEEP/W to calculate the pore water pressures through the profile under possible upstream water level scenarios. The stability analysis was performed using 2-dimensional limit equilibrium analysis based on the method of slices according to the Spencer Method using SLOPE/W. This method satisfies both force and moment equilibrium and incorporates the effects of interslice forces. Search methods built into the software were used to determine the minimum (critical) factors of safety for circular and block failure geometries.

The analyses performed consider the impoundment under conditions that will exist a sufficient length of time after construction to reach equilibrium both within and underneath the impoundment. In this scenario, the embankment is no longer acting as a dam that is impounding water, steady-state seepage and/or hydrostatic conditions have developed, and drained (effective stress) shear strengths were used for all materials. In addition, a pseudo-static analysis was performed to model the effects of earthquake loading on the cross-section. In this scenario, undrained (total stress) parameters were also used for materials with low permeability.

CALCULATIONS:

1.0 Geometry and Material Properties

The geometry of the modeled section was first developed based upon the final grading configuration as shown on the design drawings. Profile 1 from Sheet C-1.5 was used to develop the final grades in the SLOPE/W and SEEP/W models.

After the final grades were established, the subsurface geometries were also incorporated into the model. These geometries were developed based upon previous sections from the Phase 2 Reconstitution of Design report (Reference 1). Section 17+50 for the 1982 Ash Basin Dam was used to determine the subsurface geometries, as it closely matched the intersection of Profile 1 through the embankment.

Material properties for this analysis were established from the previously developed values from the Phase 2 Reconstitution of Design report. The materials previously used in the Phase 2 Reconstitution of Design report consist of “Embankment Fill”, “Sand Drain”, “Foundation Soil (Residuum)”, and “Weathered Rock”. As part of this analysis, an additional material named “Backfill” was also developed to represent the backfill soils used in the final grading design. Since the backfill will consist of embankment soils as part of the balanced breach design, the material properties of these two materials were modeled as the same. See **Table 1** for a summary of material properties used in the analysis.

Table 1 – Material Properties used in the Analysis

Unit	Material Description	Unit Weight (psf)	Shear Strength				Coefficient of Permeability
			Effective		Total		
			c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77×10^{-8}
🟧	Sand Drain	120	0	36	0	36	3.28×10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63×10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63×10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77×10^{-8}

2.0 Seepage Modeling

The seepage modeling was performed with SEEP/W using the permeability values and functions previously developed as part of the Phase 2 Reconstitution of Design report. For the current model, the upstream boundary conditions was modeled using a total head of 2110'. This elevation corresponds with the emergence of Wet Area 1 as shown on the design drawings. Thus, the phreatic surface for this model was analyzed by using the observed wet area as the primary source of flow upstream of the balanced breach. SEEP/W was used to predict the phreatic surface through the remainder of the cross-section, with the results showing a consistent drop down to the "Sand Drain" layer shown in the model at the exit of the existing embankment. The results from the seepage modeling are included as **Attachment 1**.

3.0 Slope Stability Modeling

As mentioned previously, slope stability results were generated for two scenarios: steady-state conditions and pseudo-static conditions. In both scenarios, the phreatic surface generated from the seepage modeling was used, and both circular and block failures were considered. In the steady-state models, the effective stresses of the materials were used for each region as shown in **Table 1**. These models result in a circular failure factor of safety of 2.54 and a block failure factor of safety of 5.02.

In the pseudo-static models, the total stresses of the materials were used for each region as shown in **Table 1**. In addition, a horizontal seismic coefficient of 0.20g was also applied to the model, as was performed previously in the Phase 2 Reconstitution of Design report. This horizontal seismic coefficient represents the anticipated earthquake accelerations predicted for the Asheville site under the design earthquake. These models result in a circular failure factor of safety of 1.08 and a block failure factor of safety of 1.85.

DISCUSSION:

The seepage and slope stability modeling performed for this analysis resulted in slope stability factors of safety above 2.5 for steady-state conditions and above 1.0 for pseudo-static conditions. According to geotechnical engineering standards of practice, minimum acceptable values for each of these scenarios are regarded as 1.5 for steady-state conditions and 1.0 for pseudo-static conditions. Therefore, the slope stability results in these models predict acceptable factors of safety for the final grades proposed for the 1982 Ash Basin Dam.

REFERENCES:

1. “Calculation No. G-004: Slope Stability Analysis of Embankments,” Phase 2 Reconstitution of Design, December 31, 2014.

2. SEEP/W, GeoStudio 2012, GEO-SLOPE International Ltd.

3. SLOPE/W, GeoStudio 2012, GEO-SLOPE International Ltd.

ATTACHMENTS:

Attachment 1 – SEEP/W Output File

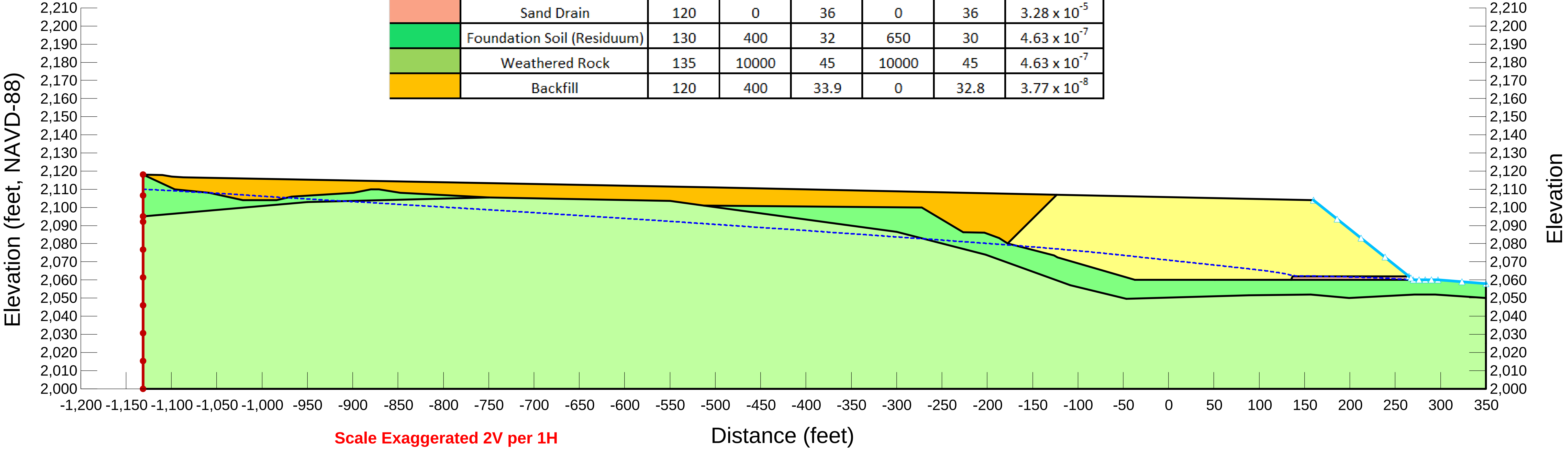
Attachment 2 – SLOPE/W Output Files

Attachment 1

SEEP/W Output File

Seepage Analysis

Unit	Material Description	Unit Weight (psf)	Shear Strength				Coefficient of Permeability
			Effective		Total		
			c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77×10^{-8}
🟥	Sand Drain	120	0	36	0	36	3.28×10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63×10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63×10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77×10^{-8}



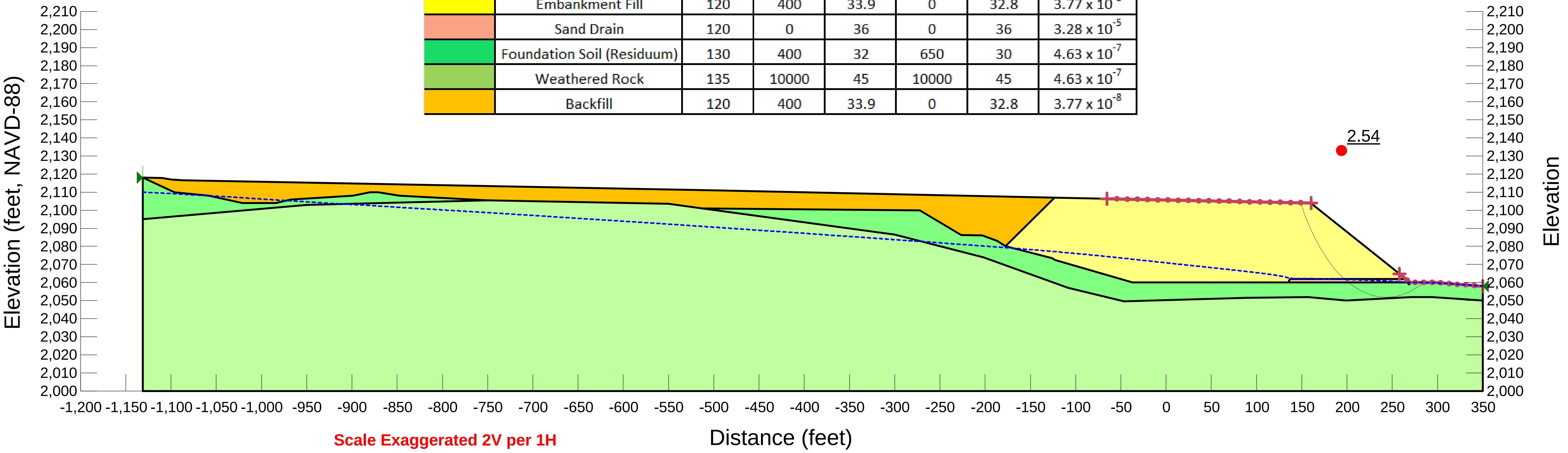
Scale Exaggerated 2V per 1H

Attachment 2

SLOPE/W Output Files

Steady-State Analysis
Circular Failure

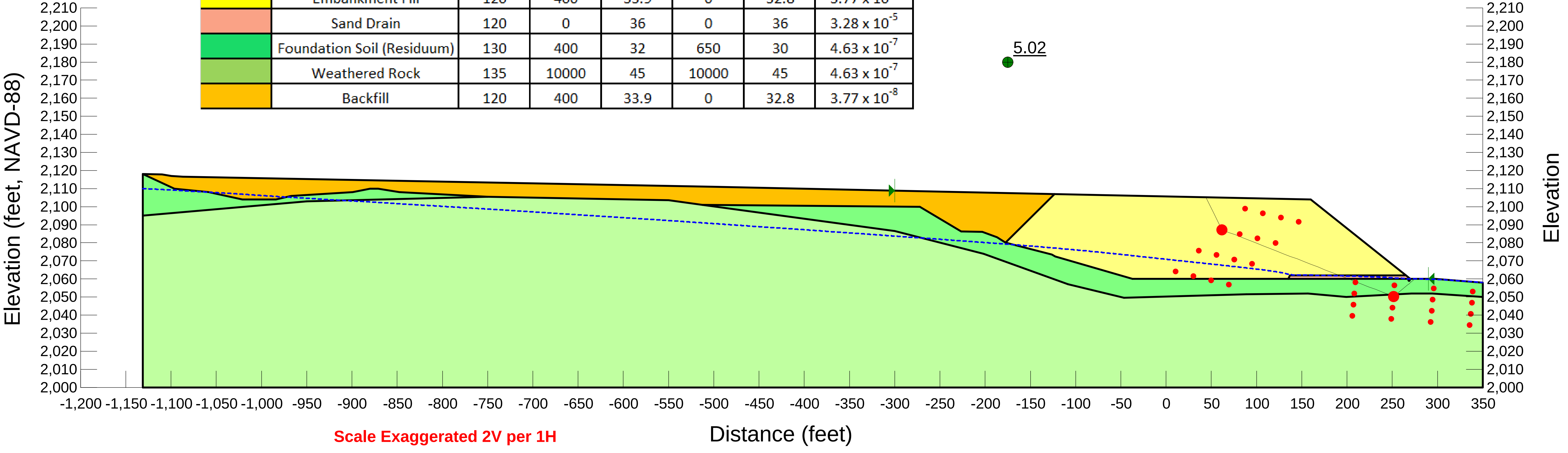
			Shear Strength				Coefficient of Permeability
			Effective		Total		
Unit	Material Description	Unit Weight (psf)	c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77 x 10^{-8}
🟥	Sand Drain	120	0	36	0	36	3.28 x 10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63 x 10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63 x 10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77 x 10^{-8}



Scale Exaggerated 2V per 1H

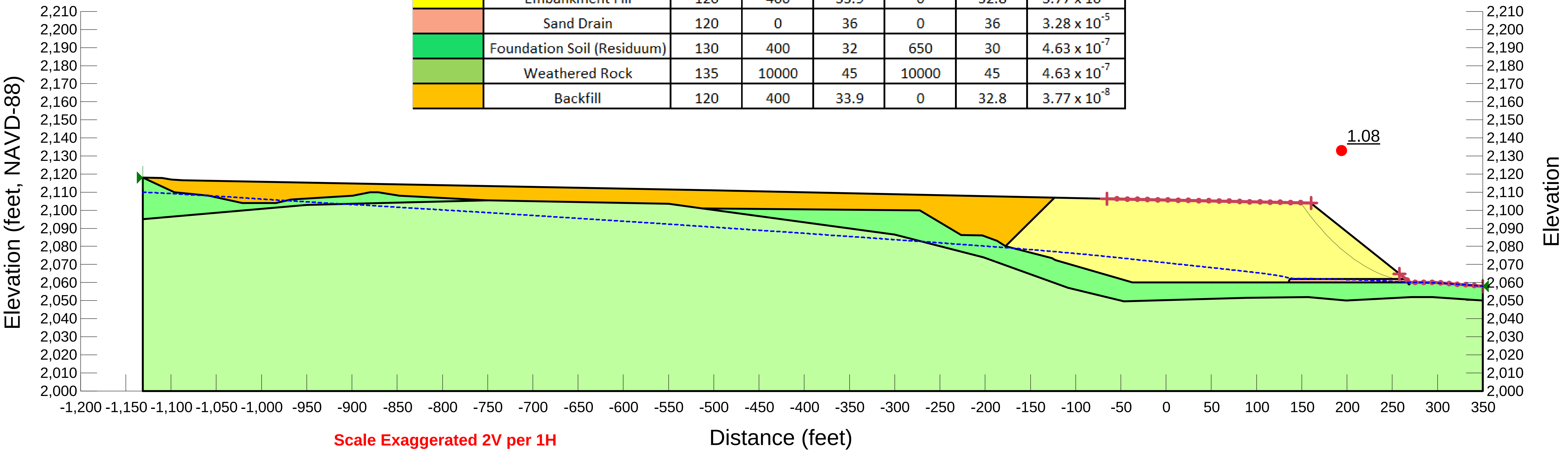
Steady-State Analysis
Block Failure

Unit	Material Description	Unit Weight (psf)	Shear Strength				Coefficient of Permeability
			Effective		Total		
			c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77×10^{-8}
🟧	Sand Drain	120	0	36	0	36	3.28×10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63×10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63×10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77×10^{-8}



Pseudo-Static Analysis
Circular Failure

			Shear Strength				Coefficient of Permeability
			Effective		Total		
Unit	Material Description	Unit Weight (psf)	c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77×10^{-8}
🟧	Sand Drain	120	0	36	0	36	3.28×10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63×10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63×10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77×10^{-8}

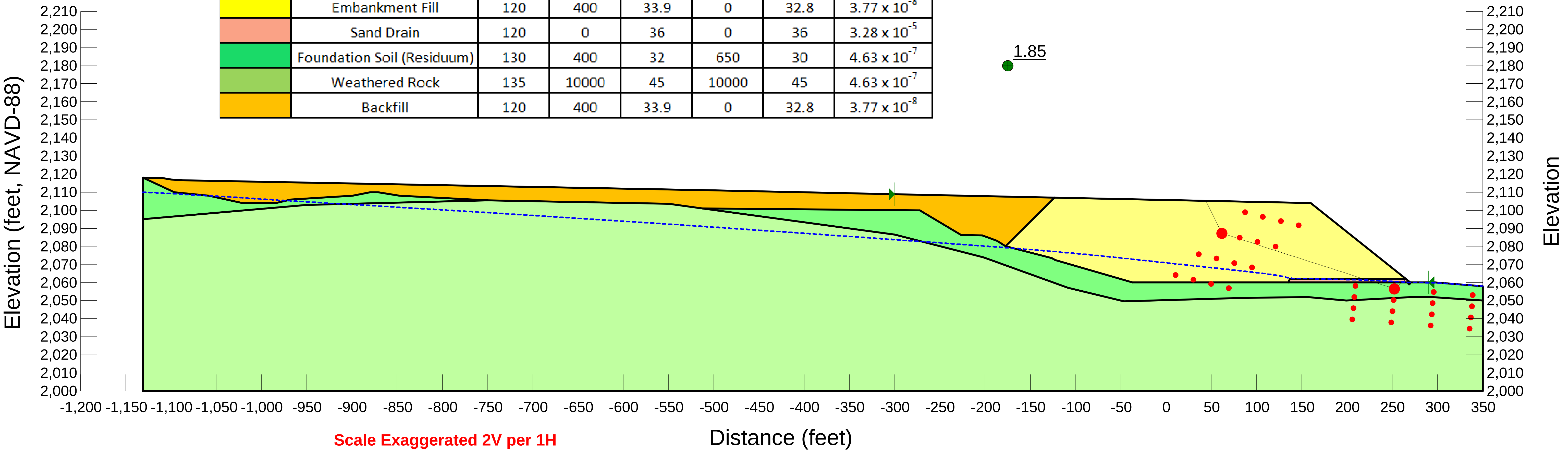


Scale Exaggerated 2V per 1H

Horz Seismic Coef.: 0.2

Pseudo-Static Analysis
Block Failure

Unit	Material Description	Unit Weight (psf)	Shear Strength				Coefficient of Permeability
			Effective		Total		
			c' (psf)	Φ' (degrees)	c (psf)	Φ (degrees)	k (ft/sec)
🟨	Embankment Fill	120	400	33.9	0	32.8	3.77×10^{-8}
🟥	Sand Drain	120	0	36	0	36	3.28×10^{-5}
🟩	Foundation Soil (Residuum)	130	400	32	650	30	4.63×10^{-7}
🟩	Weathered Rock	135	10000	45	10000	45	4.63×10^{-7}
🟧	Backfill	120	400	33.9	0	32.8	3.77×10^{-8}



Scale Exaggerated 2V per 1H

Horz Seismic Coef.: 0.2

Calculation Title:
Final Conditions Stormwater Calculation

Summary:

Stormwater channels and culverts were designed to convey stormwater for the 100 year, 24-hour design storm event (1% annual) from the 1982 and Ash Basin considering final closure conditions.

The Interstate 26 culvert crossing downstream of the 1982 basin was also evaluated for the 100-year 6-hr event.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0		**Luke C. Williams, PE** Luke C Williams SEAL 041903 LUKE C. WILLIAMS 1-14-16	**Daniel R. Smith** 1/14/16

OBJECTIVE:

The objective of this calculation is to design the stormwater conveyance measures based on proposed conditions after decommissioning of the 1982 Ash Basin.

METHOD:

Stormwater flow rates were calculated using the SCS runoff method. The hydraulic capacity of proposed stormwater channels was evaluated using Manning's equation. Channel lining was determined using the permissible shear stress approach specified in FHWA HEC-15. The Interstate 26 culvert was evaluated using standard procedures specified in FHWA HDS-5.

CALCULATIONS:

1.0 Hydrology

Drainage areas were developed from the final grading plan drawings and represent final condition after closure of the 1982 Ash Basin. The drainage areas are shown in Figure 1. Runoff coefficients (SCS curve number) and flow travel times (time concentration) were determined using standard methods documented in the National Engineering Hand Book Part 630 Hydrology for each of the drainage areas.

The runoff coefficients for the 1982 basin considered the ground surface to be vegetated and have a minimum of 75 percent grass cover. The soils for the ash basin and existing plant footprints were considered to have moderately high runoff potential (HSG C classification) because of the disturbed nature of these soils. Area outside the 1982 ash basin and existing plant footprints were considered to have moderately low runoff potential (HSG B classification) as determined from NRCS soil mapping data.

The hydrologic input parameters for the 1982 basin are summarized in the Table 1.

Table 1: Summary of Drainage Areas 1982 Basin

Drainage Area	Area (acres)	Area (mi^2)	Curve Number CN	Tc (hr)	Lag Time (min)
1982 East1	31.3	0.0489	68	0.44	16
1982 East2	28.5	0.0445	71	0.468	17
1982 East Lower	5.9	0.0092	74	0.186	7
1982 West	40.9	0.0638	79	0.564	20
1982 Lower	15.5	0.0242	58	0.329	12

Proposed stormwater channels were designed for the 100-year 24-hour storm event. Temporary sediment control structures were designed for the 10-year 24-hour storm event. Table 2 below shows the precipitation depth for these three storm events. Precipitation depths were retrieved from NOAA Precipitation Frequency Data Server (Atlas 14) (Attachment 1).

Table 2: Summary of Precipitation Depths

Design Event	Precipitation Depth (in)	Precipitation Distribution
10-year (24-hr)	4.28	SCS Type II
100-year (24-hr)	6.31	SCS Type II

Peak runoff rates for the drainage areas were determined using the SCS runoff approach within the USACE HEC-HMS hydrology model. Peak runoff rates for the 1982 basin are shown in Table 3.

Table 3: Summary 1982 Basin Peak Flowrates

Drainage Area	Peak 10-year Flow (cfs)	Peak 100-year Flow (cfs)	Peak 500-year Flow (cfs)
1982 East1	40	87	126
1982 East2	41	85	120
1982 East Lower	15	29	40
1982 West	76	138	187
1982 Lower	11	33	52

2.0 Hydraulics

2.1 Proposed Stormwater Channels

Stormwater channels were designed to convey runoff from the 1982 basin for the 100-year flood event in a safe and non-erosive manner. The Manning formula was used to determine the 100-year flow depth in the channels.

The shear stress along the channel bottom and sides was calculated to determine appropriate channel lining following the HEC-15 approach for design of riprap lined channels.

The stormwater channels located within the basins generally have slopes near 1 percent and were lined with North Carolina Department of Transportation (NCDOT) Class B riprap having a median diameter of 8 inches. The stormwater channels that convey stormwater from the dam breach location to the toe of the abutment, called “outlet” channels on the design drawings, have relatively steep slopes and were lined with NCDOT Class 2 riprap having a median diameter of 14 inches.

The proposed stormwater channel dimensions are presented in Table 4. Table 5 shows the riprap sizes for the NCDOT Class B and Class 2 riprap.

Table 4: Summary of Stormwater Channels 1982 Basin

1982 Basin Channel Summary								
Channel ID	Q100 (cfs)	Average Velocity (ft/s)	Slope (ft/ft)	Channel Type	Side Slope (H:V)	Bottom Width (ft)	Flow Depth (ft)	Lining Type
1982 West	138	3.7	0.01	Trapezoidal	2	5	3.2	Class B
1982 West Outlet	138	8.9	0.15	Trapezoidal	3	15	0.9	Class 2
1982 East 2	85	3.1	0.01	Trapezoidal	2	5	2.6	Class B
1982 East 1	87	3.2	0.01	Trapezoidal	2	5	2.7	Class B
1982 East	171	3.9	0.01	Trapezoidal	2	8	3.1	Class B
1982 East Outlet	186	9.5	0.15	Trapezoidal	3	20	0.9	Class 2

Table 5: NCDOT Riprap Sizes

Acceptance Criteria for Rip Rap and Stone for Erosion Control			
Class	Required Stone Sizes (inches)		
	Minimum	Midrange	Maximum
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

3.0 Interstate 26 Culvert

Interstate 26 is located below the 1982 basin. Stormwater runoff from the 1982 basin will be directed to existing culvert running underneath I-26. The culvert underneath I-26 is a 66-in diameter RCP culvert with a concrete headwall. A summary of I-26 culvert is shown in Table 6 below.

Table 6: Summary of I-26 Culvert

I-26 Culvert	Structure	Inlet Invert (ft)	Outlet Invert (ft)	Length (ft)	Slope (ft/ft)	Top Road Elevation (ft)
Below 1982 Basin	66" RCP	2043.5	2040	273	0.013	2052.6

Table 7 and Figure 1 show the headwater elevations versus culvert discharge for the 66” CMP I-26 culvert below the 1982 basin. Note the tailwater condition (elevation) for the I-26 culvert was considered to be the water elevation for the 10-year flood elevation of the French Broad or the normal flow depth of the downstream channel whichever was greater. The French Broad River has a 10-year flood elevation near 2039’ (culvert outlet not submerged) at the culvert location which is lower than the normal flow depth of the downstream channel. Therefore, for the I-26 culvert analysis the culvert tailwater condition was set to normal depth of the downstream channel.

Headwater elevations for the I-26 culverts were estimated to determine the impact of the proposed 1982 basin closure and stormwater plan. The 100-year headwater elevation was evaluated. Flood storage behind the I-26 road embankment was considered and a storage routing model was developed in HEC-HMS.

Topography data from USGS digital elevation model (1 meter) was utilized in estimating available flood storage volumes behind the I-26 embankment. Figure 2 shows the rating curve for the storage area between the toe of the 1982 basin and upstream the I-26 embankment.

Table 7: Discharge Curve for I-26 Culvert (1982)

I-26 Culvert (1982)	
Headwater Elevation (ft)	Flow (cfs)
2043.5	0
2045.71	36
2046.8	72
2047.74	108
2048.59	144
2049.47	180
2050.45	216
2051.6	252
*Top Pavement Elevation = 2052.6'	
**Inlet Invert Elevation = 2043.5'	

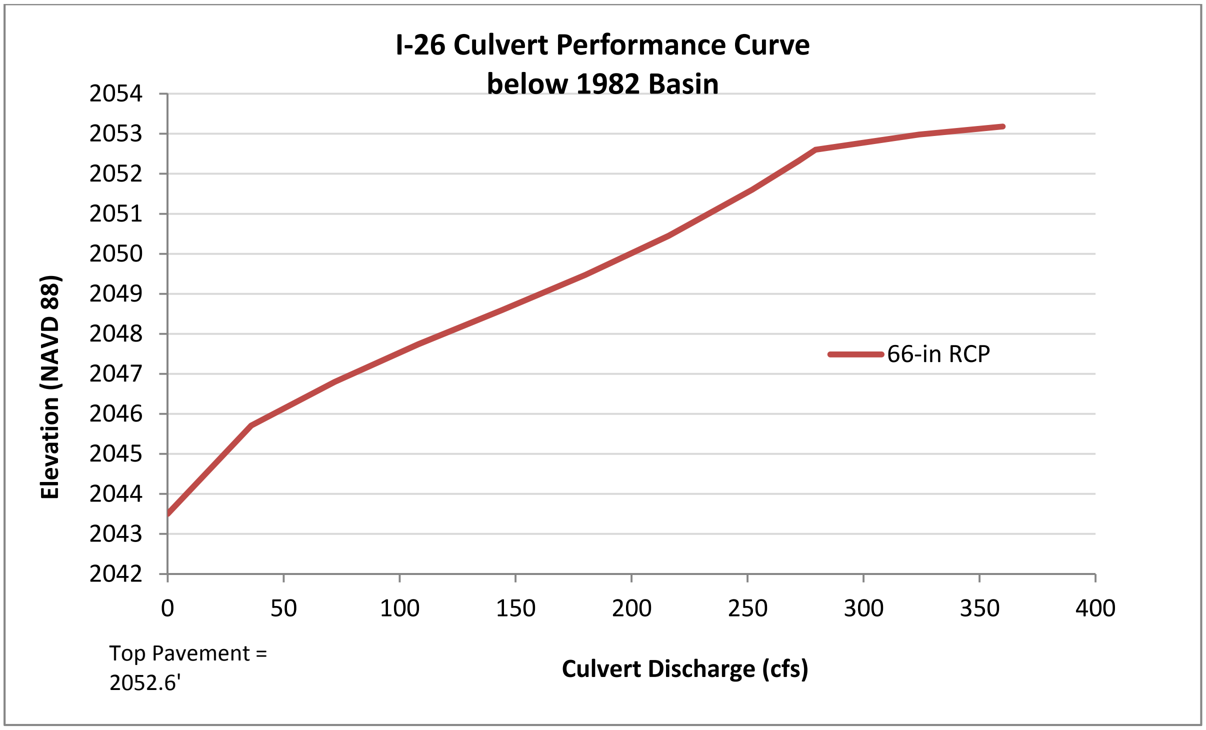


Figure 1: Discharge Curve for I-26 Culvert (1982)

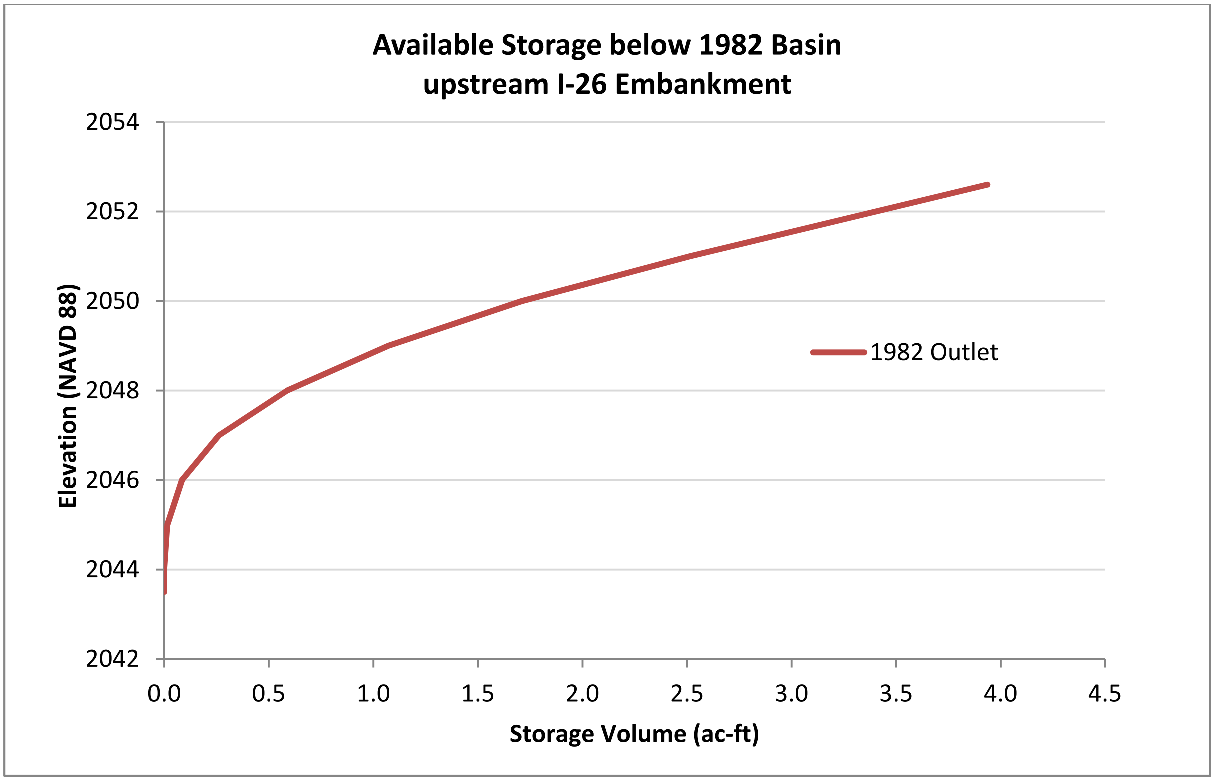


Figure 2: Storage Curve for I-26 Culvert (1982)

The headwater elevation behind the I-26 embankment for the 100-year 6-hr flood is shown in Table 8. The headwater elevation below the 1982 basin for the 100-year event is 2050.7' which is approximately 1.9 feet below the road embankment.

Coordination with NCDOT will be required to determine if additional flow capacity is needed below the 1982 basin to lower the headwater depths upstream of I-26.

Table 8: Headwater Elevations at I-26 Embankment

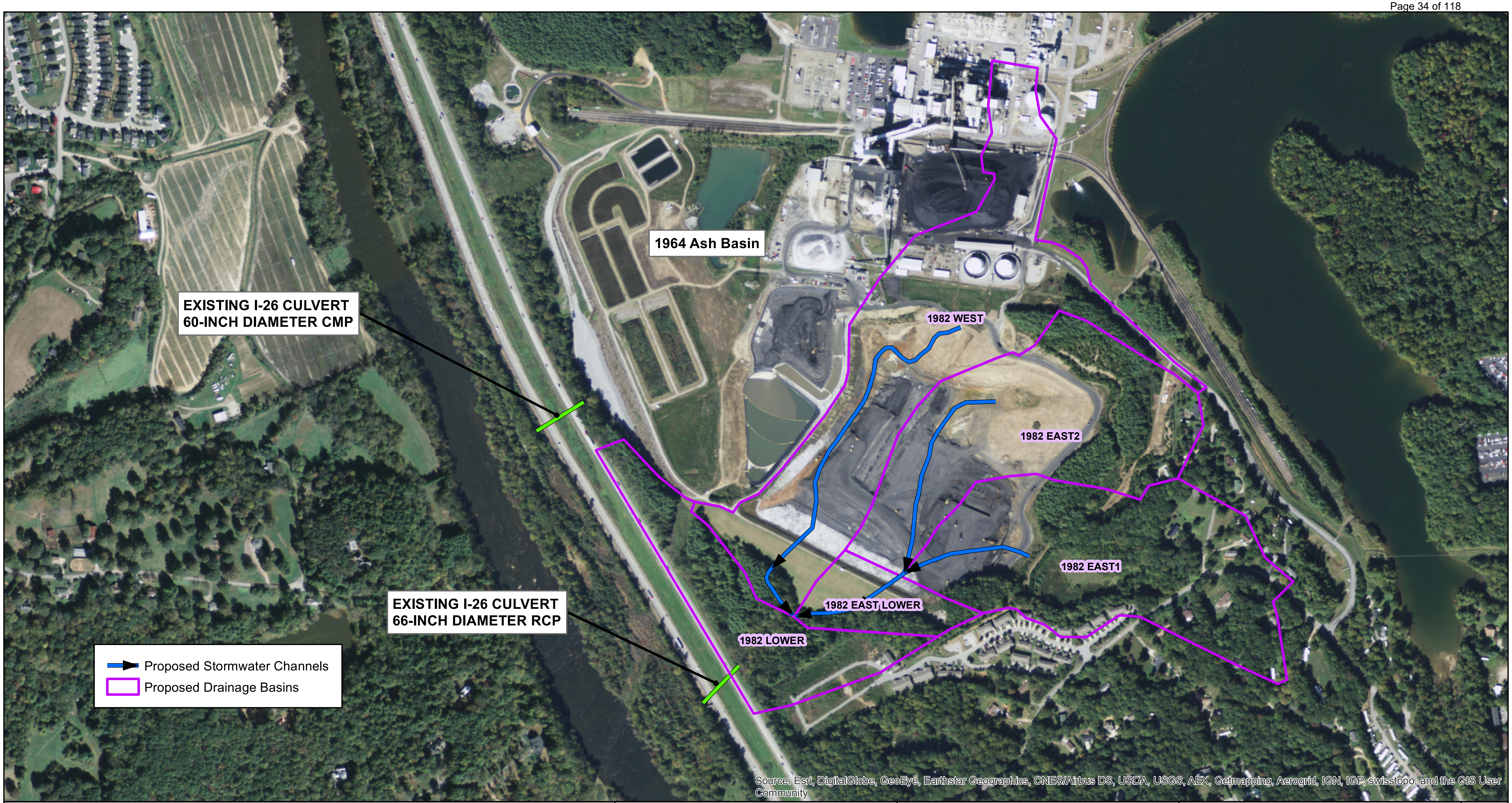
I-26 Culverts	Inlet Invert (ft)	100-year 6-hour Flood		
		Headwater Elevation (ft)	Freeboard from Top Pavement (ft)	HW/D
Below 1982 Basin	2043.5	2050.7	1.9	1.3

FIGURES:

1. General Site Drainage Map

REFERENCES:

1. NOAA Atlas 14, Point Precipitation Frequency Estimates", NOAA National Weather Service.
2. HEC-15, Hydraulic Engineering Circular No. 15, Third Edition. "Design of Roadside Channels with Flexible Linings". September 2005.
3. HDS-5, Hydraulic Design Series Number 5. Hydraulic Design of Highway Culverts, Third Edition. January 2012.
4. North Carolina Department of Environment and Natural Resources, "Erosion and Sediment Control Planning and Design Manual", Revised May 2013.
5. "Standard Specification for Roads and Structures", North Carolina Department of Transportation, Raleigh, January 2012.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

NOTES:

N

0 0.05 0.1 0.2 Miles

amec foster wheeler

Environment & Infrastructure, Inc.
3020 Falling Waters, Rd., Suite 300
Knoxville, TN 37922

CLIENT:

DUKE ENERGY.

PROJECT:

DAM DECOMMISSIONING PLAN
ASHEVILLE STEAM STATION

TITLE:

DRAINAGE AREAS AND PROPOSED STORMWATER CHANNELS

DATE: 11/04/2015

PROJECT: 7810150250

DRAWN BY: JMP

CHECKED BY: LCW

Figure No.

1

Calculation Title:
Temporary Silt Basin Calculations

Summary:

The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) "Erosion and Sediment Control, Field Guide." Using this guide, appropriately-sized silt basins were designed with storage capacities of approximately 84,600 ft^3 each, which is greater than the minimum required capacities of 82,800 ft^3 each.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	Luke C. Williams, P.E. SEAL 041963 Luke C. Williams Luke 1/15-16	Daniel R. Smith 1/14/16

OBJECTIVE:

The objective of this calculation is to design the temporary silt basins for the interim closure conditions of the 1982 Ash Basin.

METHOD:

The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) “Erosion and Sediment Control, Field Guide” [Ref. 1]. Areas used in the calculation were generated from the project drawings using AutoCAD Civil 3D [Ref. 2].

CALCULATIONS:

1.0 Determination of Disturbed Area

The limits of disturbance for the dam decommissioning and closure activities at the 1982 Ash Basin are shown on Sheet C-1.3 of the project drawings. The disturbed area is noted as “Limits of Ash Excavation” and represents the area in which ash will be excavated from the basin. Using AutoCAD Civil 3D, this area was calculated as approximately 46 acres.

The stormwater flows within this area will be routed through the basin with two separate stormwater channels, noted as “1982 West” and “1982 East” as shown on Sheet C-1.4 of the project drawings. Each channel will convey flows from approximately half of the disturbed areas within the basin.

2.0 Silt Basin Design

Silt Basins were designed to intercept flows from the stormwater channels along the excavation limits adjacent to the existing 1982 Ash Basin Dam. The Silt Basins were designed in accordance with the NCDOT “Erosion and Sediment Control, Field Guide” for Silt Basin, Type B recommendations. According to the design guide, each silt basin shall be designed with a storage capacity of 3,600 cubic feet per disturbed acre.

Each silt basin will intercept the proposed stormwater channels, and each channel conveys the flows from approximately half of the existing ash basin area. Therefore, each silt basin was designed for half of the total disturbed area (23 acres). As a result, the required storage capacity for each silt basin is 82,800 ft^3 (23 acres x 3600 ft^3/acre).

The silt basin design also incorporated the sizing requirements for Silt Basin, Type B recommendations. The requirements included a minimum of 2’ depth, maximum of 1.5:1 side slopes, and a minimum length of 2 times the width. The silt basin design is shown on Detail 4 of Sheet E-1.2. The design consists of surface dimensions of 100’ x 225’ and a depth of 4’. The calculated volume for this design is approximately 84,600 ft^3, which is greater than the minimum required 82,800 ft^3 of storage capacity.

DISCUSSION:

The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) “Erosion and Sediment Control, Field Guide.” Using this guide, appropriately-sized silt basins were designed with storage capacities of approximately 84,600 ft^3 each, which is greater than the minimum required capacities of 82,800 ft^3 each.

REFERENCES:

1. North Carolina Department of Transportation, “Erosion and Sediment Control, Field Guide”, 2013.
2. AutoCAD Civil 3D 2015, AutoDesk Inc.

Calculation Title:
Underdrain Sizing Calculations

Summary:

This document provides a summary of the design and calculations performed for the proposed underdrain to be installed in the 1982 Ash Basin as part of the Dam Decommissioning Plan. This underdrain will intercept Wet Area 1 and convey flows to the downstream face of the existing dam. Calculations were performed to determine the flow capacities of the proposed HDPE drainage pipes and No. 57 Stone that form the underdrain.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	Luke C. Williams, PE SEAL 041903 1-14-16	Daniel R. Smith 1/14/16

OBJECTIVE:

The objective of this calculation is to design the underdrain for the 1982 Ash Basin based on long-term conditions after decommissioning of the Ash Basin dam and also achieving final grades as shown on the plans.

METHOD:

Design for the underdrain consists of a combination of geotextile fabric, HDPE drainage pipes and No. 57 Stone backfill. Flow rates through the HDPE drainage pipes were calculated using Manning's equation and FlowMaster modeling software. Flow rates through the No. 57 Stone backfill were estimated using Darcy's Law.

DEFINITION OF VARIABLES:

τ = shear;
A = area perpendicular to the flow direction;
b = bottom width;
CN = curve number;
d = flow depth;
D = channel depth;
i = hydraulic gradient;
k = hydraulic conductivity;
L = length;
n = Manning's n;
P = wetted perimeter;
Q = flow;
R = hydraulic radius;
S = longitudinal slope;
t = time
T = top width;
T_c = time of concentration;
V = velocity; and
Z = channel side slope.

CALCULATIONS:

1.0 Design of the Underdrain

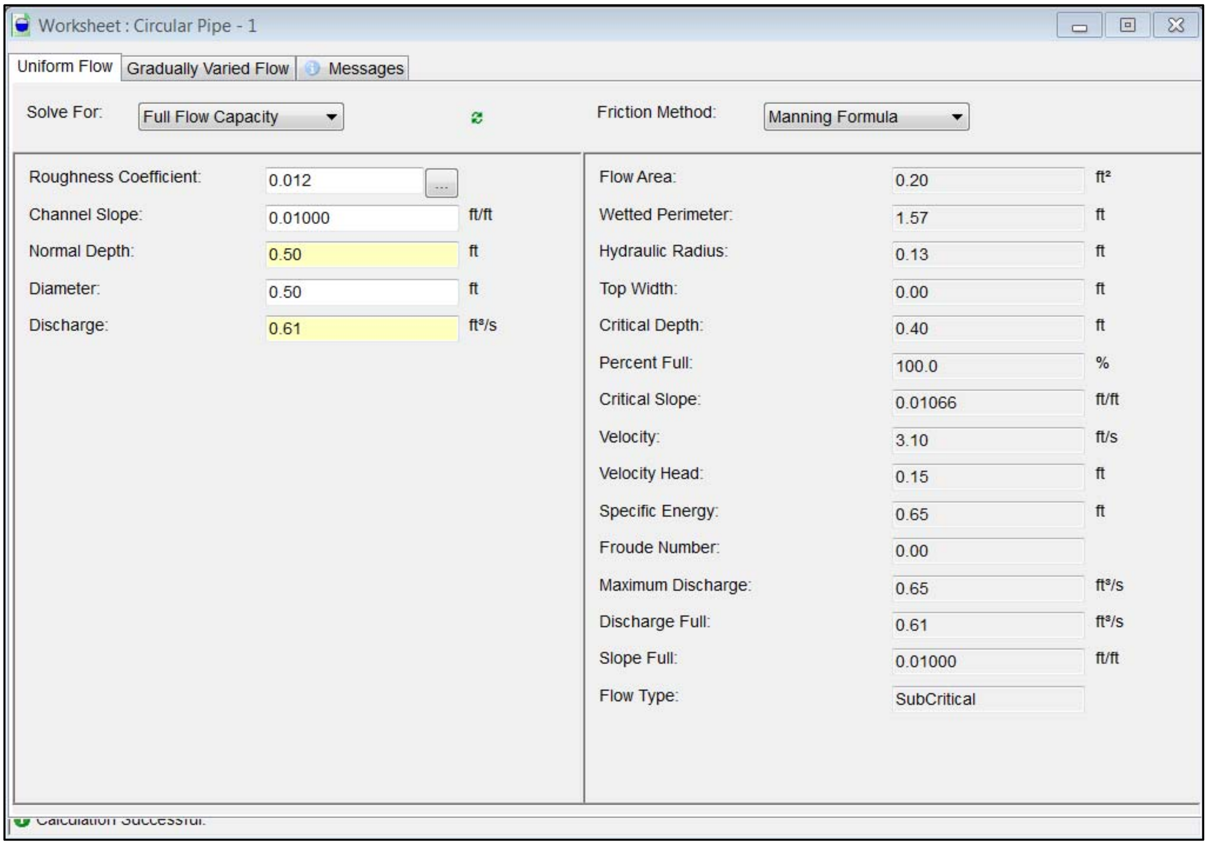
The underdrain is designed to intercept the existing Wet Area 1 as shown on the Project Drawings. The current flows from this wet area are estimated to be at 15-25 gpm (gallons per minute). The actual ground water exit point feeding the wet areas is covered with fill and actual flow rates to size the drain may be revised as additional flow measurements are obtained. Additionally, if field conditions allow a spring box configuration may be used to capture the flow closer to the source eliminating the need for pipe perforations described below.

The underdrain is proposed to begin to the north of Wet Area 1 at approximately Elevation 2116', and continue southward at an approximately 1.0% grade to intercept the wet area at approximately Elevation 2114'. After intercepting the wet area, the underdrain is proposed to continue southward through the existing 1982 Ash Basin Dam at a slope of 1.0%. The underdrain will daylight on the downstream face of the dam at approximately Elevation 2102’ and intercept the proposed stormwater ditch to be conveyed to the proposed outfall location.

In cross-sectional view, the underdrain is proposed to be constructed to a channel depth (D) of 4’, a bottom width (b) of 12’, and a top width (T) of 20’. A total of two 6” HDPE DR 26 perforated drainage pipes will be placed along the bottom of the underdrain to convey flows. The remainder of the underdrain area will be backfilled with No. 57 Stone to the dimensions referenced above. The underdrain will be wrapped with 12-oz Geotextile filter fabric overlapped a minimum of 2’ across the top of the underdrain.

2.0 HDPE Flow Rate Calculations

Flow rates for the HDPE drainage pipes were calculated using the program FlowMaster. As part of these calculations, the following variables were required to calculate the full flow capacity of each pipe: Manning’s n (n), channel slope (S), and diameter of the pipe. The Manning’s n was estimated as 0.012 from Mays, 2005. The critical channel slope was defined as 1.0% per the Project Drawings, and the diameter of each HDPE pipe is known as 6”. This calculation resulted in a maximum flow through each pipe of 0.61 ft^3/sec, or a total flow through both pipes of 1.22 ft^3/sec (548 gpm). Thus, the HDPE drainage pipes are able to convey approximately 548 gpm of flow from the wet area. See Figure 1 below for the output from FlowMaster.



Solve For: Full Flow Capacity

Friction Method: Manning Formula

Roughness Coefficient: 0.012
Channel Slope: 0.01000 ft/ft
Normal Depth: 0.50 ft
Diameter: 0.50 ft
Discharge: 0.61 ft^3/s

Flow Area: 0.20 ft^2
Wetted Perimeter: 1.57 ft
Hydraulic Radius: 0.13 ft
Top Width: 0.00 ft
Critical Depth: 0.40 ft
Percent Full: 100.0 %
Critical Slope: 0.01066 ft/ft
Velocity: 3.10 ft/s
Velocity Head: 0.15 ft
Specific Energy: 0.65 ft
Froude Number: 0.00
Maximum Discharge: 0.65 ft^3/s
Discharge Full: 0.61 ft^3/s
Slope Full: 0.01000 ft/ft
Flow Type: SubCritical

Calculation Successful.

Figure 1: HDPE drainage pipe calculations from FlowMaster

However, the pipe can only convey flows that enter the pipe through the orifices of the perforations. The orifice calculations are shown below.

Orifice Flow Equation

$Q = 25 \times A \times k \times h^{0.5}$

where:

25 is a conversion for square inches and gpm
A = area
k = constant based on inlet configuration k= 0.82 for thick wall pipe
h = head

constant	diameter	area	k	h	$h^{0.5}$	**q (gpm)**
25	0.25	**0.05**	**0.82**	1	**1**	**1.01**

There will be four (4) perforations placed around the pipe circumference on 1 foot intervals.

4 x 1.01 4.03 gpm/foot

For a Factor of Safety of 10 for underdrains the capacity should be:

10 x 25 250 gpm

The wet area flow will be contained in the pipe within:

250 ÷ 4.03 62.11 feet

3.0 No. 57 Stone Flow Rate Calculations

Flow rates for the #57 stone backfill were estimated using Darcy's Law, shown in the following equation:

$Q = kiA$ [Ref. 2]

Where *Q* is the flow rate, *k* is the hydraulic conductivity, *i* is the hydraulic gradient, and *A* is the area perpendicular to the flow direction. The equation was solved for the flow rate (Q) of the 4' by 12' cross-sectional area of the underdrain. The hydraulic gradient was set as the critical slope of the underdrain of 1.0%. The hydraulic conductivity of the No. 57 Stone was estimated as 0.3 ft/sec based upon values provided in Coduto, 1999. These calculations resulted in a flow rate of approximately 65 gpm.

Flow through rock to 6" diameter pipe

q = kia

k = 0.3
I = gradient top of under drain (4 feet)/ orifice spacing (1 foot)
a = flow area, use orifice area x 4

k	i	a	q (cfs)	gpm/ 1 cfs	gpm	
0.3	0.50	0.20	0.03	448.83	13.22	> 4.03 gpm

DISCUSSION:

The underdrain flow rates are controlled by the orifices in the HDPE drainage pipes. As a result, a factor of safety of 10 is achieved through this design.

REFERENCES:

1. Mays, L.W., “Water Resources Engineering, 2005 Edition”, John Wiley & Sons, Inc., 2005.

2. Coduto, D.P., “Geotechnical Engineering, Principles and Practice,” Prentice-Hall, Inc. 1999.

3. Bentley FlowMaster, V8i, Bentley Systems, Inc, 2009.

Erosion & Sediment Control Plan Calculations

Calculation Title:
Final Conditions Stormwater Calculation

Summary:
Stormwater channels and culverts were designed to convey stormwater for the 100 year, 24-hour design storm event (1% annual) from the 1982 and Ash Basin considering final closure conditions.

The Interstate 26 culvert crossing downstream of the 1982 basin was also evaluated for the 100-year 6-hr event.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0		**Matt Bishop** Matt Bishop 2/23/16	**Luke C. Williams, PE** Luke C Williams 2/23/16

OBJECTIVE:

The objective of this calculation is to design the stormwater conveyance measures based on proposed conditions after decommissioning of the 1982 Ash Basin.

METHOD:

Stormwater flow rates were calculated using the SCS runoff method. The hydraulic capacity of proposed stormwater channels was evaluated using Manning's equation. Channel lining was determined using the permissible shear stress approach specified in FHWA HEC-15. The Interstate 26 culvert was evaluated using standard procedures specified in FHWA HDS-5.

CALCULATIONS:

1.0 Hydrology

Drainage areas were developed from the final grading plan drawings and represent final condition after closure of the 1982 Ash Basin. The drainage areas are shown in Figure 1. Runoff coefficients (SCS curve number) and flow travel times (time concentration) were determined using standard methods documented in the National Engineering Hand Book Part 630 Hydrology for each of the drainage areas.

The runoff coefficients for the 1982 basin considered the ground surface to be vegetated and have a minimum of 75 percent grass cover. The soils for the ash basin and existing plant footprints were considered to have moderately high runoff potential (HSG C classification) because of the disturbed nature of these soils. Area outside the 1982 ash basin and existing plant footprints were considered to have moderately low runoff potential (HSG B classification) as determined from NRCS soil mapping data.

The hydrologic input parameters for the 1982 basin are summarized in the Table 1.

Table 1: Summary of Drainage Areas 1982 Basin

Drainage Area	Area (acres)	Area (mi^2)	Curve Number CN	Tc (hr)	Lag Time (min)
1982 East1	31.3	0.0489	68	0.44	16
1982 East2	28.5	0.0445	71	0.468	17
1982 East Lower	5.9	0.0092	74	0.186	7
1982 West	40.9	0.0638	79	0.564	20
1982 Lower	15.5	0.0242	58	0.329	12

Proposed stormwater channels were designed for the 100-year 24-hour storm event. Temporary sediment control structures were designed for the 10-year 24-hour storm event. Table 2 below shows the precipitation depth for these three storm events. Precipitation depths were retrieved from NOAA Precipitation Frequency Data Server (Atlas 14) (Attachment 1).

Table 2: Summary of Precipitation Depths

Design Event	Precipitation Depth (in)	Precipitation Distribution
10-year (24-hr)	4.28	SCS Type II
100-year (24-hr)	6.31	SCS Type II

Peak runoff rates for the drainage areas were determined using the SCS runoff approach within the USACE HEC-HMS hydrology model. Peak runoff rates for the 1982 basin are shown in Table 3.

Table 3: Summary 1982 Basin Peak Flowrates

Drainage Area	Peak 10-year Flow (cfs)	Peak 100-year Flow (cfs)	Peak 500-year Flow (cfs)
1982 East1	40	87	126
1982 East2	41	85	120
1982 East Lower	15	29	40
1982 West	76	138	187
1982 Lower	11	33	52

2.0 Hydraulics

2.1 Proposed Stormwater Channels

Stormwater channels were designed to convey runoff from the 1982 basin for the 100-year flood event in a safe and non-erosive manner. The Manning formula was used to determine the 100-year flow depth in the channels.

The shear stress along the channel bottom and sides was calculated to determine appropriate channel lining following the HEC-15 approach for design of riprap lined channels.

The stormwater channels located within the basins generally have slopes near 1 percent and were lined with North Carolina Department of Transportation (NCDOT) Class B riprap having a median diameter of 8 inches. The stormwater channels that convey stormwater from the dam breach location to the toe of the abutment, called “outlet” channels on the design drawings, have relatively steep slopes and were lined with NCDOT Class 2 riprap having a median diameter of 14 inches.

The proposed stormwater channel dimensions are presented in Table 4. Table 5 shows the riprap sizes for the NCDOT Class B and Class 2 riprap.

Table 4: Summary of Stormwater Channels 1982 Basin

1982 Basin Channel Summary								
Channel ID	Q100 (cfs)	Average Velocity (ft/s)	Slope (ft/ft)	Channel Type	Side Slope (H:V)	Bottom Width (ft)	Flow Depth (ft)	Lining Type
1982 West	138	3.7	0.01	Trapezoidal	2	5	3.2	Class B
1982 West Outlet	138	8.9	0.15	Trapezoidal	3	15	0.9	Class 2
1982 East 2	85	3.1	0.01	Trapezoidal	2	5	2.6	Class B
1982 East 1	87	3.2	0.01	Trapezoidal	2	5	2.7	Class B
1982 East	171	3.9	0.01	Trapezoidal	2	8	3.1	Class B
1982 East Outlet	186	9.5	0.15	Trapezoidal	3	20	0.9	Class 2

Table 5: NCDOT Riprap Sizes

Acceptance Criteria for Rip Rap and Stone for Erosion Control			
Class	Required Stone Sizes (inches)		
	Minimum	Midrange	Maximum
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

3.0 Interstate 26 Culvert

Interstate 26 is located below the 1982 basin. Stormwater runoff from the 1982 basin will be directed to existing culvert running underneath I-26. The culvert underneath I-26 is a 66-in diameter RCP culvert with a concrete headwall. A summary of I-26 culvert is shown in Table 6 below.

Table 6: Summary of I-26 Culvert

I-26 Culvert	Structure	Inlet Invert (ft)	Outlet Invert (ft)	Length (ft)	Slope (ft/ft)	Top Road Elevation (ft)
Below 1982 Basin	66" RCP	2043.5	2040	273	0.013	2052.6

Table 7 and Figure 1 show the headwater elevations versus culvert discharge for the 66” CMP I-26 culvert below the 1982 basin. Note the tailwater condition (elevation) for the I-26 culvert was considered to be the water elevation for the 10-year flood elevation of the French Broad or the normal flow depth of the downstream channel whichever was greater. The French Broad River has a 10-year flood elevation near 2039’ (culvert outlet not submerged) at the culvert location which is lower than the normal flow depth of the downstream channel. Therefore, for the I-26 culvert analysis the culvert tailwater condition was set to normal depth of the downstream channel.

Headwater elevations for the I-26 culverts were estimated to determine the impact of the proposed 1982 basin closure and stormwater plan. The 100-year headwater elevation was evaluated. Flood storage behind the I-26 road embankment was considered and a storage routing model was developed in HEC-HMS.

Topography data from USGS digital elevation model (1 meter) was utilized in estimating available flood storage volumes behind the I-26 embankment. Figure 2 shows the rating curve for the storage area between the toe of the 1982 basin and upstream the I-26 embankment.

Table 7: Discharge Curve for I-26 Culvert (1982)

I-26 Culvert (1982)	
Headwater Elevation (ft)	Flow (cfs)
2043.5	0
2045.71	36
2046.8	72
2047.74	108
2048.59	144
2049.47	180
2050.45	216
2051.6	252
*Top Pavement Elevation = 2052.6'	
**Inlet Invert Elevation = 2043.5'	

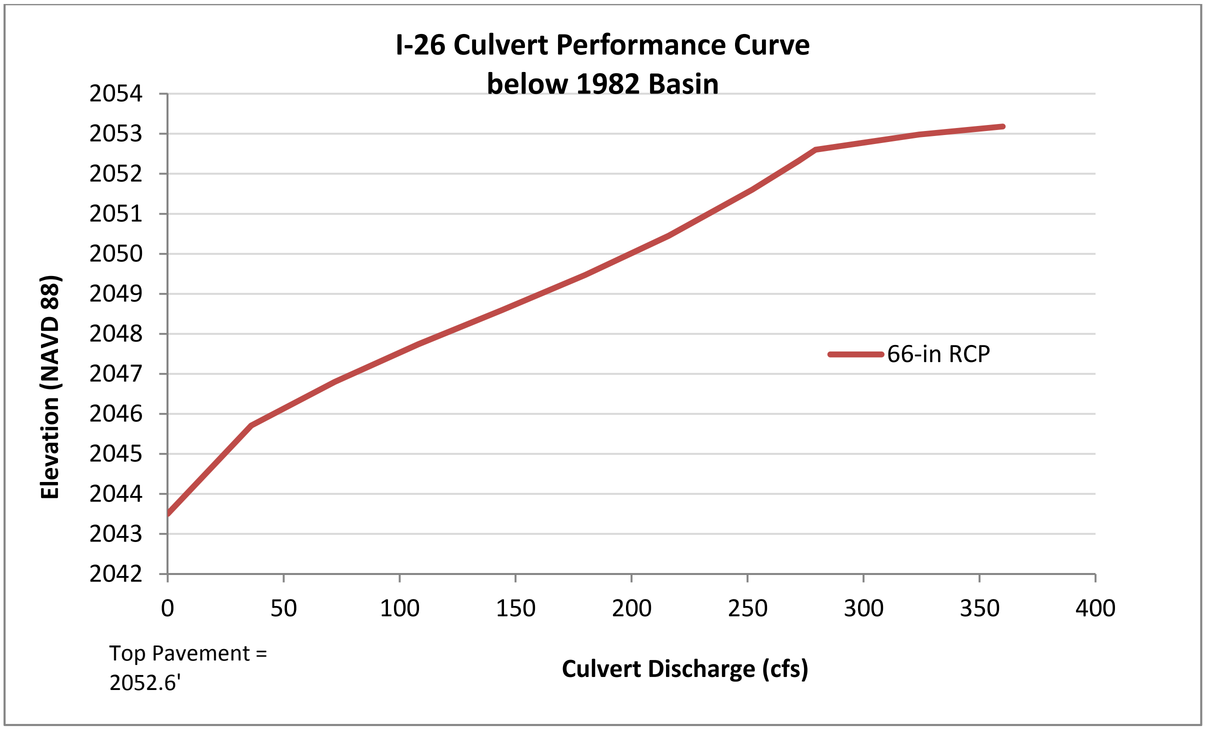


Figure 1: Discharge Curve for I-26 Culvert (1982)

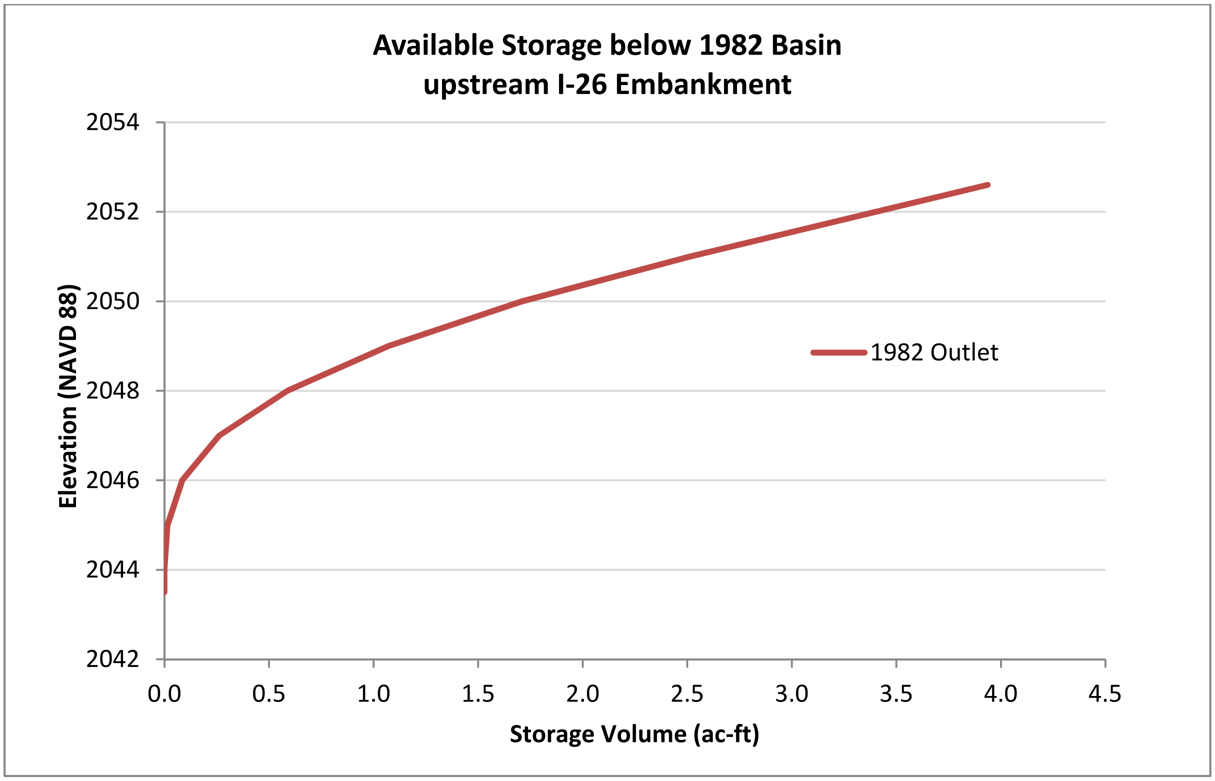


Figure 2: Storage Curve for I-26 Culvert (1982)

The headwater elevation behind the I-26 embankment for the 100-year 6-hr flood is shown in Table 8. The headwater elevation below the 1982 basin for the 100-year event is 2050.7' which is approximately 1.9 feet below the road embankment.

Coordination with NCDOT will be required to determine if additional flow capacity is needed below the 1982 basin to lower the headwater depths upstream of I-26.

Table 8: Headwater Elevations at I-26 Embankment

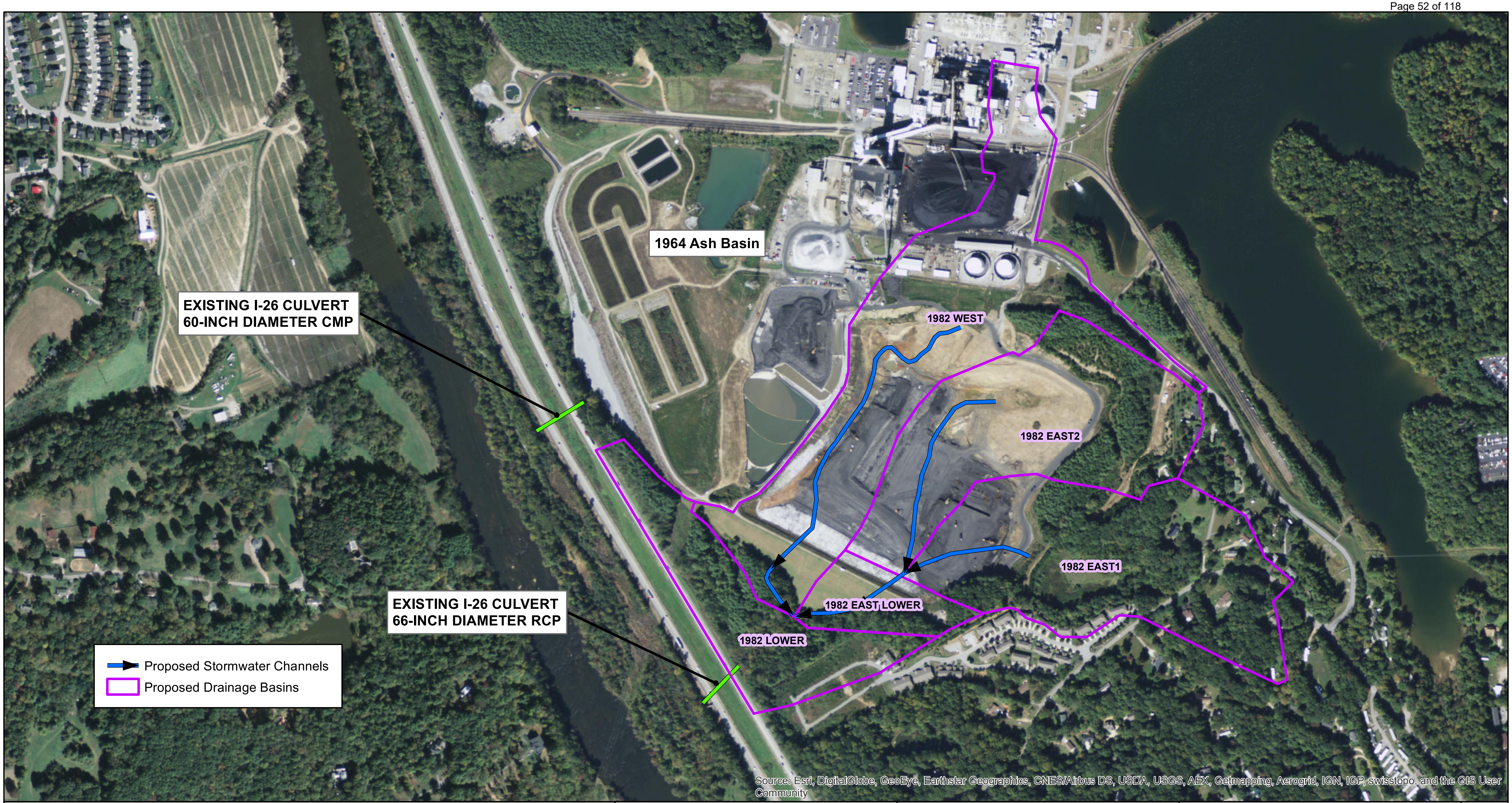
I-26 Culverts	Inlet Invert (ft)	100-year 6-hour Flood		
		Headwater Elevation (ft)	Freeboard from Top Pavement (ft)	HW/D
Below 1982 Basin	2043.5	2050.7	1.9	1.3

FIGURES:

1. General Site Drainage Map

REFERENCES:

1. NOAA Atlas 14, Point Precipitation Frequency Estimates", NOAA National Weather Service.
2. HEC-15, Hydraulic Engineering Circular No. 15, Third Edition. "Design of Roadside Channels with Flexible Linings". September 2005.
3. HDS-5, Hydraulic Design Series Number 5. Hydraulic Design of Highway Culverts, Third Edition. January 2012.
4. North Carolina Department of Environment and Natural Resources, "Erosion and Sediment Control Planning and Design Manual", Revised May 2013.
5. "Standard Specification for Roads and Structures", North Carolina Department of Transportation, Raleigh, January 2012.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

NOTES:

N

0 0.05 0.1 0.2 Miles

amec foster wheeler

Environment & Infrastructure, Inc.
3020 Falling Waters, Rd., Suite 300
Knoxville, TN 37922

CLIENT:

DUKE ENERGY.

PROJECT:

DAM DECOMMISSIONING PLAN
ASHEVILLE STEAM STATION

TITLE:

DRAINAGE AREAS AND PROPOSED STORMWATER CHANNELS

DATE: 11/04/2015

PROJECT: 7810150250

DRAWN BY: JMP

CHECKED BY: LCW

Figure No.

1

Attachment 1

Precipitation depths from NOAA Precipitation Frequency Data Server

Bednarcik Exhibit 8
Docket No. E-2 Sub 1219
Asheville SARP Appendix D
Page 54 of 118

OFFICIAL COPY

Oct 30 2019

NOAA Atlas 14, Volume 2, Version 3
Location name: Asheville, North Carolina, US*
Latitude: 35.5321°, Longitude: -82.5545°
Elevation: 2023 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.347** (0.315-0.381)	**0.412** (0.376-0.454)	**0.495** (0.450-0.545)	**0.558** (0.506-0.614)	**0.641** (0.578-0.705)	**0.704** (0.630-0.773)	**0.767** (0.683-0.844)	**0.829** (0.733-0.916)	**0.911** (0.796-1.01)	**0.975** (0.844-1.09)
10-min	**0.554** (0.503-0.609)	**0.659** (0.601-0.726)	**0.793** (0.721-0.873)	**0.893** (0.810-0.982)	**1.02** (0.921-1.12)	**1.12** (1.00-1.23)	**1.22** (1.09-1.34)	**1.31** (1.16-1.45)	**1.44** (1.26-1.60)	**1.54** (1.33-1.72)
15-min	**0.692** (0.629-0.761)	**0.828** (0.755-0.912)	**1.00** (0.912-1.11)	**1.13** (1.02-1.24)	**1.30** (1.17-1.42)	**1.42** (1.27-1.56)	**1.54** (1.37-1.70)	**1.66** (1.47-1.83)	**1.81** (1.58-2.02)	**1.93** (1.67-2.16)
30-min	**0.949** (0.862-1.04)	**1.14** (1.04-1.26)	**1.43** (1.30-1.57)	**1.64** (1.49-1.80)	**1.92** (1.73-2.11)	**2.14** (1.91-2.35)	**2.36** (2.10-2.60)	**2.58** (2.28-2.85)	**2.89** (2.52-3.21)	**3.12** (2.70-3.49)
60-min	**1.18** (1.08-1.30)	**1.44** (1.31-1.58)	**1.83** (1.66-2.01)	**2.13** (1.93-2.34)	**2.56** (2.30-2.81)	**2.90** (2.59-3.18)	**3.25** (2.89-3.58)	**3.62** (3.20-4.00)	**4.14** (3.62-4.60)	**4.56** (3.94-5.10)
2-hr	**1.37** (1.24-1.50)	**1.65** (1.51-1.82)	**2.10** (1.90-2.30)	**2.45** (2.22-2.69)	**2.95** (2.65-3.24)	**3.36** (2.99-3.69)	**3.78** (3.34-4.16)	**4.23** (3.71-4.66)	**4.85** (4.20-5.38)	**5.35** (4.59-5.98)
3-hr	**1.44** (1.32-1.59)	**1.73** (1.58-1.91)	**2.18** (1.99-2.40)	**2.55** (2.31-2.81)	**3.09** (2.78-3.39)	**3.54** (3.15-3.89)	**4.01** (3.54-4.42)	**4.52** (3.95-4.99)	**5.25** (4.52-5.84)	**5.84** (4.96-6.54)
6-hr	**1.75** (1.61-1.91)	**2.07** (1.90-2.26)	**2.56** (2.35-2.79)	**2.98** (2.72-3.24)	**3.59** (3.25-3.91)	**4.11** (3.69-4.47)	**4.67** (4.15-5.09)	**5.26** (4.63-5.76)	**6.13** (5.29-6.75)	**6.84** (5.82-7.56)
12-hr	**2.17** (2.01-2.35)	**2.57** (2.38-2.79)	**3.16** (2.91-3.43)	**3.63** (3.35-3.94)	**4.29** (3.94-4.65)	**4.83** (4.41-5.24)	**5.37** (4.88-5.84)	**5.93** (5.34-6.48)	**6.70** (5.98-7.37)	**7.29** (6.45-8.06)
24-hr	**2.50** (2.33-2.70)	**3.00** (2.80-3.24)	**3.71** (3.45-4.00)	**4.28** (3.97-4.60)	**5.05** (4.68-5.43)	**5.67** (5.24-6.10)	**6.31** (5.81-6.78)	**6.96** (6.39-7.47)	**7.85** (7.16-8.43)	**8.54** (7.74-9.18)
2-day	**2.96** (2.77-3.18)	**3.54** (3.31-3.80)	**4.34** (4.05-4.65)	**4.96** (4.63-5.32)	**5.83** (5.42-6.24)	**6.51** (6.04-6.97)	**7.20** (6.66-7.72)	**7.91** (7.29-8.48)	**8.87** (8.12-9.51)	**9.60** (8.75-10.3)
3-day	**3.16** (2.96-3.38)	**3.77** (3.53-4.04)	**4.58** (4.28-4.90)	**5.22** (4.87-5.58)	**6.08** (5.66-6.50)	**6.76** (6.28-7.22)	**7.45** (6.90-7.96)	**8.14** (7.51-8.70)	**9.06** (8.32-9.70)	**9.77** (8.94-10.5)
4-day	**3.36** (3.15-3.58)	**4.00** (3.75-4.27)	**4.82** (4.51-5.15)	**5.47** (5.11-5.83)	**6.34** (5.91-6.75)	**7.01** (6.52-7.48)	**7.69** (7.13-8.20)	**8.36** (7.74-8.93)	**9.26** (8.52-9.89)	**9.94** (9.12-10.6)
7-day	**3.93** (3.69-4.20)	**4.67** (4.39-5.00)	**5.61** (5.26-5.99)	**6.35** (5.95-6.78)	**7.35** (6.86-7.83)	**8.13** (7.57-8.67)	**8.92** (8.27-9.51)	**9.71** (8.98-10.4)	**10.8** (9.89-11.5)	**11.6** (10.6-12.4)
10-day	**4.51** (4.25-4.78)	**5.34** (5.03-5.67)	**6.34** (5.98-6.74)	**7.12** (6.72-7.56)	**8.18** (7.69-8.68)	**9.00** (8.44-9.55)	**9.83** (9.19-10.4)	**10.7** (9.92-11.3)	**11.7** (10.9-12.5)	**12.6** (11.6-13.4)
20-day	**6.16** (5.84-6.51)	**7.25** (6.87-7.66)	**8.44** (7.99-8.92)	**9.37** (8.86-9.89)	**10.6** (9.98-11.2)	**11.5** (10.8-12.1)	**12.4** (11.6-13.1)	**13.2** (12.4-14.0)	**14.3** (13.4-15.2)	**15.2** (14.1-16.1)
30-day	**7.61** (7.25-8.00)	**8.92** (8.49-9.38)	**10.2** (9.72-10.7)	**11.2** (10.6-11.7)	**12.4** (11.8-13.0)	**13.3** (12.6-14.0)	**14.1** (13.4-14.9)	**14.9** (14.1-15.7)	**15.9** (15.0-16.8)	**16.6** (15.6-17.6)
45-day	**9.70** (9.25-10.2)	**11.3** (10.8-11.9)	**12.8** (12.2-13.4)	**13.8** (13.2-14.4)	**15.1** (14.4-15.8)	**16.0** (15.2-16.7)	**16.8** (16.0-17.6)	**17.5** (16.7-18.4)	**18.4** (17.5-19.3)	**19.0** (18.0-20.0)
60-day	**11.6** (11.1-12.2)	**13.6** (13.0-14.2)	**15.1** (14.5-15.9)	**16.3** (15.6-17.1)	**17.7** (16.9-18.5)	**18.6** (17.8-19.5)	**19.5** (18.6-20.5)	**20.3** (19.3-21.3)	**21.2** (20.2-22.3)	**21.8** (20.7-22.9)

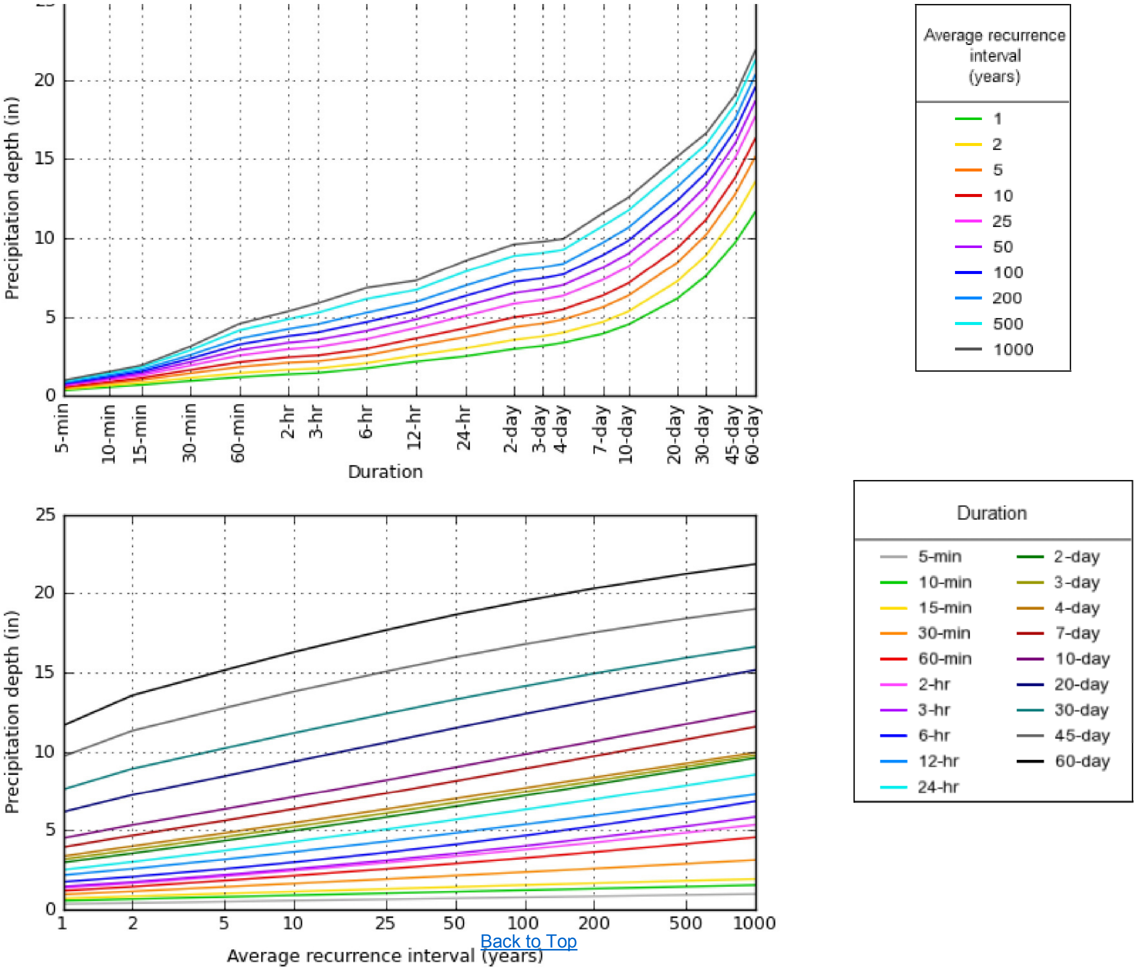
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



Back to Top

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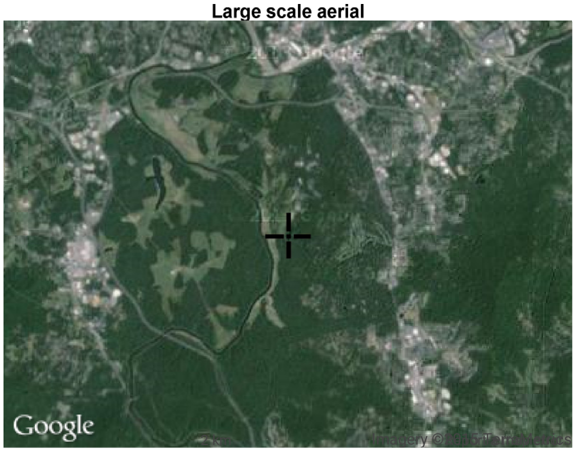
Created (GMT): Tue Aug 11 19:18:34 2015

Maps & aerials

Small scale terrain

Large scale terrain

Large scale aerial



Back to Top

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Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Calculation Title:
Temporary Silt Basin Calculations

Summary:
The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) "Erosion and Sediment Control, Field Guide." Using this guide, appropriately-sized silt basins were designed with storage capacities of approximately 84,600 ft^3 each, which is greater than the minimum required capacities of 82,800 ft^3 each.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	**Matt Bishop** Matt Bishop 2/23/16	**Luke C. Williams, PE** Luke C Williams 2/23/16

OBJECTIVE:

The objective of this calculation is to design the temporary silt basins for the interim closure conditions of the 1982 Ash Basin.

METHOD:

The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) "Erosion and Sediment Control, Field Guide" [Ref. 1]. Areas used in the calculation were generated from the project drawings using AutoCAD Civil 3D [Ref. 2].

CALCULATIONS:

1.0 Determination of Disturbed Area

The limits of disturbance for the dam decommissioning and closure activities at the 1982 Ash Basin are shown on Sheet C-1.3 of the project drawings. The disturbed areas are noted on the drawings as the following:

- Limits of Dam Breach Excavation (5.8 acres),
- Approximate Limits of Impoundment Backfill (13.5 acres), and
- Limits of Disturbance for Channel Construction (0.9 acres), *note that this area is a result of all channels shown on the plan (0.35 + 0.20 + 0.05 + 0.30 acres)*.

Thus, the total estimated disturbed area is approximately 20.2 acres. In addition, current ash excavation operations are underway and encompass a total area of approximately 46 acres (including the proposed 20.2 acres). There will be some overlap between the current ash excavation work and the proposed disturbance included in this submittal. Therefore, the silt basins included in this calculation were sized to be able to handle the total disturbance area within the ash basin of 46 acres, instead of the disturbed area of 20.2 acres as shown on the E&SC Permit Drawings.

The stormwater flows within the disturbed areas will be routed through the basin with two separate stormwater channels: one network of channels along the west limits of the fill, and one network of channels along the east limits of the fill. Each channel will convey flows from approximately half of the disturbed area within the basin. Therefore, <u>each</u> silt basin will be designed to handle half of the total disturbance area within the basin of 23 acres (46 acres / 2).

2.0 Silt Basin Design

Silt Basins were designed to intercept flows from the stormwater channels along the excavation limits adjacent to the existing 1982 Ash Basin Dam. The Silt Basins were designed in accordance with the NCDOT "Erosion and Sediment Control, Field Guide" for Silt Basin, Type B recommendations. According to the design guide, each silt basin shall be designed with a storage capacity of 3,600 cubic feet per disturbed acre.

As mentioned previously, each silt basin was designed to handle half of the total disturbance area within the basin of 23 acres. As a result, the required storage capacity for each silt basin is 82,800 ft^3 (23 acres x 3600 ft^3/acre).

The silt basin design also incorporated the sizing requirements for Silt Basin, Type B recommendations. The requirements included a minimum of 2' depth, maximum of 1.5:1 side slopes, and a minimum length of 2 times the width. The silt basin design is shown on Detail 4 of Sheet E-1.2. The design consists of surface dimensions of 100' x 225' and a depth of 4'. The calculated volume for this design is approximately 84,600 ft^3, which is greater than the minimum required 82,800 ft^3 of storage capacity.

DISCUSSION:

The temporary silt basins were designed in accordance with the North Carolina Department of Transportation (NCDOT) "Erosion and Sediment Control, Field Guide." Using this guide, appropriately-sized silt basins were designed with storage capacities of approximately 84,600 ft^3 each, which is greater than the minimum required capacities of 82,800 ft^3 each.

REFERENCES:

1. North Carolina Department of Transportation, "Erosion and Sediment Control, Field Guide", 2013.
2. AutoCAD Civil 3D 2015, AutoDesk Inc.

Calculation Title:
Temporary Stormwater Containment Berm Calculations

Summary:

The objective of this calculation is to design the temporary stormwater containment berms for the interim closure conditions of the 1982 Ash Basin. The temporary stormwater containment basins were designed to adequately contain the 25-year stormwater runoff volumes for each of their respective tributary areas. Each Berm has sufficient capacity to contain the rainfall event with adequate freeboard without overtopping.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	**Matt Bishop** Matt Bishop 2/23/16	**Luke C. Williams, PE** Luke C Williams 2/23/16

OBJECTIVE:

The objective of this calculation is to design the temporary stormwater containment berms for the interim closure conditions of the 1982 Ash Basin.

METHOD:

The temporary stormwater containment berms were designed to store the 25-year storm event. Stormwater flow rates were calculated using the SCS runoff method. Stage-storage curves were developed for the Upper and Lower Berms using AutoCAD Civil 3D and Microsoft Excel.

CALCULATIONS:

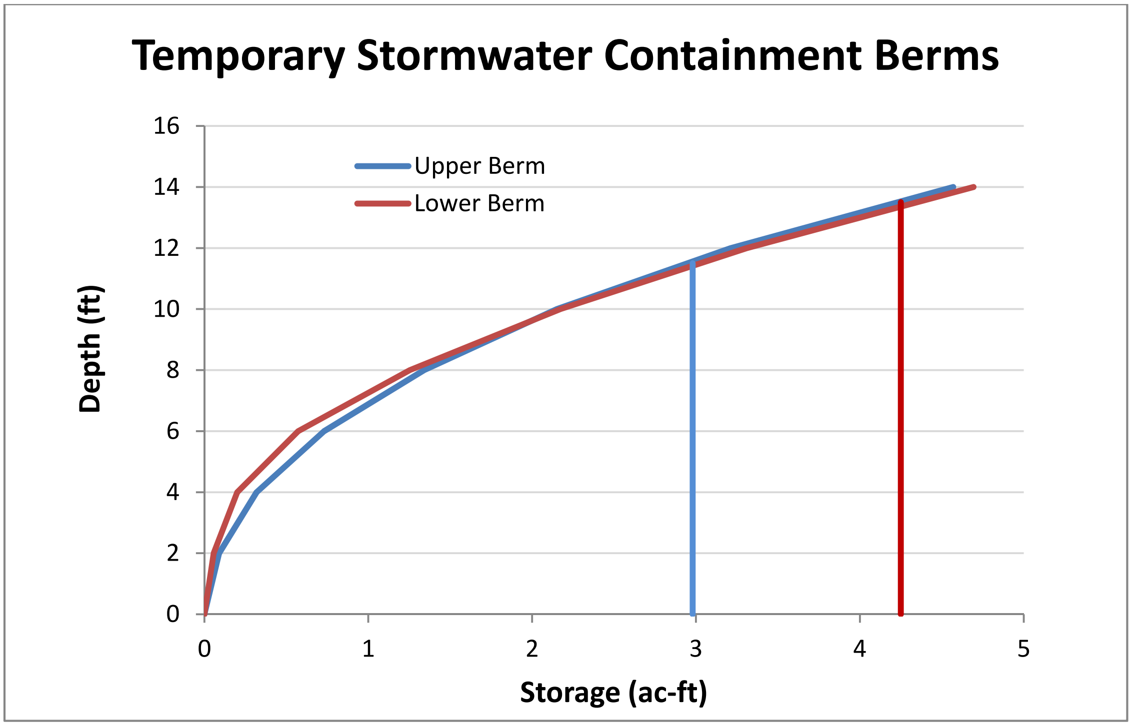
1.0 Determination of Stormwater Runoff Volume

The stormwater runoff volume for the drainage areas upstream of each berm were calculated according to the SCS runoff method as presented in the "Final Conditions Stormwater Calculation," included with this submittal. The following runoff volumes and peak pool elevations were determined for each Berm:

	Drainage Area (ac)	25-yr Runoff Volume (ac-ft)	Peak Pool (ft)
Upper Berm	16.6	2.98	2131.6
Lower Berm	26.6	4.245	2125.4

2.0 Berm Design

Each Berm was designed using AutoCAD Civil 3D software with a maximum height of 14 feet. Using the 25-yr Runoff Volume as shown in the table above, stage-storage curves were generated to calculate the peak pool elevations and their associated depths. The figure below shows the stage-storage curves for the Berms.



DISCUSSION:

The temporary stormwater containment basins were designed to adequately contain the 25-year stormwater runoff volumes for each of their respective tributary areas. As shown on the previous figure, each Berm has sufficient capacity to contain the rainfall event with adequate freeboard without overtopping.

REFERENCES:

1. NOAA Atlas 14, Point Precipitation Frequency Estimates", NOAA National Weather Service.
2. HEC-15, Hydraulic Engineering Circular No. 15, Third Edition. "Design of Roadside Channels with Flexible Linings". September 2005.
3. HDS-5, Hydraulic Design Series Number 5. Hydraulic Design of Highway Culverts, Third Edition. January 2012.
4. North Carolina Department of Environment and Natural Resources, "Erosion and Sediment Control Planning and Design Manual", Revised May 2013.
5. "Standard Specification for Roads and Structures", North Carolina Department of Transportation, Raleigh, January 2012.

Calculation Title:
Compost Sock Calculations

Summary:
The below calculations are for the compost socks for the interim closure conditions of the 1982 Ash Basin. The compost socks were designed to handle the 10-year runoff volume.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	**Joe Parker** JParker 7/18/2016	**Luke C. Williams, PE** Luke Williams by Matt [illegible] w/ permission 07/18/2016

OBJECTIVE:

The objective of this calculation is to design the compost socks for the interim closure conditions of the 1982 Ash Basin.

METHOD:

The compost socks located on the west and east excavated dam abutments were designed to filter the 10-year runoff volume without overtopping. The compost socks located on the main backfill area were not specifically designed to handle the 10-year runoff volume because the runoff from this area drains to the west and east sediment ponds, which were sized to handle sediment washoff from the main backfill area. Stormwater runoff volumes were calculated using the SCS runoff method considering a conservative runoff curve number of 88 (disturbed soil).

CALCULATIONS:

Composts socks were designed using the recommended criteria documented in the Chapter 6 Section 6.66 “Compost Sock” in the NCDEQ Erosion and Sediment Control Planning and Design Manual (NCDEQ, 2013). The compost socks will be installed on the west and east excavated dam abutments to handle the 10-year runoff volumes. Compost socks will be placed at every 10 foot change in elevation and will have 12-inch diameter as shown in the design drawings. The abutment cut has a slope of approximately 10H:1V or 10 percent. Table 1 shows the recommended design flow rate per length of compost sock. Table 2 shows that the compost sock for the west and east excavated dam abutments have adequate capacity in handling the 10-year runoff volume. Specially, the 10-year runoff volume per length of compost sock is less than the maximum recommend flow rate specified in Table 1.

Table 1: Recommended Sock Flow Rate (NCDEQ, 2013)

Compost Sock Design Diameter (in)	Flow per foot of sock (gpm/ft)
8	7.5
12	11.3
18	15
24	22.5
32	30

Table 2: Sock Flow Rate Calculations Summary

Sock Slope Elevation (ft)	Length of sock (ft)	Cumulative Drainage Area (ac)	Peak runoff (cfs)	Flow per foot of sock (gpm/ft)
West Abutment				
2160	61	0.028	0.14	1.0
2150	113	0.116	0.56	2.2
2140	155	0.35	1.69	4.9
2130	195	0.612	2.95	6.8
2120	237	0.936	4.51	8.5
2110	284	1.149	5.53	8.7
2104	309	1.287	6.2	9.0
East Abutment				
2160	52	0.025	0.12	1.0
2150	87	0.12	0.58	3.0
2140	141	0.234	1.13	3.6
2130	203	0.423	2.04	4.5
2120	250	0.642	3.09	5.5
2110	301	0.727	3.5	5.2
2106	326	1.037	5	6.9

DISCUSSION:

The temporary compost socks were designed to adequately filter the 10-year stormwater runoff volumes for each of their drainage areas to allow for proper sediment control.

REFERENCES:

1. North Carolina Department of Environment and Natural Resources, (NCDEQ) “Erosion and Sediment Control Planning and Design Manual”, Revised May 2013.

Calculation Title:
Riprap Energy Dissipaters Calculations

Summary:

The following calculations are for the riprap basin energy dissipaters for the interim closure conditions of the 1982 Ash Basin. Riprap basins will be located at the outlets of the west and east outlet channels. The riprap basins will serve as a transition from the outlet channels to the downstream wetland area. The riprap basins were designed for the 100-year stormwater runoff volumes for each of their respective tributary areas.

Notes:

Revision Log:

No.	Description	Originator / Date	Technical Reviewer / Date
0	Initial Submittal	**Joe Parker** 7/18/2016	**Luke C. Williams, PE** Luke Williams by Matt [illegible] w/permission 07/18/2016

OBJECTIVE:

The objective of this calculation is to design the riprap basin energy dissipaters for the interim closure conditions of the 1982 Ash Basin.

METHOD:

The riprap basin energy dissipaters were designed using guidelines found in Chapter 10: *Riprap Basins and Aprons* from HEC-14 "Hydraulic Design of Energy Dissipaters" (FHWA, 2006). Stormwater runoff volumes were calculated using the SCS runoff method. Further calculation on the inflow volumes for the riprap basins can be found in the H&H calculation package for the channels. The riprap basins were sized for the 100-year runoff event.

CALCULATIONS:

Riprap basin energy dissipaters will be located at the outlet of the both the west and east outlet channel to transition flow from the channel to the wetland areas. The following guidelines from FHWA were used to size the riprap basins:

- The basin is pre-shaped and lined with riprap that is a least $2D_{50}$ thick;
- The riprap floor is constructed at the approximate depth of scour, h_s, that would occur in a thick pad of riprap. The h_s/D_{50} of the material should be greater than 2;
- The length of the energy dissipating pool, L_S, is 10hs, but no less than $3W_o$; the length of the apron, L_A, is $5h_S$, but no less than W_o. The overall length of the basin (pool plus apron), L_B, is $15h_S$, but no less than $4W_o$.

Tables 1 and 2 show the dimensions of the west and east dissipater basins, respectively.
Tables 3 and 4 shows the calculation steps for the west and east dissipater basins, respectively.

Table 1: Riprap Basin Energy Dissipater West Basin Summary

Riprap Basin Energy Dissipater (West Outlet Channel)	
Entrance Channel Width, W_O (ft)	7.5
Entrance Channel Flow Depth, Y_e (ft)	0.9
Pool Depth, h_S (ft)	1.5
Exit Channel Tailwater Depth, TW (ft)	0.7
Dissipater Pool Length, L_S (ft)	22.5
Apron Length, L_A (ft)	7.5
Total Basin Length, L_B (ft)	30.0
Apron Width, W_B (ft)	27.5

Table 2: Riprap Basin Energy Dissipater East Basin

Riprap Basin Energy Dissipater (East Outlet Channel)	
Entrance Channel Width, W_O (ft)	10.0
Entrance Channel Flow Depth, Y_e (ft)	1.0
Pool Depth, h_S (ft)	1.6
Exit Channel Tailwater Depth, TW (ft)	0.7
Dissipater Pool Length, L_S (ft)	30.0
Apron Length, L_A (ft)	10.0
Total Basin Length, L_B (ft)	40.0
Apron Width, W_B (ft)	36.7

Table 3: Riprap Basin Energy Dissipater West Basin Calculations

FHWA HEC-14				
Input				
West Channel				
Step 1	Parameter	Unit	Value	Comment
Design Flow	Q	(cfs)	138	
Flow Width	Wo	(ft)	7.5	
Flow Depth	ye	(ft)	0.932	
Manning (n)			0.03	
Outlet velocity	Vo	(ft)	15.812545	
Froude number	Fr		2.89	
Step 2				
Rock median diameter	D50	(ft)	0.67	
D50/ye			0.72	(>= 0.1 OK)
Tailwater	TW	(ft)	0.71	
TW/ye			0.76	
Tailwater parameter	Co		1.40	
Pool Depth	hs	(ft)	1.47	
hs/D50			2.19	(>= 2 recommended)
Step 3				
Pool Length	Ls	(ft)	14.69	
Pool Length(min)	Lsmin	(ft)	22.50	
Apron length	La	(ft)	7.35	
Apron length(min)	Lamin	(ft)	7.50	
Total Length (pool + apron)	Lb		22.04	
Min total length	Lbmin	(ft)	30.00	
Apron width	Wb	(ft)	27.50	
Step 4				
Flow	Q	(ft3/s)	138	
gravity	g	(ft2/s)	32.2	
Critical depth	yc	(ft)	0.9	iterate
Basin side slope	z1		2	
Apron width	Wb	(ft)	27.50	
Q^2/g			591.42857	
Ac^3/Tc			589.617	
Wetted Area	Ac	(ft2)	26.37	
Wetted Perimeter	Tc	(ft)	31.1	
Exit Velocity	Vc	(ft/s)	5.2332196	(OK)
Step 5				
TW/yo			0.7639485	(OK)

Table 4: Riprap Basin Energy Dissipater East Basin Calculations

FHWA HEC-14				
Input				
East Channel				
Step 1	Parameter	Unit	Value	Comment
Design Flow	Q	(cfs)	186	
Flow Width	Wo	(ft)	10	
Flow Depth	ye	(ft)	0.95	
Manning (n)			0.03	
Outlet velocity	Vo	(ft)	16.45289695	
Froude number	Fr		2.97	
Step 2				
Rock median diameter	D50	(ft)	0.67	
D50/ye			0.71	(>= 0.1 OK)
Tailwater	TW	(ft)	0.73	
TW/ye			0.77	
Tailwater parameter	Co		1.40	
Pool Depth	hs	(ft)	1.61	
hs/D50			2.41	(>= 2 recommended)
Step 3				
Pool Length	Ls	(ft)	16.15	
Pool Length(min)	Lsmin	(ft)	30.00	
Apron length	La	(ft)	8.07	
Apron length(min)	Lamin	(ft)	10.00	
Total Length (pool + apron)	Lb		24.22	
Min total length	Lbmin	(ft)	40.00	
Apron width	Wb	(ft)	36.67	
Step 4				
Flow	Q	(ft3/s)	186	
gravity	g	(ft2/s)	32.2	
Critical depth	yc	(ft)	0.9	iterate
Basin side slope	z1		2	
Apron width	Wb	(ft)	36.67	
Q^2/g			1074.409938	
Ac^3/Tc			1030.470376	
Wetted Area	Ac	(ft2)	34.62	
Wetted Perimeter	Tc	(ft)	40.26666667	
Exit Velocity	Vc	(ft/s)	5.372616984	(OK)
Step 5				
TW/yo			0.772631579	(OK)

DISCUSSION:

Both the east and west riprap basin energy dissipaters are adequately sized to handle the 100-yr peak flow for their respective tributary areas. The design drawings further show the locations and construction details for each of the riprap basin energy dissipaters.

REFERENCES:

1. Federal Highway Administration (FHWA). Hydraulic Engineering Circular No. 14, Third Edition, "Hydraulic Design of Energy Dissipaters for Culverts and Channels", July 2006.
2. North Carolina Department of Environment and Natural Resources, "Erosion and Sediment Control Planning and Design Manual", Revised May 2013.

Stormwater Management Plan Calculations

Calculation Title:
Attachment 3a
Stormwater Management Plan

Summary:

This document presents calculations from both Amec Foster Wheeler as well as Burns and McDonnell as preparers of Phase 1 (Tasks 1 and 2) of the 1982 basin construction.

Amec Foster Wheeler is the preparer of the Phase 1, Task 1 stormwater management calculations related to the 1982 dam breach and dam decommissioning.

Burns and McDonnell is the preparer of the Phase 1, Task 2 stormwater management calculations related to the structural fill placement and grading in preparation for the combined cycle power plant construction.

Notes:

Revision Log:

No.	Description	Originator / Date		Technical Reviewer / Date
0	Initial Submittal	**Section 1 – 4** **Joe Parker (Amec Foster Wheeler)** **Section 5** **Andy Fries (Burns and McDonnell)**		**Section 1 – 4** **Luke C. Williams, PE (Amec Foster Wheeler)** **Section 5** **Andy Fries (Burns and McDonnell)**

OBJECTIVE:

The objective of this calculation package is to present the pre-construction and post-construction runoff calculations and stormwater management practices for Phase 1 (1982 basin decommissioning and structural fill placement).

METHOD:

Runoff volume calculations were performed using the SCS Curve Number method. Runoff hydrographs were developed using the SCS unit hydrograph method.

CALCULATIONS:

1.0 Determination of Pre-Construction Stormwater Runoff

The pre-construction condition was considered to be the land condition prior to the building of the 1982 dam at the Asheville Steam Electric Generating Plant. The runoff volumes for the pre-construction condition were determined using historic aerial imagery and topography from the United States Geological Survey (USGS). The outlet of the project drainage area is located at the inlet of the I-26 culvert crossing. The total drainage area was delineated using the 1965 USGS Skyland, NC quad and was determined to be 119.1 acres. **Figure 1** shows this drainage area.

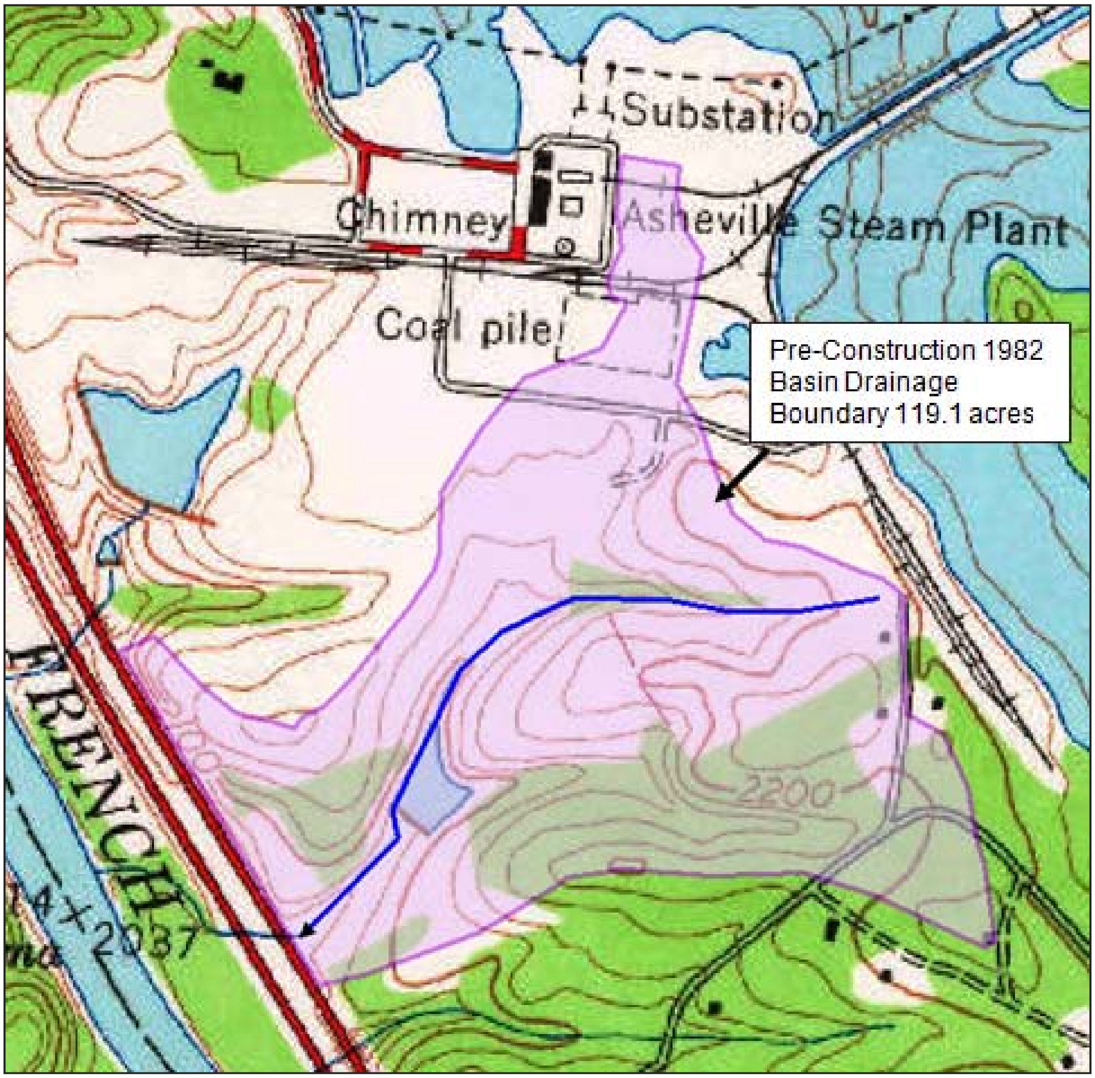


Figure 1: Pre-Construction Topography and Drainage Area (USGS Skyland, NC Quad 1965)

Figure 2 shows the 1964 aerial imagery for the 1982 basin. Prior to the building of the 1982 dam the majority of the 1982 drainage area was pasture. **Table 1** provides a summary of the land cover, hydrologic soil group, and runoff curve for the 1982 basin prior to the construction of the 1982 dam. The hydrologic soil groups were determined from Buncombe County Soil Survey. Please note the currently available Buncombe County Soil Survey was published in 2013 and the soils shown in the survey do not reflect pre-construction (i.e. pre-1982 dam) condition. Therefore to accurately estimate the pre-construction runoff the soils within the 1982 basin were estimated using the soil data for the surrounding undistributed or native soils shown in the survey. The native soils surrounding the site generally are type B soils. Developed areas associated with the plant were considered to be type C soils because of their disturbed nature. The weighted runoff curve number for the pre-construction drainage area is 68.

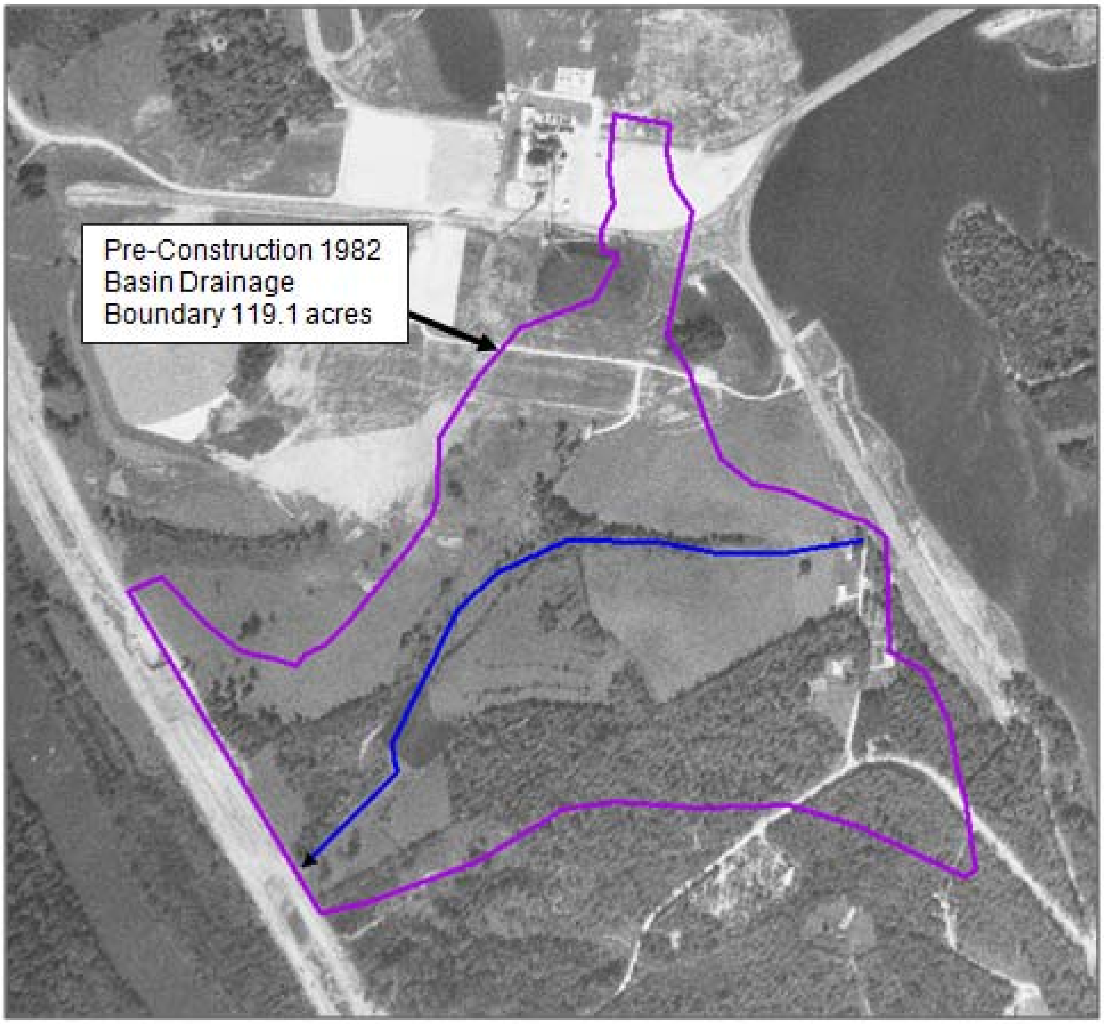


Figure 2: Pre-Construction Land Cover (USGS 09/24/1964)

Table 1: Pre-Construction 1982 Basin Runoff Curve Number Summary

Pre 1982 Dam Land Cover Summary	Area (acres)	Hydro Soil Group	CN
Industrial (72% Impervious)	8.8	C	91
Residential	5.4	B	70
Pasture	56	B	69
Pasture Tree Combination	16.3	B	65
Forest	32.6	B	60
Total	119.1	Weighted CN	68

Peak runoff flow rates were estimated using the SCS unit hydrograph method. Drainage parameters used to estimate the runoff hydrograph are shown in **Table 2** below. The peak runoff rate for the 1-year, 24-hour storm event was calculated to be 30.4 cfs (**Table 3**). The 1-

year, 24-hour rainfall depth is 2.5 inches as determined from NOAA Atlas 14. A SCS Type II storm distribution was used for the 1-year, 24-hour rainfall event.

Attachment 3b “Pre-1982 Dam Runoff Calculations” provides the supporting runoff calculations for the Pre-1982 dam condition.

Table 2: Pre-Construction 1982 Basin Drainage Area Summary

Drainage Area	Area (acres)	Area (mi2)	Curve Number CN	Tc (min)
Pre-1982 Dam Conditions				
Drainage Area upstream I-26	119.1	0.1861	68	25

Table 3: Pre-Construction 1982 Basin Runoff Summary

Storm Event	Runoff Volume (ac-ft)	Peak Runoff (cfs)
Pre-1982 Dam Conditions		
1-year, 24-hour	3.7	30.4

2.0 Determination of Post-Construction Stormwater Runoff

The Post-construction condition was considered to be the land condition after the breach and decommissioning of the 1982 dam and placement of Structural Fill as shown on the “Final Grading and Drainage” sheet in the drawing package.

The runoff volumes for the post-construction condition were determined considering the interior of the 1982 basin will be vegetated with grass. The soils within the 1982 basin footprint were considered disturbed and the hydrologic soil group was set to C to account for compaction of heavy equipment and general ground disturbance. The total drainage area was delineated using recent survey data of the site and was determined to be 107.5 acres. The drainage area was subdivided into multiple subbasins to allow for analysis of the East and West Stormwater Basins. The reduction in drainage area from the pre-construction conditions is a result of the low volume stormwater system (LVSW) which captures runoff from the plant area and diverts runoff away from the 1982 basin to an NPDES discharge point. **Figure 3** shows the drainage area and the area of the LVSW system. **Table 4** provides a summary of the land cover, hydrologic soil group, and runoff curve for the 1982 basin post breach of the 1982 dam. The weighted runoff curve number for the post-construction drainage area is 71.

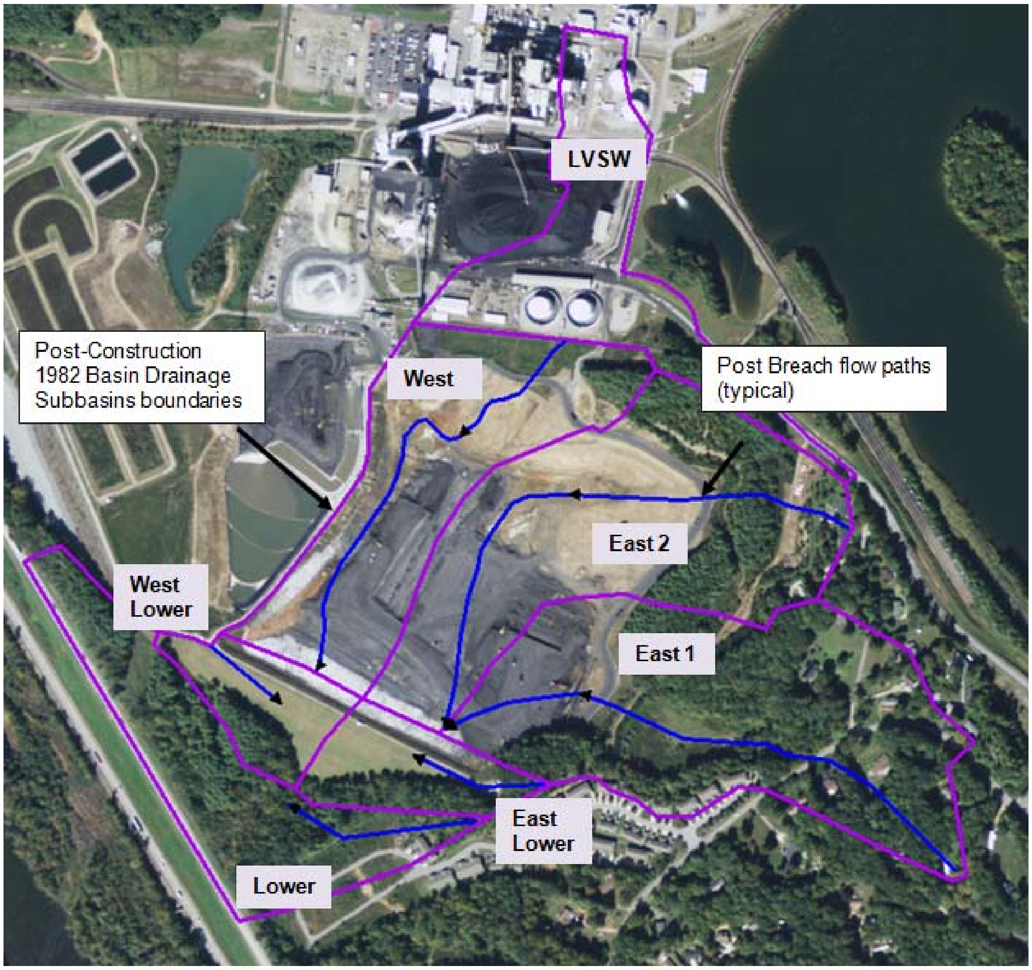


Figure 3: Post Construction Drainage Areas

Table 4: Post-Construction 1982 Basin Runoff Curve Number Summary

Subbasin	Land Cover Type	Area (acres)	Hydro Soil Group	CN
LVSW	Grass developed area	3.1	C	74
	Industrial (72% Impervious)	12.0	C	91
West	Grass developed area	20.4	C	74
West Lower	Grass developed area	5.4	C	74
East 1	Grass developed area	11.2	C	74
	Grass woods Combination	20.1	B	68
East 2	Grass developed area	19.0	C	74
	Grass woods Combination	10.1	B	70
East Lower	Grass developed area	5.9	C	74
Lower	Grass woods Combination	15.5	B	65
	Total without LVSW	107.5	Weigthed CN	71

Peak runoff flow rates were estimated using the SCS unit hydrograph method. Drainage parameters used to estimate the runoff hydrograph for each of the subbasins are shown in **Table 5** below. **Attachment 3c** “Post-1982 Dam Runoff Calculations” provide the supporting subbasin runoff calculations for the Post-1982 dam condition. Two Stormwater basins will be constructed within the 1982 basin and will reduce peak flows leaving the project area. The Stormwater Basins details are discussed in Section 3.0. **Table 6** shows the peak runoff rate for the 1-year, 24-hour from the project site considering the stormwater basins.

Table 5: Post-Construction 1982 Basin Runoff Summary

Drainage Area	Area (acres)	Area (mi2)	Curve Number CN	Tc (min)
Post-1982 Dam Breach Conditions				
West	20.4	0.0318	74	22.8
West Lower	5.4	0.0085	74	7.1
East 1	31.3	0.0489	70	26.4
East 2	29.1	0.0454	73	28.1
East Lower	5.9	0.0092	74	11.2
Lower	15.5	0.0242	65	19.7

Table 6: Post-Construction 1982 Basin Runoff Summary

Storm Event	Runoff Volume (ac-ft)	Peak Runoff (cfs)
Post-1982 Dam Conditions		
1-year, 24-hour	4.4	12.1

3.0 Stormwater Basins

During the breaching activities of the 1982 dam two sediment ponds will be constructed at the toe of the interior face of the dam. The sediment ponds will provide erosion and sediment control during construction and were sized using guidelines from Section 6.61 NCDEQ *Erosion and Sediment Control Planning Design Manual*.

These two sediment ponds will be modified once construction is complete to function as permanent stormwater basins to control peak runoff flow from the project site. These modifications to the sediment ponds include: 1) removal of the skimmer, 2) cleanout of deposited sediment, and 3) reduction in the principal spillway riser height to 4 feet. A 4" diameter orifice will also be put in the riser pipe to keep the stormwater basins dry.

The two stormwater basins identified as “East” and “West” stormwater basins on the project drawings are located near the dam breach and will be below final grade to allow for runoff to be collected into the basins. Further details on the permanent stormwater basins are provided below.

East Stormwater Basin

The principal spillway for the East Stormwater Basin is a riser barrel type spillway. The riser pipe is 3 feet in diameter and has a height of 4 feet from the bottom of the pond. The top of the riser is open and serves as the principal spillway for the basin. The basin is dewatered by a 4-in diameter orifice located at the bottom of the riser. The horizontal barrel section of the principal spillway is a corrugated metal pipe 2 feet in diameter. The emergency spillway for the West Stormwater Basin is a trapezoidal channel with a 5’ bottom width and 3H:1V side slopes. The spillway is set 7 feet off the bottom of the pond. The stage storage information for the East Stormwater Basin is provided in **Table 7** and **Figure 4**. **Table 8 – 11 and Figure 5** provide the spillway discharge information for the East Stormwater Basin.

Table 7: East Stormwater Basin Stage Storage

Stage (ft)	Surface (ft2)	Surface Area (ac)	Cumulative Storage Volume (ac-ft)
2098	0	0.000	0.0000
2099	2063	0.047	0.0237
2100	6464	0.148	0.1216
2101	11227	0.258	0.3246
2102	13886	0.319	0.6129
2103	15230	0.350	0.9471
2104	16599	0.381	1.3124
2105	17994	0.413	1.7095
2106	19424	0.446	2.1390
2107	20772	0.477	2.6004
2108	22119	0.508	3.0927

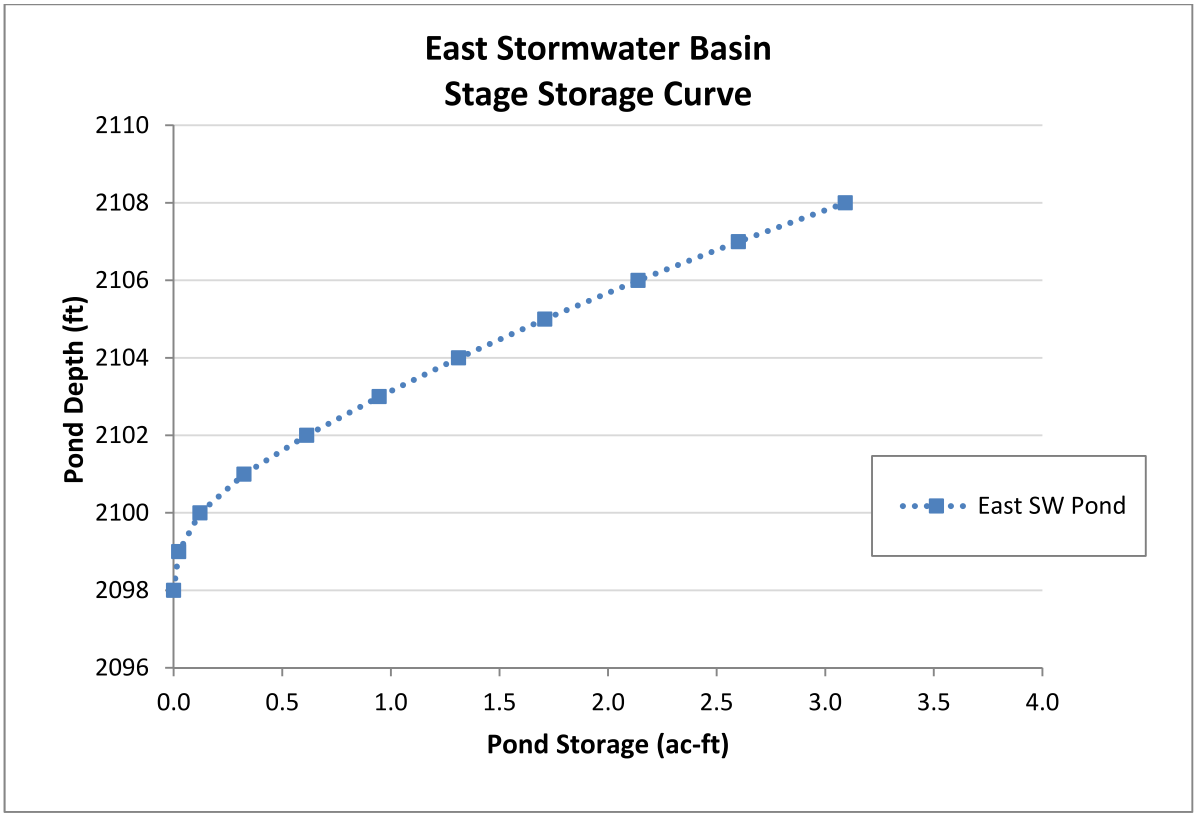


Figure 4: East Stormwater Basin Stage Storage

Table 8: East Stormwater Basin Outlet Riser Calculations

Principal Spillway Riser Equations	
Riser Weir	
Q = CLH^1.5	
C	3.3
Crest length (ft)	9.4
Riser Orifice	
Q = CA(2gH)^0.5	
C	0.8
Riser orifice diameter (in)	36
Area (ft2)	7.1
Dewatering Orifice	
Q = CA(2gH)^0.5	
C	0.4
Dewatering orifice diameter (in)	4
Area (ft2)	0.1

Table 9: East Stormwater Basin Outlet Barrel Calculations

Principal Spillway Outlet Pipe Flow Equations	
Q = A(2gH)^0.5/(1+ke+kb+f(L/D))^0.5	
f = 185*n^2/(D)^(1/3)	
Entrance Loss coefficient (ke)	0.5
Bend Loss coefficient (kb)	0.1
Friction Loss coefficient (f)	0.084576728
z	3
Outlet Pipe length, L (ft)	300
Outlet Pipe diameter, D (ft)	2
Manning's Roughness (n)	0.024

Table 10: East Stormwater Basin Emergency Spillway Calculations

Emergency Spillway Equations		
Q = CLH^1.5		
Weir Coefficient		3.1
Trapezoidal (side slope)		3
Bottom Width of Spillway (ft)		5
Elevation	**H1**	**Q**
2105	0	0
2105.5	0.5	7
2106	1	25
2106.5	1.5	54
2107	2	96
2107.5	2.5	153
2108	3	226

Table 11: East Stormwater Basin Stage Discharge Information

Elevation (ft)	Riser Weir Flow (cfs)	Riser Orifice Flow (cfs)	Dewatering orifice Flow (cfs)	Outlet pipe Flow (cfs)	Principal Spillway Control** (cfs)	Emergency Spillway (cfs)	Combined East Stormwater Basin Discharge (cfs)
2098	0	0	0.0	0	0		0
2098.5	0	0	0.2	6.8	0.2		0.2
2099	0	0	0.3	9.6	0.3		0.3
2099.5	0	0	0.3	11.7	0.3		0.3
2100	0	0	0.4	13.5	0.4		0.4
2100.5	0	0	0.4	15.1	0.4		0.4
2101	0	0	0.5	16.6	0.5		0.5
2101.5	0	0	0.5	17.9	0.5		0.5
2102	0	0	0.6	19.1	0.6		0.6
2102.5	11	32.1	0.6	20.3	11.6		11.6
2103	31	45.4	0.6	21.4	21.4		21.4
2103.5	57	55.6	0.7	22.4	22.4		22.4
2104	88	64.2	0.7	23.4	23.4		23.4
2104.5	123	71.8	0.7	24.4	24.4		24.4
2105	162	78.6	0.7	25.3	25.3	0	25.3
2105.5	204	84.9	0.8	26.2	26.2	7	33.3
2106	249	90.8	0.8	27.1	27.1	25	51.9
2106.5	297	96.3	0.8	27.9	27.9	54	82
2107	348	101.5	0.8	28.7	28.7	96	125.1
2107.5	401	106.4	0.9	29.5	29.5	153	182.7
2108	457	111.2	0.9	30.2	30.2	226	255.8

*Top Principal Spillway Riser = 2102'; Invert Emergency Spillway = 2105'

**Principal Spillway Control Flow includes flow from the dewatering orifice.

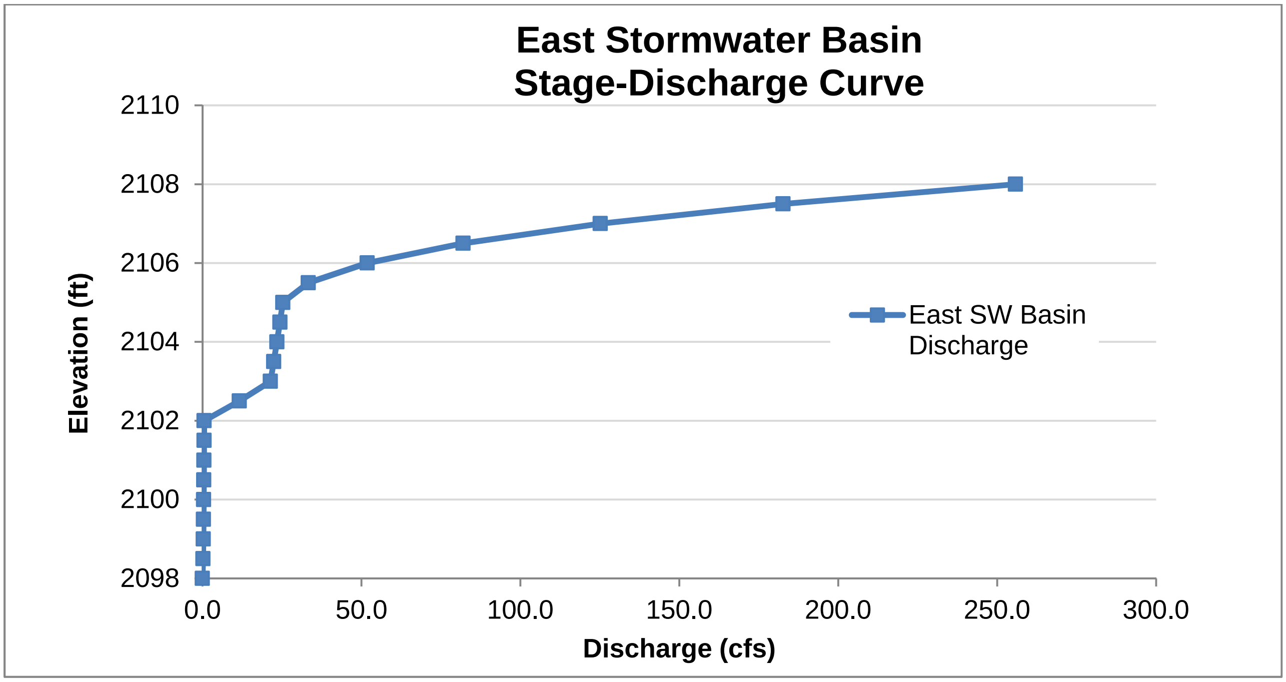


Figure 5: East Stormwater Basin Stage Discharge Curve

West Stormwater Basin

The principal spillway for the West Stormwater Basin is a riser barrel type spillway. The riser pipe is 3 feet in diameter and has a height of 4 feet from the bottom of the pond. The top of the riser is open and serves as the principal spillway for the basin. The basin is dewatered by a 4-in diameter orifice located at the bottom of the riser. The horizontal barrel section of the principal is spillway is a corrugated metal pipe 2 feet in diameter. The emergency spillway for the West Stormwater Basin is a trapezoidal channel with a 5' bottom width and 3H:1V side slopes. The spillway is set 8 feet off the bottom of the pond. The stage storage information for the West Stormwater Basin is provided in **Table 12** and **Figure 6**. **Table 13 – 16 and Figure 7** provide the spillway discharge information for the West Stormwater Basin.

Table 12: West Stormwater Basin Stage Storage

Stage (ft)	Surface Area (ft2)	Surface Area (ac)	Incremental Storage Volume(ac-ft)	Cumulative Storage Volume (ac-ft)
2097	0	0.000	0.000	0.000
2098	1773	0.041	0.020	0.020
2099	5229	0.120	0.080	0.101
2100	9396	0.216	0.168	0.269
2101	13330	0.306	0.261	0.529
2102	14691	0.337	0.322	0.851
2103	16068	0.369	0.353	1.204
2104	17469	0.401	0.385	1.589
2105	18897	0.434	0.417	2.007
2106	20352	0.467	0.451	2.457
2107	21992	0.505	0.486	2.943
2108	23631	0.542	0.524	3.467

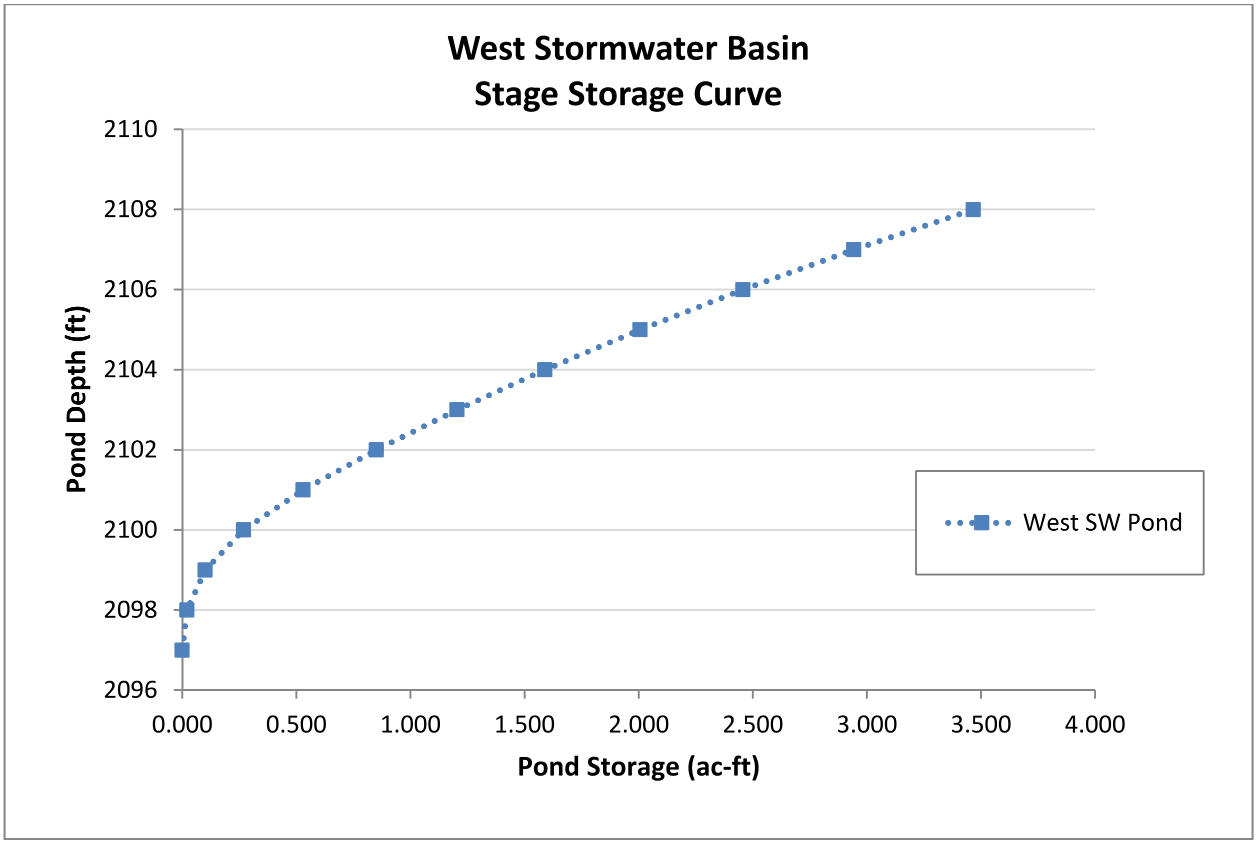


Figure 6: West Stormwater Basin Stage Storage

Table 13: West Stormwater Basin Outlet Riser Calculations

Principal Spillway Riser Equations	
Riser Weir	
Q = CLH^1.5	
C	3.3
Crest length (ft)	9.4
Riser Orifice	
Q = CA(2gH)^0.5	
C	0.8
Riser orifice diameter (in)	36
Area (ft2)	7.1
Dewatering Orifice	
Q = CA(2gH)^0.5	
C	0.4
Dewatering orifice diameter (in)	4
Area (ft2)	0.1

Table 14: West Stormwater Basin Outlet Barrel Calculations

Principal Spillway Outlet Pipe Flow Equations	
Q = A(2gH)^0.5/(1+ke+kb+f(L/D))^0.5	
f = 185*n^2/(D)^(1/3)	
Entrance Loss coefficient (ke)	0.5
Bend Loss coefficient (kb)	0.1
Friction Loss coefficient (f)	0.084576728
z	3
Outlet Pipe length, L (ft)	300
Outlet Pipe diameter, D (ft)	2
Manning's Roughness (n)	0.024

Table 15: West Stormwater Basin Emergency Calculations

Emergency Spillway		
Q = CLH^1.5		
Weir Coefficient		3.1
Trapezoidal (side slope)		3
Bottom Width of Spillway (ft)		5
Elevation	**H1**	**Q**
2105	0	0
2105.5	0.5	7
2106	1	25
2106.5	1.5	54
2107	2	96
2107.5	2.5	153
2108	3	226

Table 16: West Stormwater Basin Stage Discharge Information

Elevation (ft)	Riser Weir Flow (cfs)	Riser Orifice Flow (cfs)	Dewatering orifice Flow (cfs)	Outlet pipe Flow (cfs)	Principal Spillway Control** (cfs)	Emergency Spillway (cfs)	Combined East Stormwater Basin Discharge (cfs)
2097	0	0.0	0.00	0.0	0.0		0.0
2097.5	0	0.0	0.20	6.8	0.2		0.2
2098	0	0.0	0.28	9.6	0.3		0.3
2098.5	0	0.0	0.34	11.7	0.3		0.3
2099	0	0.0	0.40	13.5	0.4		0.4
2099.5	0	0.0	0.44	15.1	0.4		0.4
2100	0	0.0	0.49	16.6	0.5		0.5
2100.5	0	0.0	0.52	17.9	0.5		0.5
2101	0	0.0	0.56	19.1	0.6		0.6
2101.5	11	32.1	0.59	20.3	11.6		11.6
2102	31	45.4	0.63	21.4	21.4		21.4
2102.5	57	55.6	0.66	22.4	22.4		22.4
2103	88	64.2	0.69	23.4	23.4		23.4
2103.5	123	71.8	0.71	24.4	24.4		24.4
2104	162	78.6	0.74	25.3	25.3		25.3
2104.5	204	84.9	0.77	26.2	26.2		26.2
2105	249	90.8	0.79	27.1	27.1	0	27.1
2105.5	297	96.3	0.82	27.9	27.9	7	35.0
2106	348	101.5	0.84	28.7	28.7	25	53.5
2106.5	401	106.4	0.86	29.5	29.5	54	83.6
2107	457	111.2	0.89	30.2	30.2	96	126.7

*Top Principal Spillway Riser = 2101'; Invert Emergency Spillway = 2105'

**Principal Spillway Control Flow includes flow from the dewatering orifice.

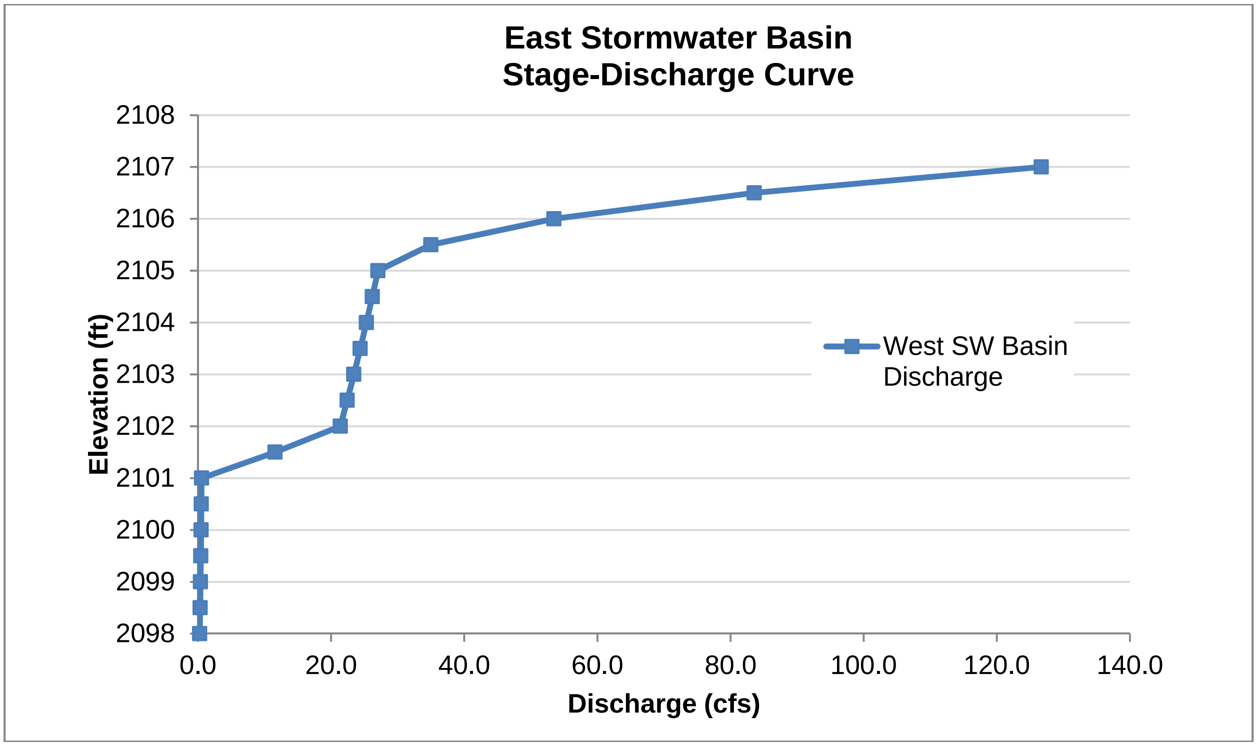


Figure 7: West Stormwater Basin Stage Discharge Curve

4.0 Outlet Hydrograph

The USACE HMS hydrology model was used to model the storage routing within the East and West Stormwater Basins. **Figure 8** shows the inflow and outflow hydrographs for the East Stormwater Basin. **Figure 9** shows the inflow and outflow hydrographs for the West Stormwater Basin. **Figure 10** shows the outflow hydrograph at the outfall of the project site. The peak flow from the project site for post-construction conditions is 12.1 cfs.

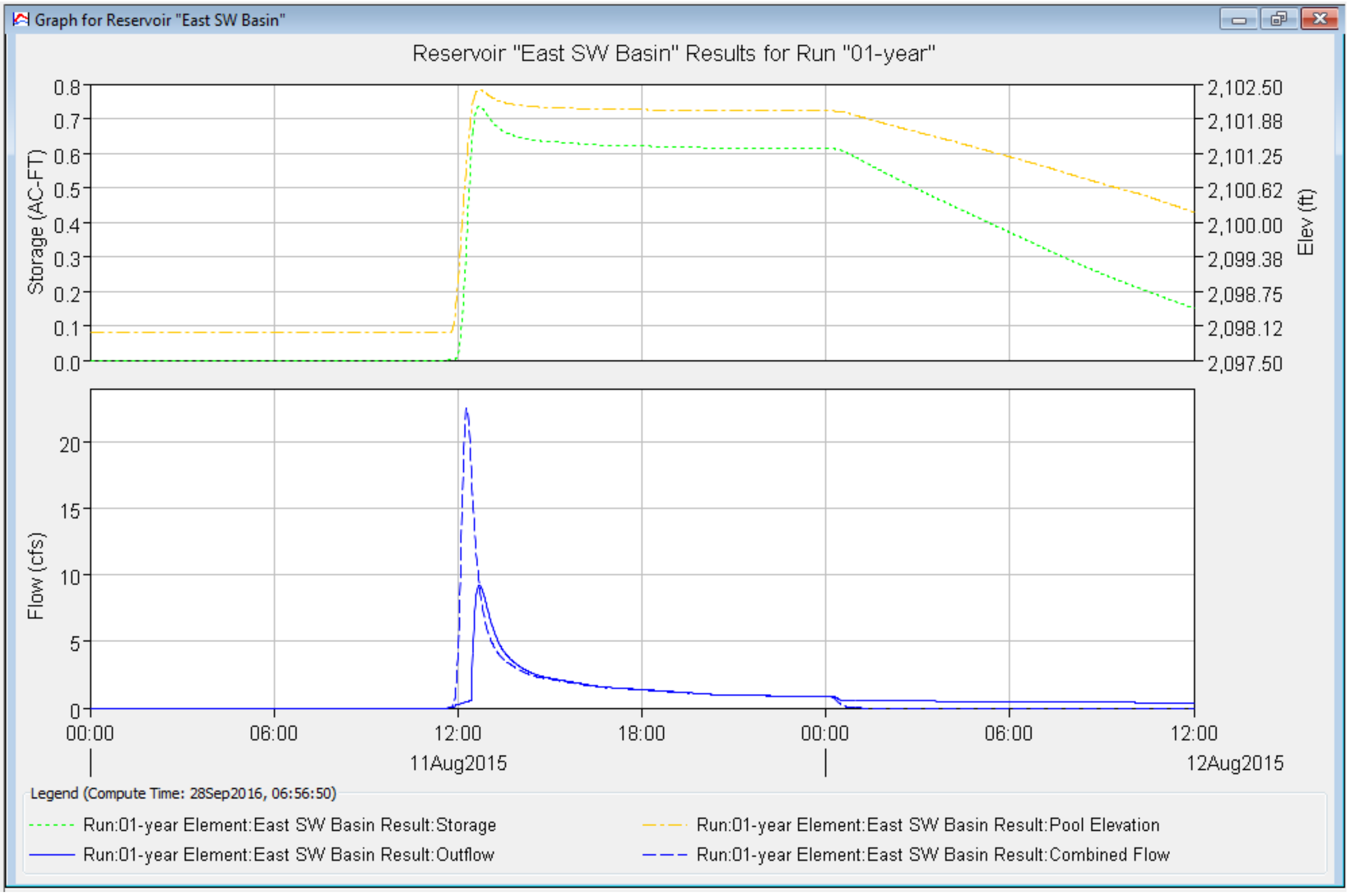


Figure 8: East Stormwater Basin Discharge Hydrograph

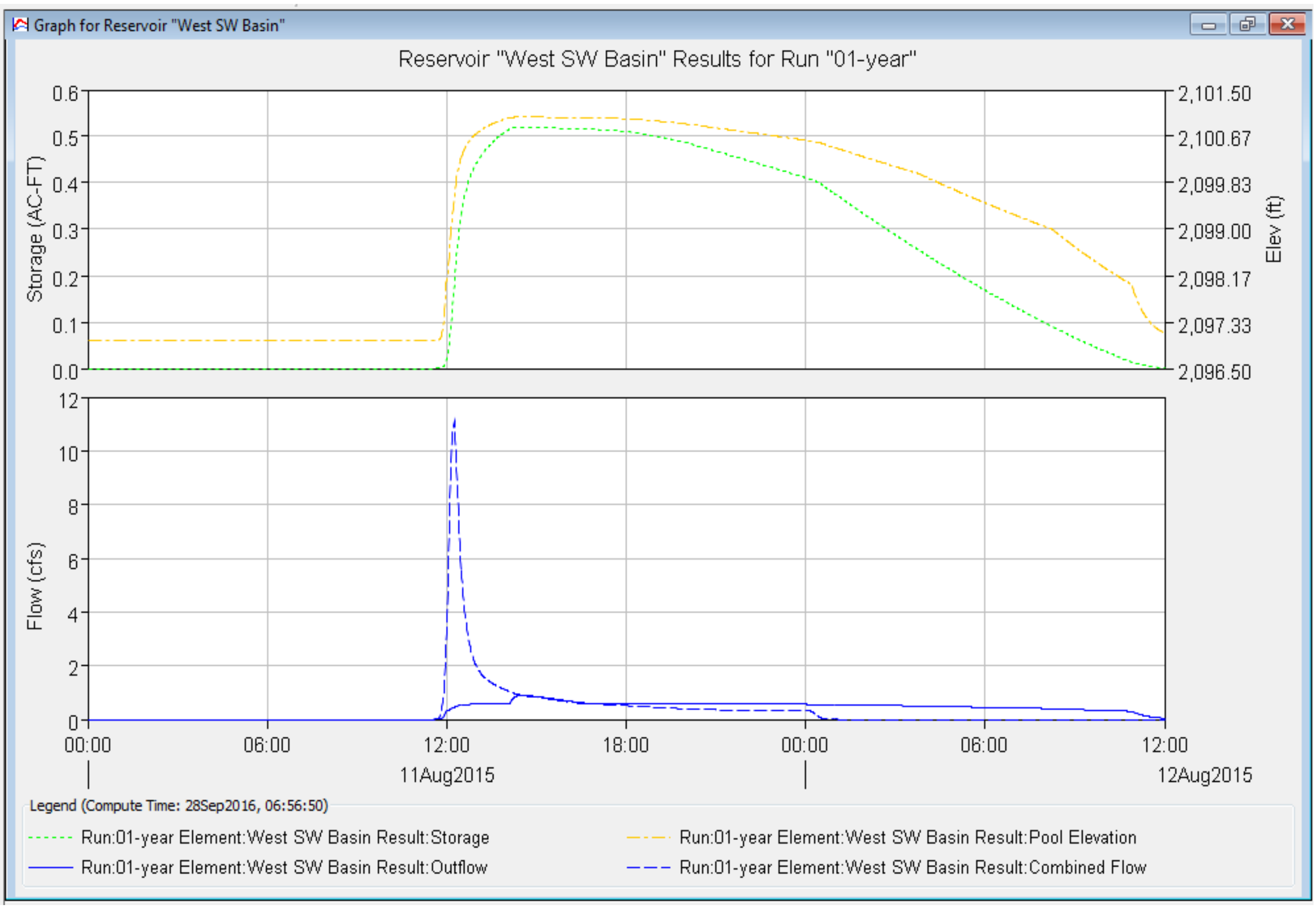


Figure 9: West Stormwater Basin Discharge Hydrograph

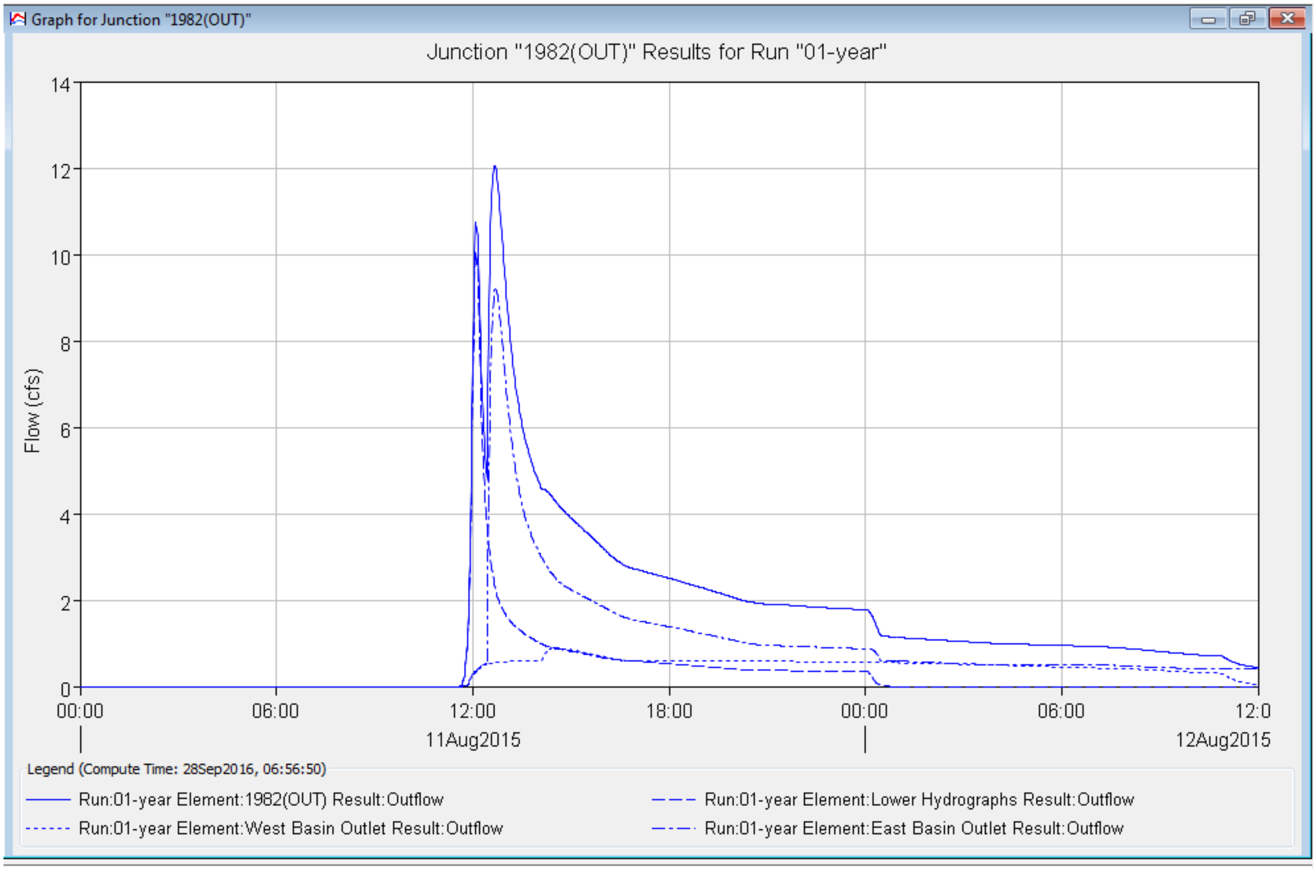


Figure 10: Project Outfall Hydrograph

5.0 Culverts

This section was developed by individuals from Burns & McDonnell in conjunction with Amec Foster Wheeler. Burns & McDonnell is the sole responsible party for information provided in this section.

Two proposed culverts will be placed within the site to convey drainage across the main site pad, as well as under the proposed access road. These culverts will be maintained by Duke Energy. The first culvert is a 48" HDPE pipe located under the aggregate road between the main site pad at elevation 2138' and the portion of the site at elevation 2150'. The second culvert is a 60" HDPE pipe located under the proposed asphalt access road and affiliated turnaround area.

Table 14: Post-Construction 1982 Basin with New Plant Grading - Culvert Calculation Summary

1982 Basin - Plant Grading Culvert Summary									
Pipe ID	Area (Ac)	Q100 (cfs)	Inlet HW (ft)	Slope (ft/ft)	Pipe Type	Critical Depth (ft)	Outlet Velocity (ft/s)	Flow Depth (ft)	Outlet Type
48"	12.9	28.38	2.4	0.005	HDPE	1.58	8.37	1.26	Class 1
60"	47.1	103.62	4.5	0.0075	HDPE	2.90	13.64	2.05	Class 2

Attachment 3b
Pre-1982 Dam
Runoff Calculations

Project Description

File Name	Pre-1982dam.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 27, 2016	00:00:00
End Analysis On	Sep 29, 2016	00:00:00
Start Reporting On	Sep 27, 2016	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:01:00	days hh:mm:ss
Routing Time Step	1	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	1
Nodes	1
Junctions	0
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	01-year	Time Series	01-year, 24-hour	Cumulative	inches					User Defined

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	Pre-1982dam	119.10	67.66	2.50	0.38	44.90	30.40	0 00:25:24

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft²)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	Pre-outfall	Outfall	2043.50					0.00	0.00					

Subbasin Hydrology

Subbasin : Pre-1982dam

Input Data

Area (ac)	119.10
Weighted Curve Number	67.66
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Urban industrial, 72% imp	8.80	C	91.00
1/2 acre lots, 25% impervious	5.40	B	70.00
Pasture, grassland, or range, Fair	56.00	B	69.00
Woods & grass combination, Fair	16.30	B	65.00
Woods, Fair	32.60	B	60.00
Composite Area & Weighted CN	119.10		67.66

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.4	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	5.3	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.11	0.00	0.00
Computed Flow Time (min) :	15.02	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1200	0.00	0.00
Slope (%) :	5.3	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	3.71	0.00	0.00
Computed Flow Time (min) :	5.39	0.00	0.00

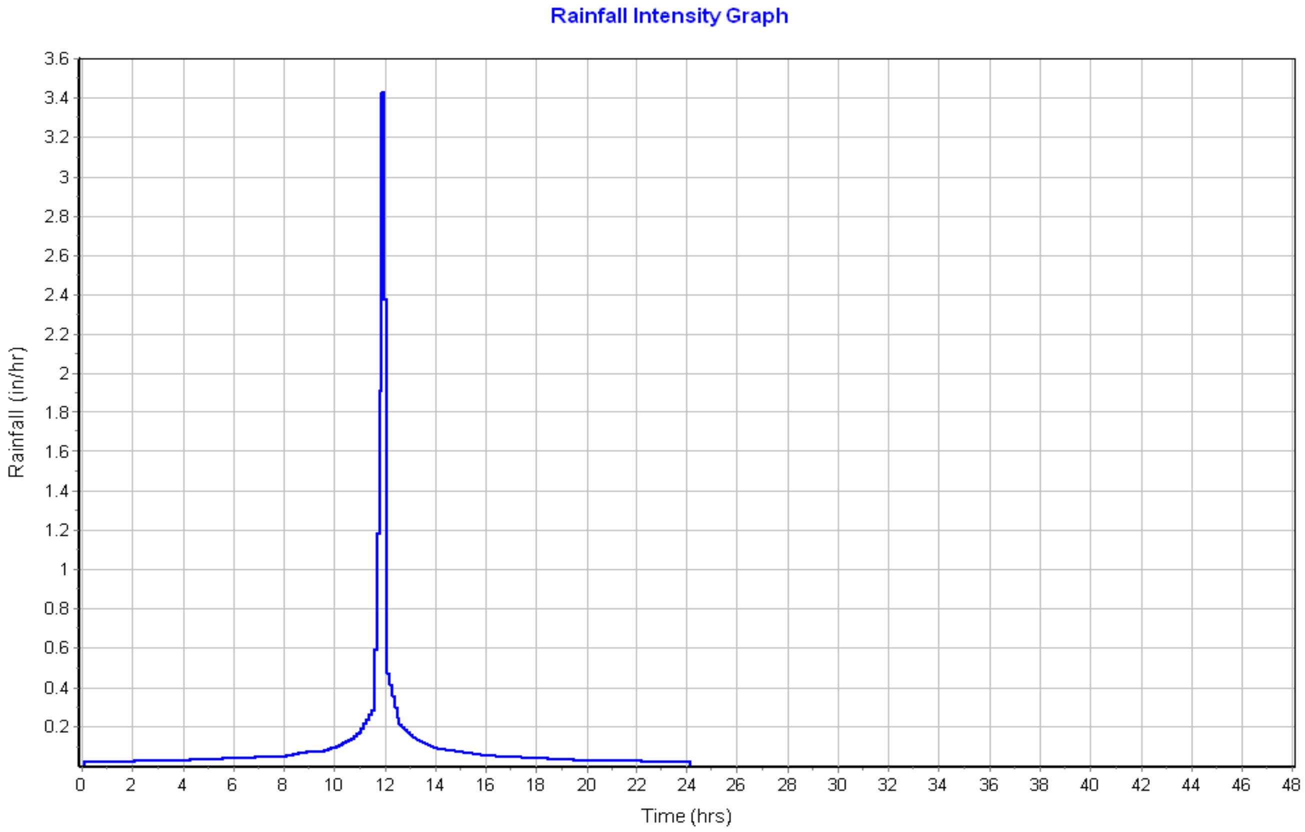
Channel Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.045	0.00	0.00
Flow Length (ft) :	1922	0.00	0.00
Channel Slope (%) :	5.3	0.00	0.00
Cross Section Area (ft²) :	7.506	0.00	0.00
Wetted Perimeter (ft) :	9.721	0.00	0.00
Velocity (ft/sec) :	6.42	0.00	0.00
Computed Flow Time (min) :	4.99	0.00	0.00

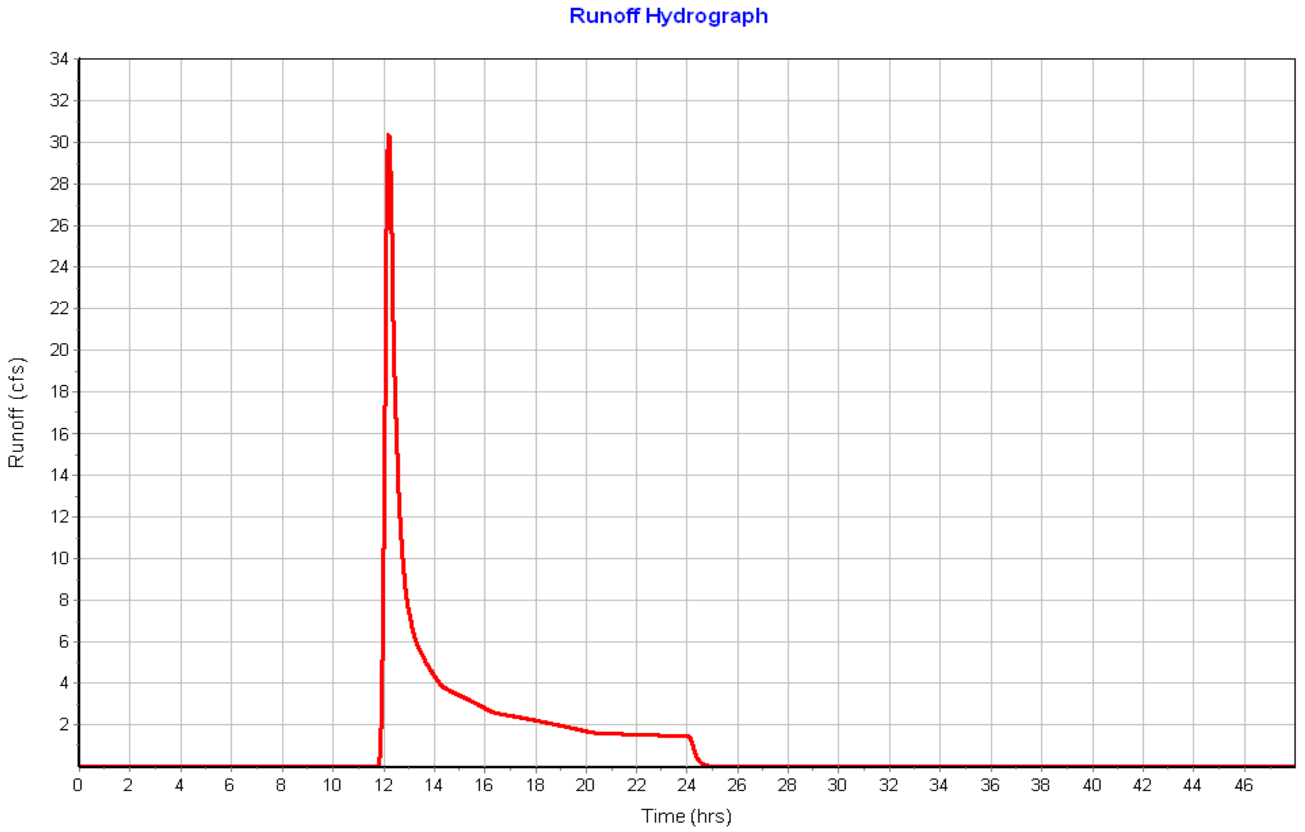
Total TOC (min) 25.40

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.38
Peak Runoff (cfs)	30.40
Weighted Curve Number	67.66
Time of Concentration (days hh:mm:ss)	0 00:25:24

Subbasin : Pre-1982dam





Attachment 3c
Post-1982 Dam
Runoff Calculations

Project Description

File Name	Post-1982dam.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Hydrodynamic
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Sep 27, 2016	00:00:00
End Analysis On	Sep 29, 2016	00:00:00
Start Reporting On	Sep 27, 2016	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	1	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	6
Nodes	4
Junctions	3
Outfalls	1
Flow Diversions	0
Inlets	0
Storage Nodes	0
Links	0
Channels	0
Pipes	0
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	01-year	Time Series	01-year, 24-hour	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	East_1	31.30	70.15	2.50	0.46	14.43	10.64	0 00:26:24
2	East_2	29.10	72.61	2.50	0.55	16.06	12.32	0 00:28:06
3	East_lower	5.90	74.00	2.50	0.61	3.59	4.52	0 00:11:10
4	Lower	15.51	65.00	2.50	0.30	4.61	3.13	0 00:19:43
5	West	20.40	74.00	2.50	0.61	12.40	11.24	0 00:22:48
6	West_lower	5.40	74.00	2.50	0.61	3.28	4.48	0 00:07:06

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Surcharge Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
4	I26	Outfall	2043.50	2108.00	0.00	0.00	0.00	0.00	0.00					
2	Lower_out	Junction	2043.50	2052.60	0.00	0.00	0.00							
3	West_SWb	Junction	2097.00	2108.00	0.00	0.00	0.00							

Subbasin Hydrology

Subbasin : East_1

Input Data

Area (ac)	31.30
Weighted Curve Number	70.15
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	11.20	C	74.00
Woods & grass combination, Fair	20.10	B	68.00
Composite Area & Weighted CN	31.30		70.15

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.4	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	7	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.12	0.00	0.00
Computed Flow Time (min) :	13.44	0.00	0.00

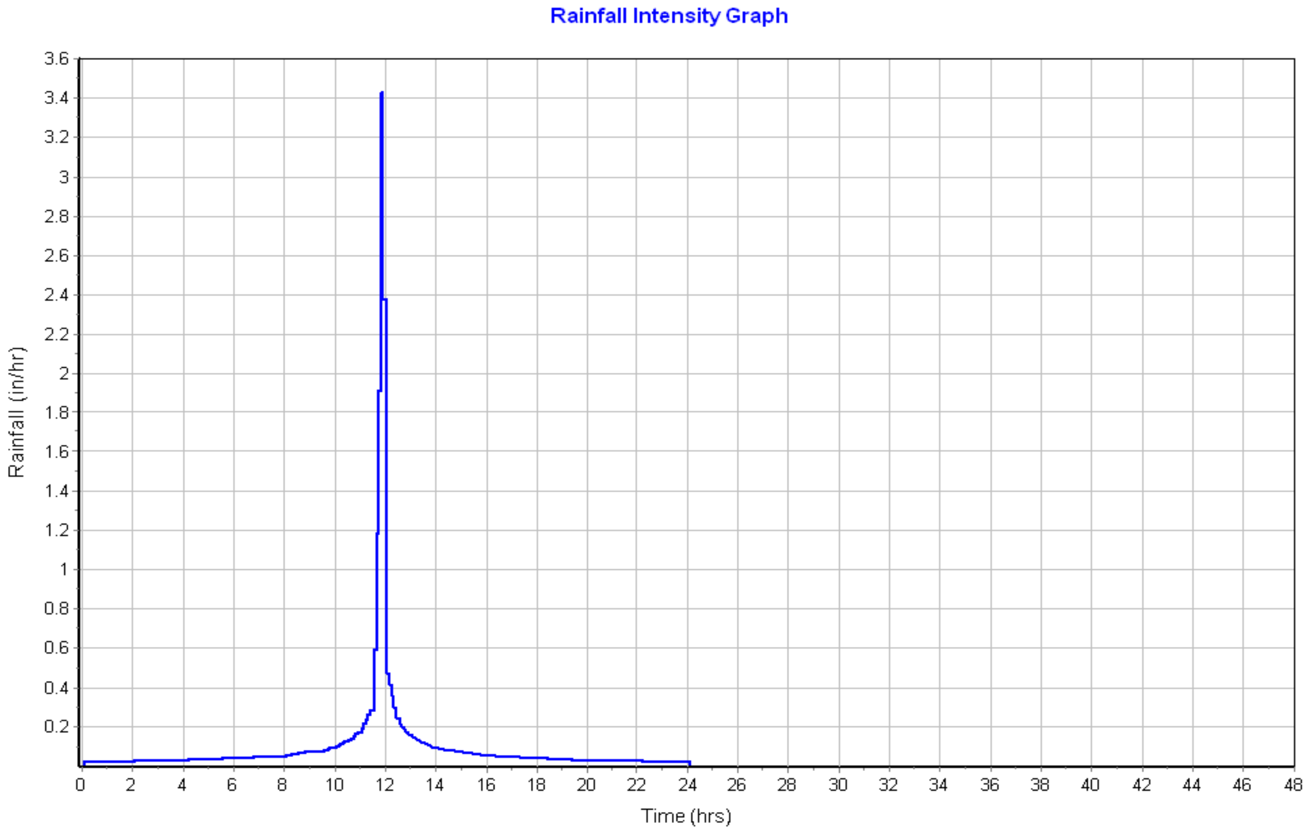
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1588	548	0.00
Slope (%) :	7	0.7	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.27	1.35	0.00
Computed Flow Time (min) :	6.20	6.77	0.00

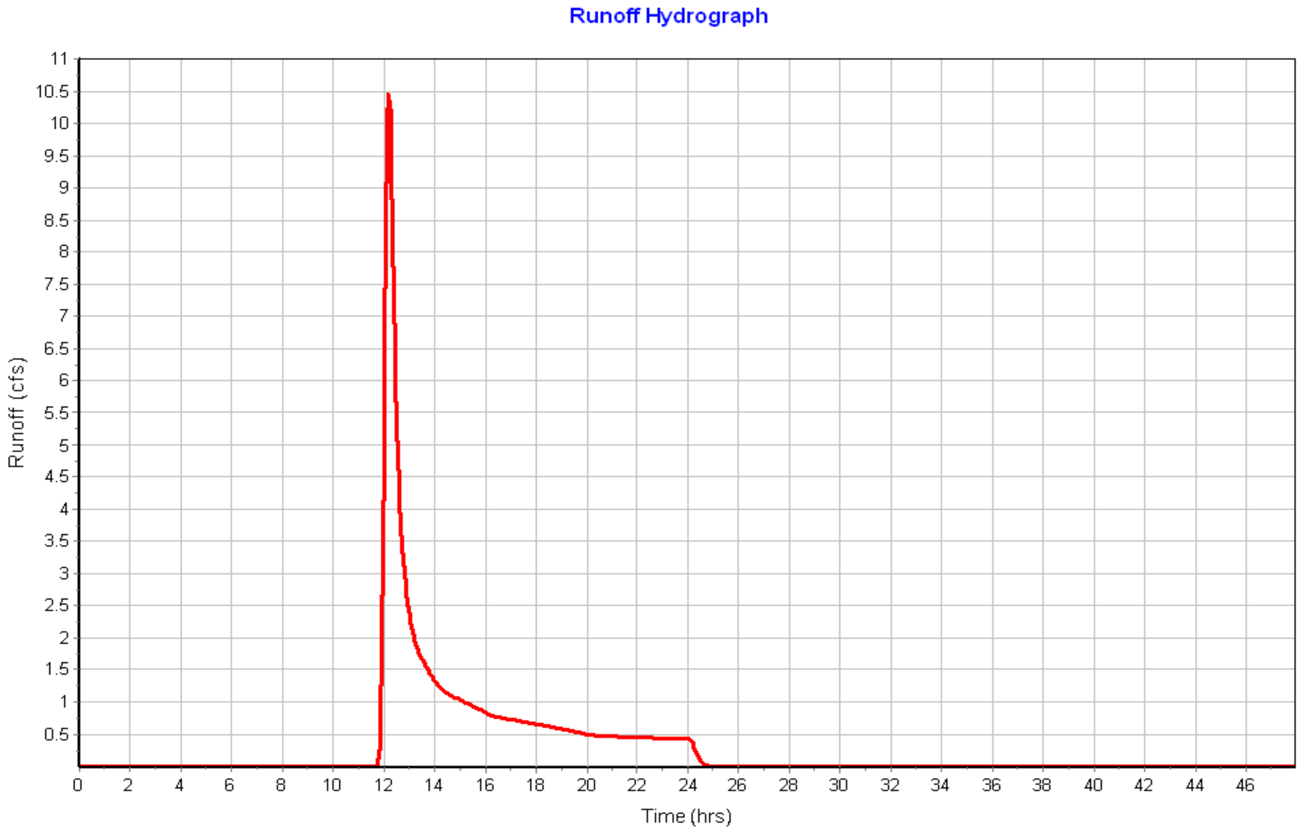
Total TOC (min) 26.40

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.46
Peak Runoff (cfs)	10.64
Weighted Curve Number	70.15
Time of Concentration (days hh:mm:ss)	0 00:26:24

Subbasin : East_1





Subbasin : East_2

Input Data

Area (ac)	29.10
Weighted Curve Number	72.61
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	19.00	C	74.00
Woods & grass combination, Fair	10.10	B	70.00
Composite Area & Weighted CN	29.10		72.61

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.40	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	7.2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.13	0.00	0.00
Computed Flow Time (min) :	13.29	0.00	0.00

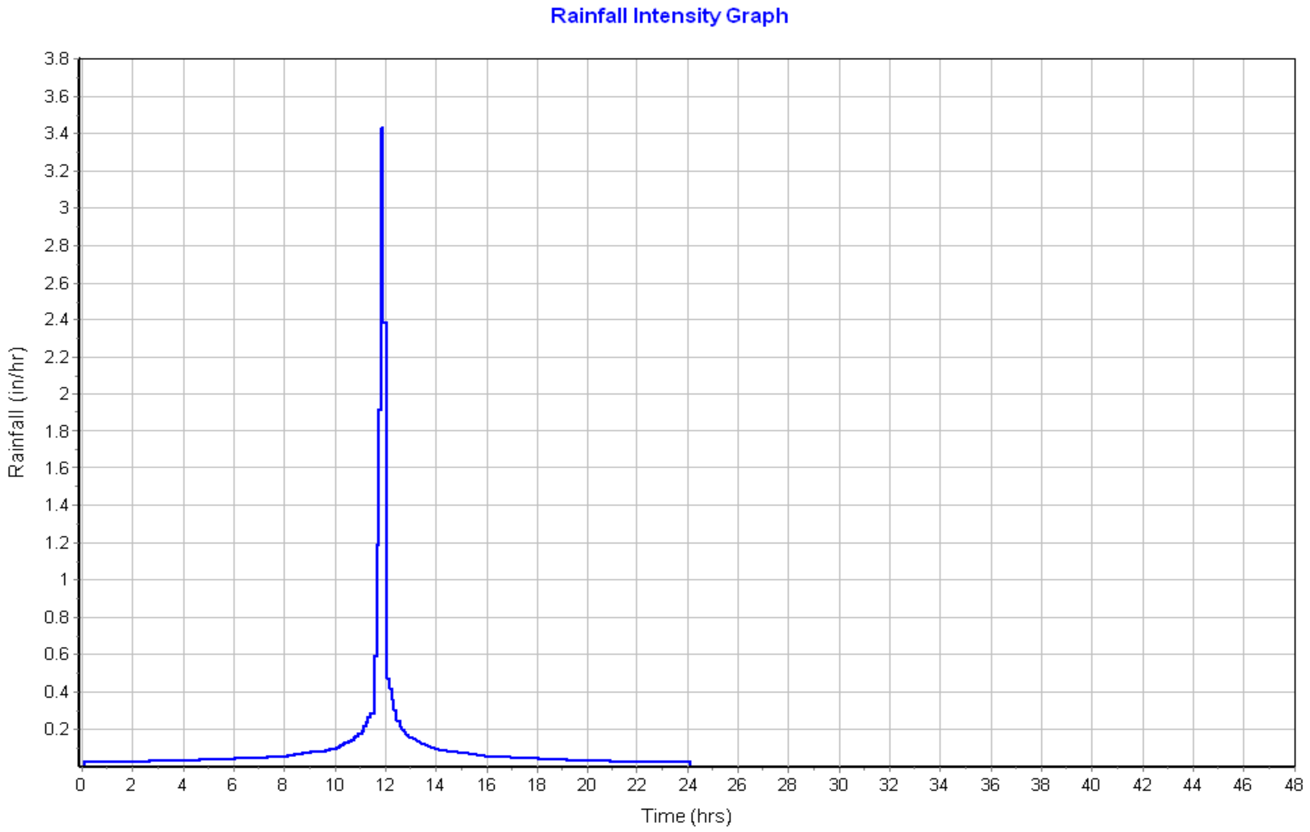
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1018	1158	0.00
Slope (%) :	7.2	1.2	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.33	1.77	0.00
Computed Flow Time (min) :	3.92	10.90	0.00

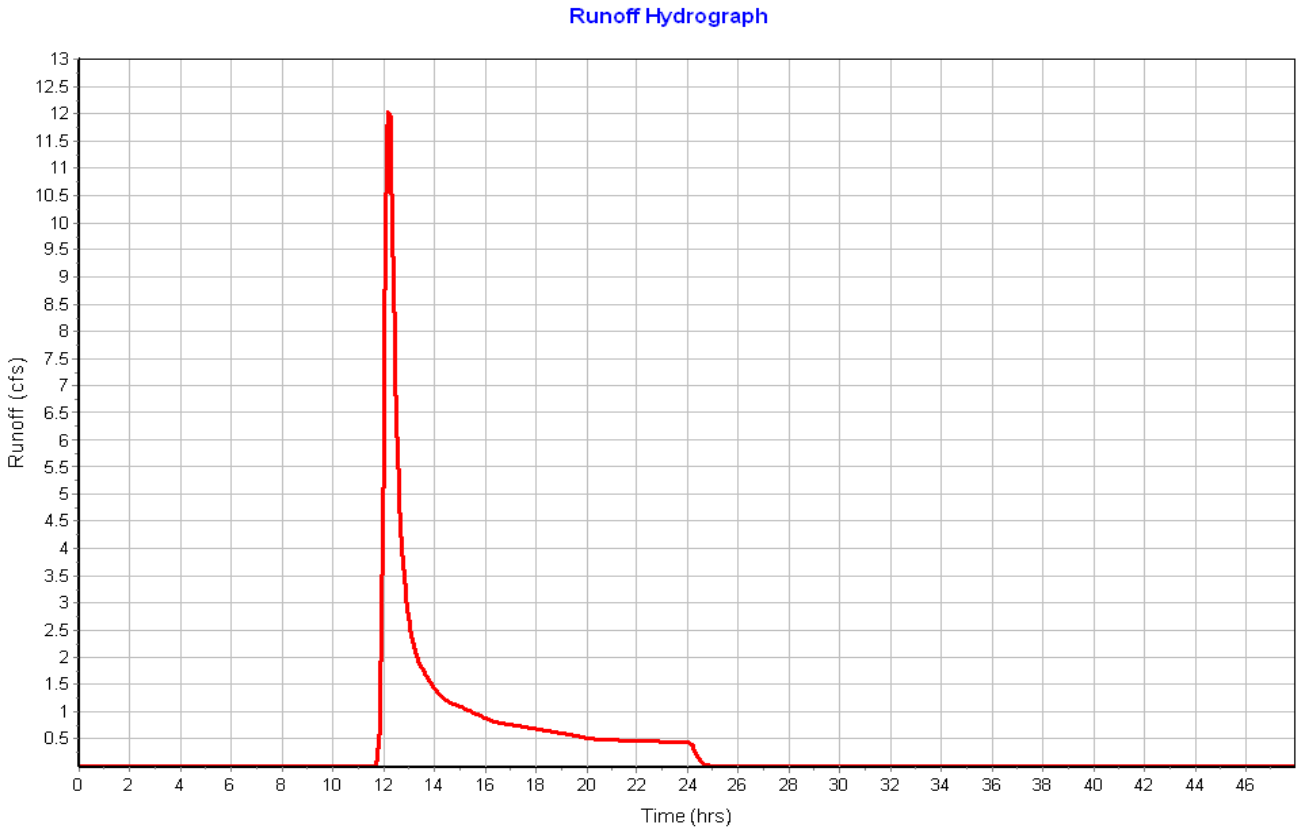
Total TOC (min) 28.11

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.55
Peak Runoff (cfs)	12.32
Weighted Curve Number	72.61
Time of Concentration (days hh:mm:ss)	0 00:28:07

Subbasin : East_2





Subbasin : East_lower

Input Data

Area (ac)	5.90
Weighted Curve Number	74.00
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	5.90	C	74.00
Composite Area & Weighted CN	5.90		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.4	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	14.7	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	9.99	0.00	0.00

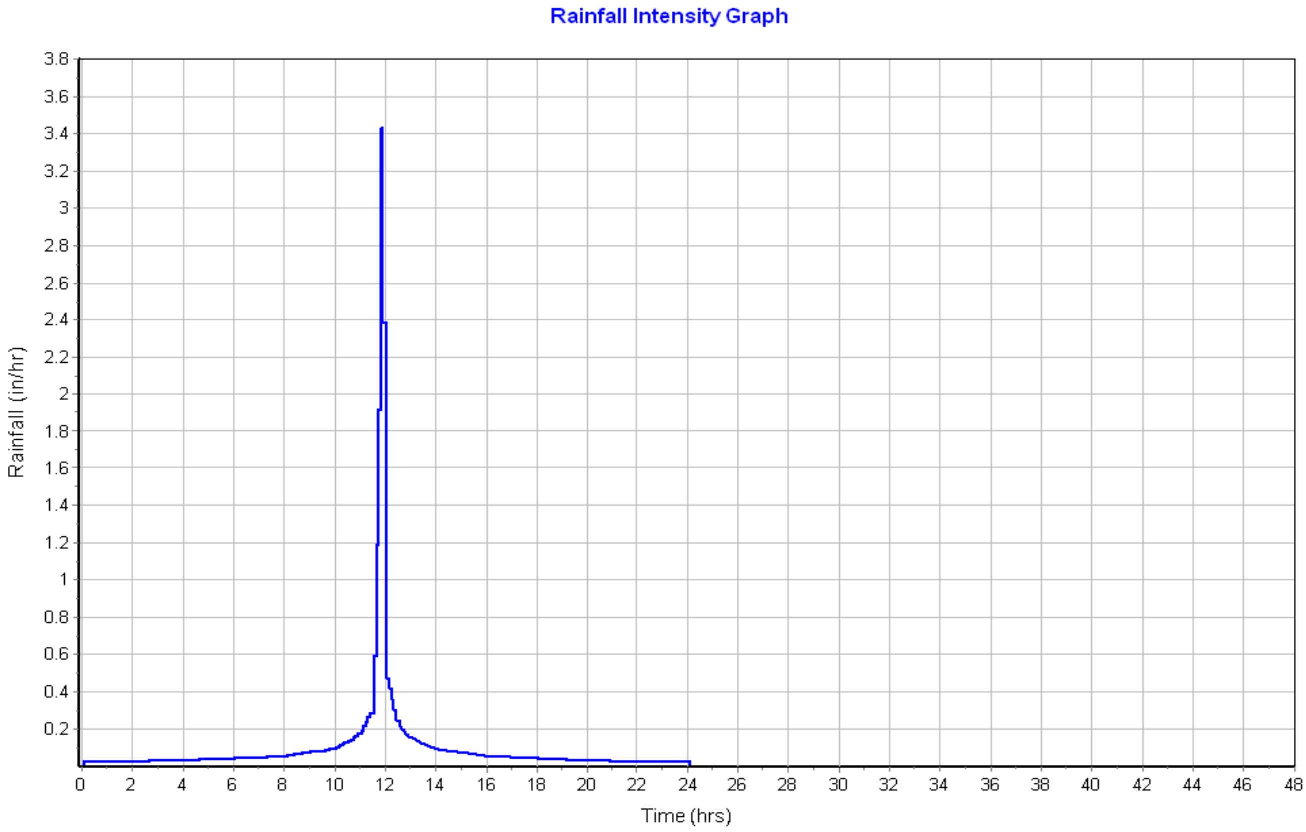
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	444	0.00	0.00
Slope (%) :	14.7	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	6.19	0.00	0.00
Computed Flow Time (min) :	1.20	0.00	0.00

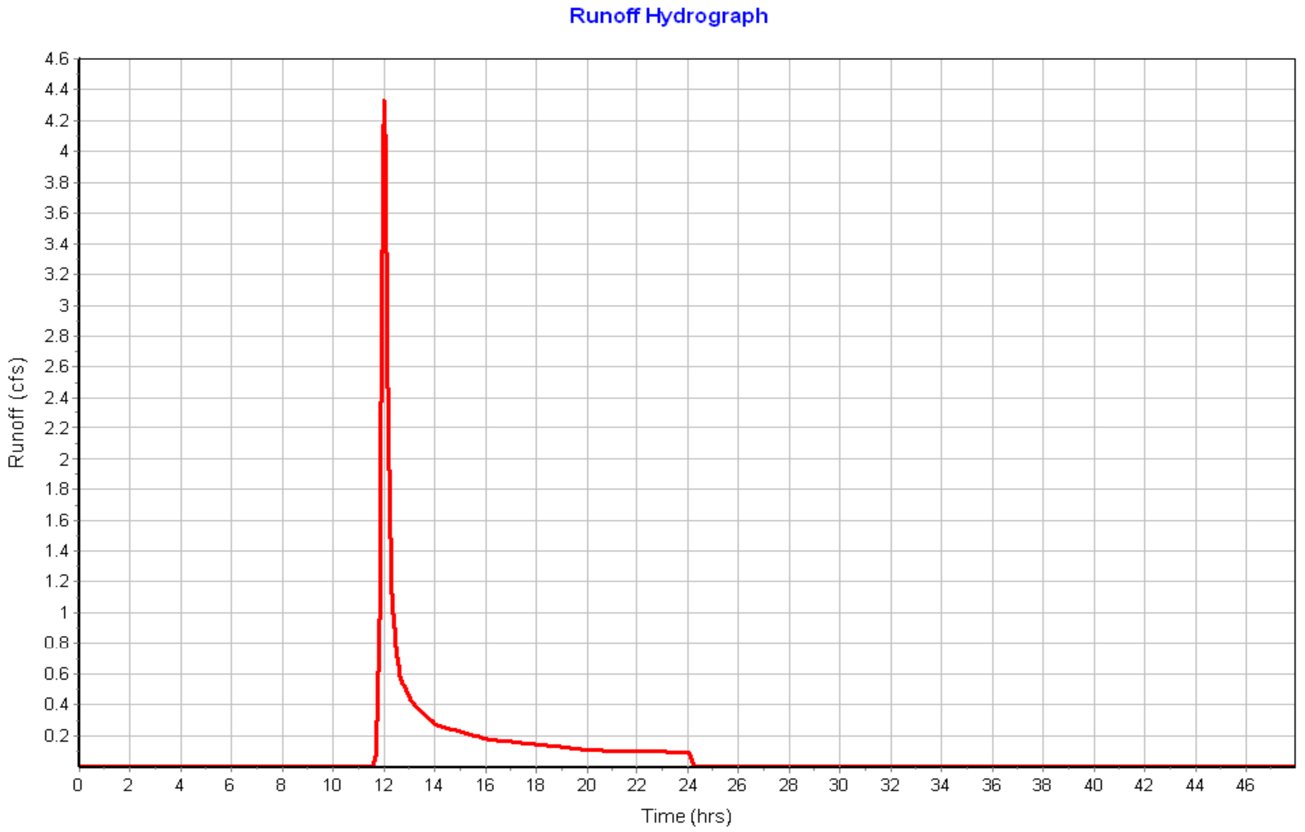
Total TOC (min) 11.18

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.61
Peak Runoff (cfs)	4.52
Weighted Curve Number	74.00
Time of Concentration (days hh:mm:ss)	0 00:11:11

Subbasin : East_lower





Subbasin : Lower

Input Data

Area (ac)	15.51
Weighted Curve Number	65.00
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Woods & grass combination, Fair	15.51	B	65.00
Composite Area & Weighted CN	15.51		65.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.8	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	13.8	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.09	0.00	0.00
Computed Flow Time (min) :	17.83	0.00	0.00

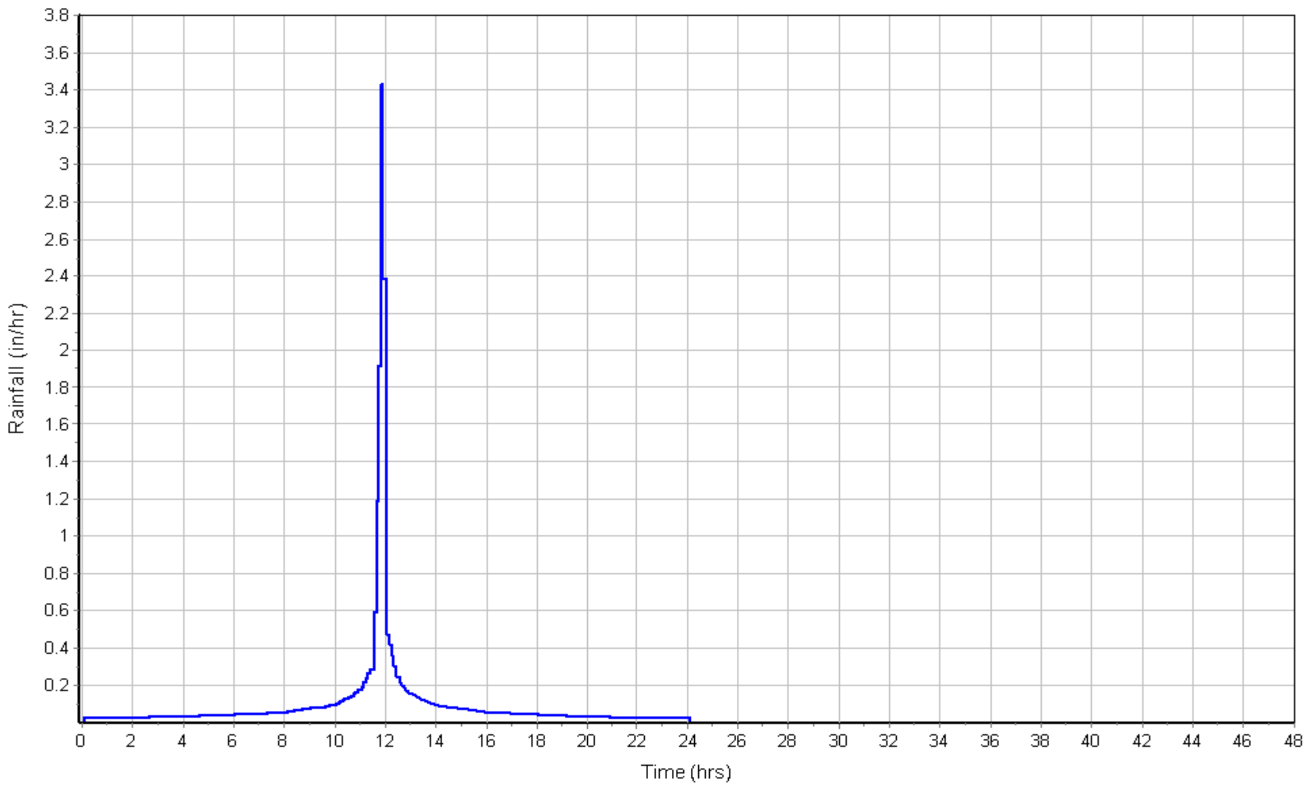
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	680	0.00	0.00
Slope (%) :	13.8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	5.99	0.00	0.00
Computed Flow Time (min) :	1.89	0.00	0.00

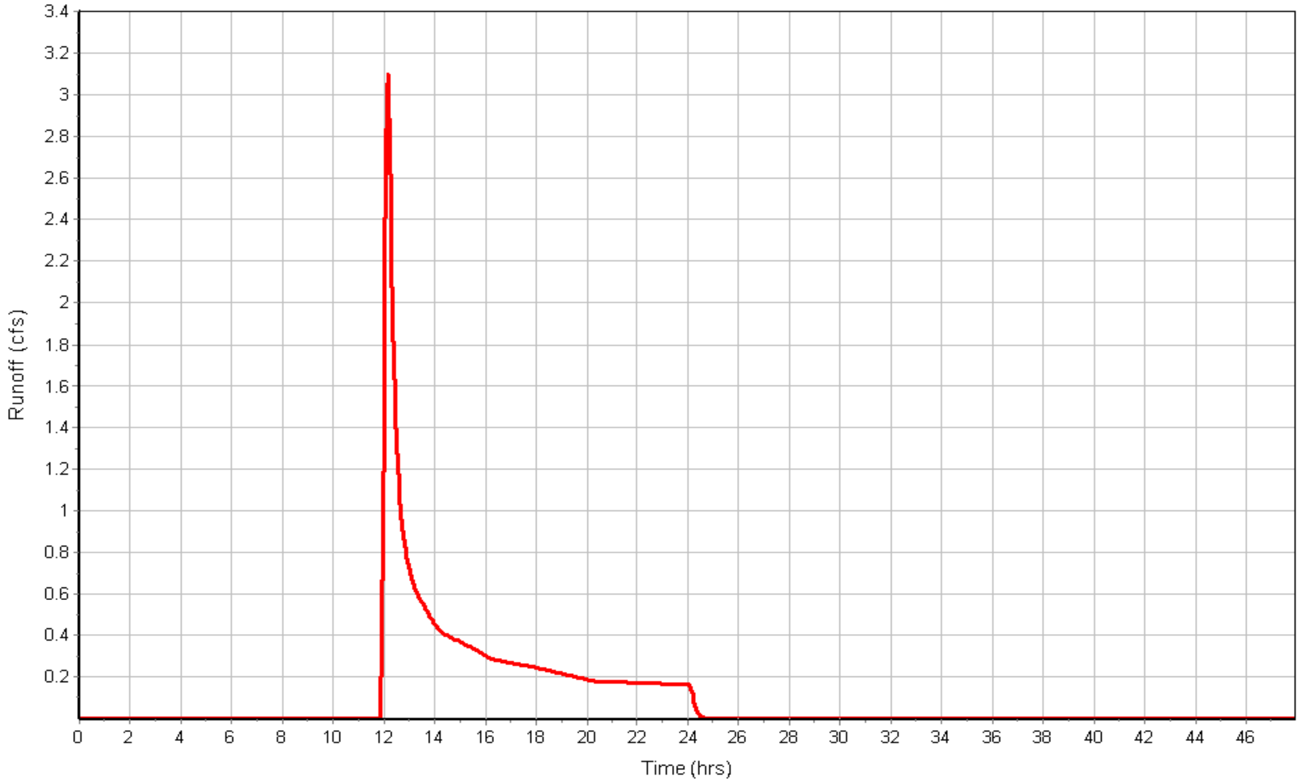
Total TOC (min) 19.72

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.30
Peak Runoff (cfs)	3.13
Weighted Curve Number	65.00
Time of Concentration (days hh:mm:ss)	0 00:19:43

Subbasin : Lower


Rainfall Intensity Graph


Runoff Hydrograph

Subbasin : West

Input Data

Area (ac) 20.40
Weighted Curve Number 74.00
Rain Gage ID 01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	20.40	C	74.00
Composite Area & Weighted CN	20.40		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.24	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	9.2	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.21	0.00	0.00
Computed Flow Time (min) :	8.00	0.00	0.00

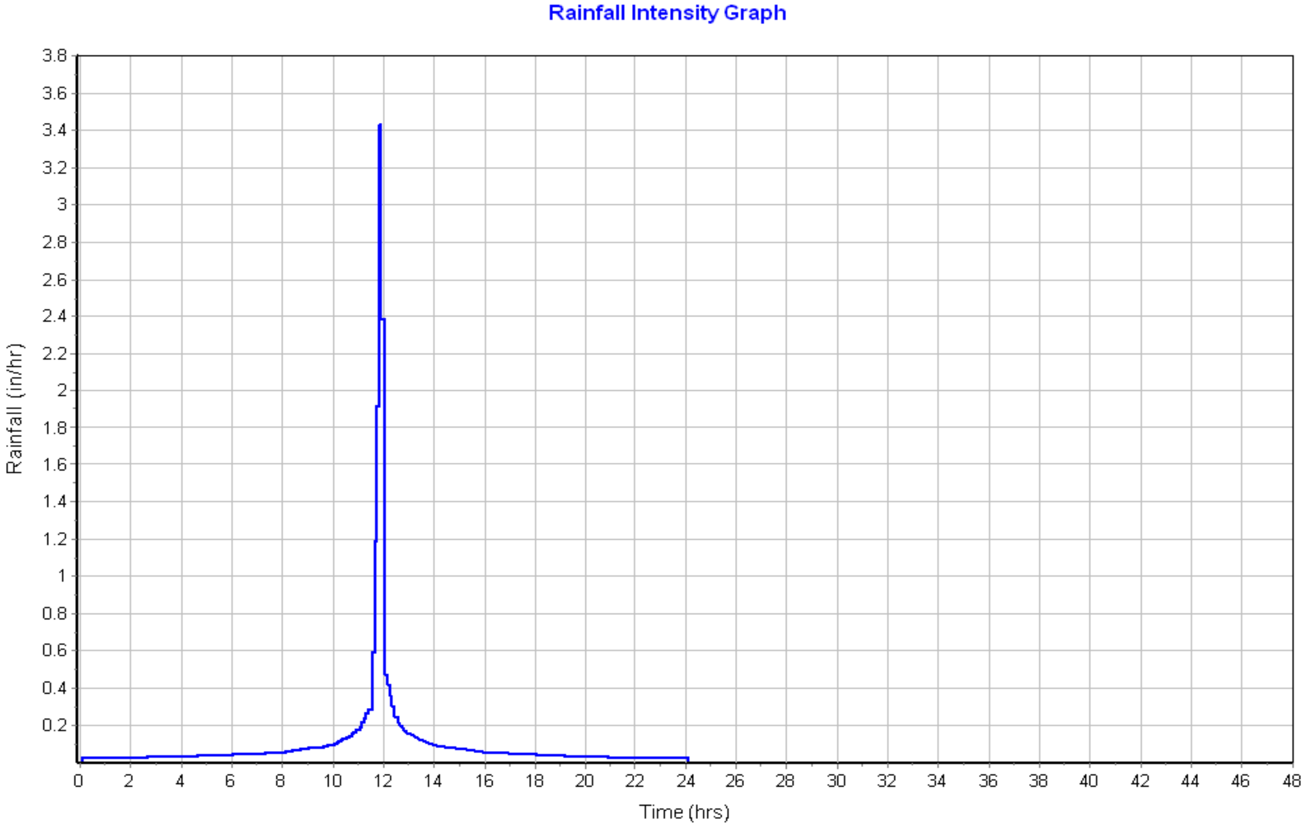
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	481	1271	0.00
Slope (%) :	9.2	1	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	4.89	1.61	0.00
Computed Flow Time (min) :	1.64	13.16	0.00

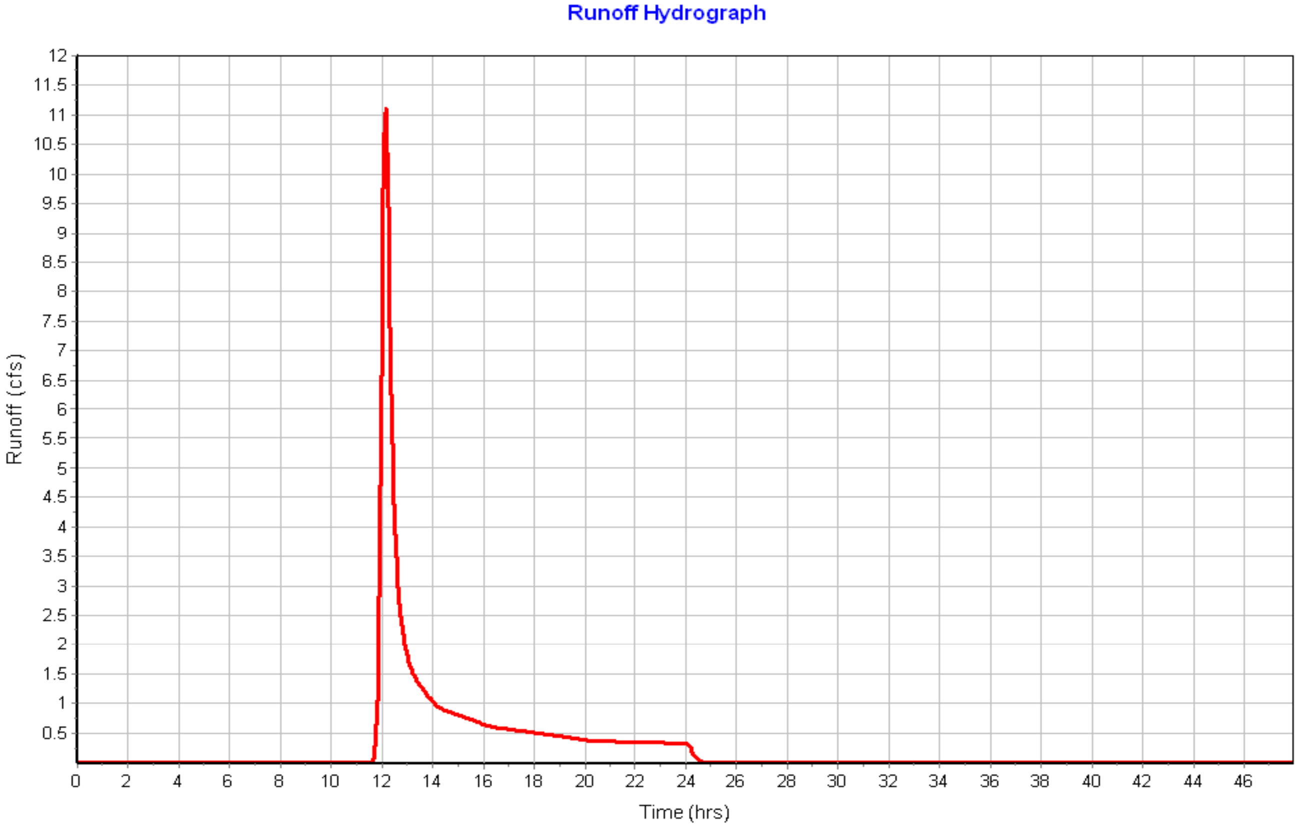
Total TOC (min) 22.80

Subbasin Runoff Results

Total Rainfall (in) 2.50
Total Runoff (in) 0.61
Peak Runoff (cfs) 11.24
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:22:48

Subbasin : West





Subbasin : West_lower

Input Data

Area (ac)	5.40
Weighted Curve Number	74.00
Rain Gage ID	01-year

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
> 75% grass cover, Good	5.40	C	74.00
Composite Area & Weighted CN	5.40		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.24	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	15.8	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3	0.00	0.00
Velocity (ft/sec) :	0.26	0.00	0.00
Computed Flow Time (min) :	6.45	0.00	0.00

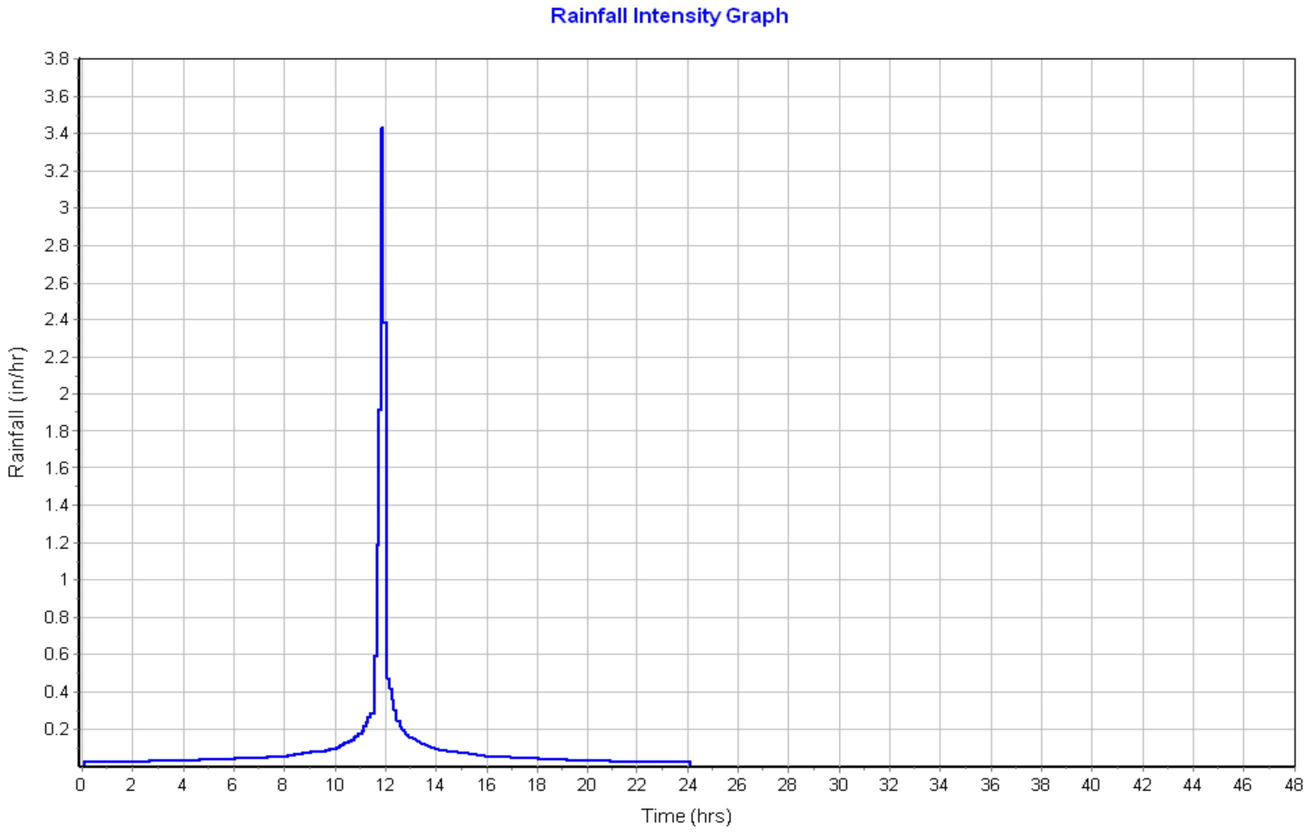
Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	254	0.00	0.00
Slope (%) :	15.8	0.00	0.00
Surface Type :	Unpaved	Unpaved	Unpaved
Velocity (ft/sec) :	6.41	0.00	0.00
Computed Flow Time (min) :	0.66	0.00	0.00

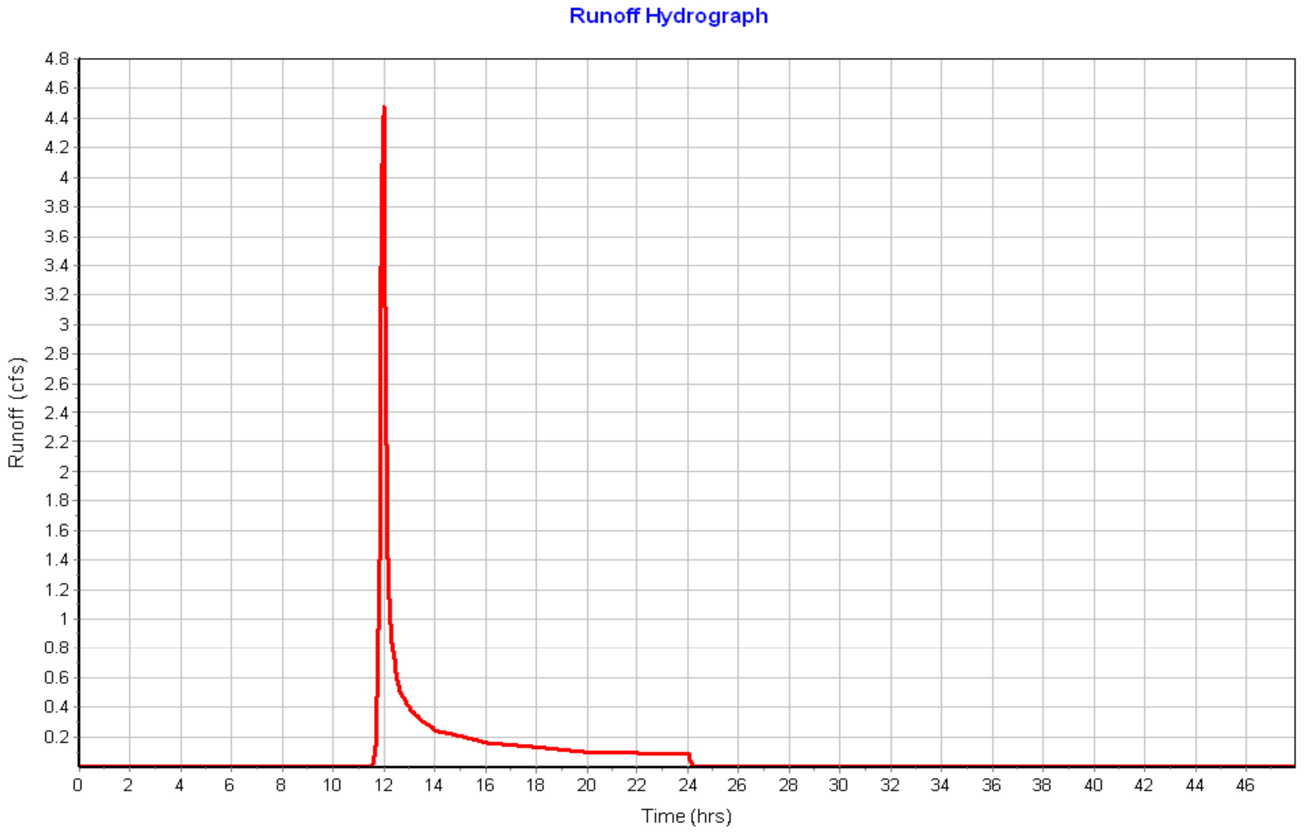
Total TOC (min) 7.11

Subbasin Runoff Results

Total Rainfall (in)	2.50
Total Runoff (in)	0.61
Peak Runoff (cfs)	4.48
Weighted Curve Number	74.00
Time of Concentration (days hh:mm:ss)	0 00:07:07

Subbasin : West_lower





Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (in)
1	East_SWbasin2	2098.00	2108.00	10.00	0.00	-2098.00	0.00	-2108.00	0.00	0.00
2	Lower_out	2043.50	2052.60	9.10	0.00	-2043.50	0.00	-2052.60	0.00	0.00
3	West_SWbasin	2097.00	2108.00	11.00	0.00	-2097.00	0.00	-2108.00	0.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	East_SWbasin2												
2	Lower_out												
3	West_SWbasin												

APPENDIX G: POST-CLOSURE OPERATIONS MAINTENANCE AND MONITORING PLAN

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POST-CLOSURE OPERATIONS MAINTENANCE AND MONITORING (OM&M) PLAN

ASHEVILLE 1982 AND 1964 ASH BASINS

DUKE ENERGY – ASHEVILLE STEAM ELECTRIC GENERATING PLANT, ARDEN, NORTH CAROLINA

REVISION 0

Prepared for

DUKE ENERGY

Duke Energy
550 South Tryon Street
Charlotte, North Carolina 28202

December 2016

amec
foster
wheeler

TABLE OF CONTENTS

List of Appendices

Appendix I	Example Post-Closure Monitoring Form

1. INTRODUCTION

This Post-Closure Operations Maintenance and Monitoring (OM&M) Plan is being submitted as part of the Asheville Steam Electric Generating Plant (Plant) Site Analysis and Removal Plan (Removal Plan), which has been prepared to address removing coal combustion residuals (CCRs) from the site and to comply with the regulatory requirements of the Federal CCR Rule §257.102(b)(1)(i-vi) and the North Carolina Coal Ash Management Act (CAMA) for closure of ash basins / surface impoundments. The information contained in this plan will be used to assist Duke Energy Progress, LLC (Duke) in the closure of inactive coal ash impoundments and the maintenance and monitoring required during the post-closure care period.

1.1 Project Information

Duke intends to decommission and remove the 1964 and 1982 Ash Basins on the property of the Plant. The primary objective of the Removal Plan is to set out the process for closing the 1982 and 1964 Ash Basins at the Plant in accordance with the requirements of CAMA and the CCR Rule. Excavation of the 1982 Ash Basin was completed on September 30, 2016. The 1982 Ash Basin was then turned over for dam decommissioning and construction of a natural gas combined cycle plant.

The CCR materials will also be excavated from the 1964 Ash Basin and removed from the site. The closure design of the 1964 Ash Basin is planned to include a balanced breach, in which the impoundment will be excavated to a design elevation. The basin will be backfilled to promote drainage, resulting in a non-impounding structure. The backfill will also be graded in a way to allow stormwater flows from the basin to pass through an existing culvert under I-26. The final long term disposition of the 1964 Ash Basin is still under evaluation.

2. DESCRIPTION OF CLOSURE COMPONENTS

Decommissioning of the CCR facilities at the Plant includes breaching the 1982 Ash Basin Dam (State ID BUNCO-089) and the 1964 Ash Basin Dam (State ID BUNCO-097). Soil removed from the dams during excavation and grading activities will be stockpiled and, if suitable, used as fill material to achieve final grades within the excavation limits of the former CCR facilities. The proposed closure components are described in the following sections of this report.

The various components to be used for the closure of the CCR facilities will consist of the following:

- Compacted fill (including soil materials excavated from onsite) placed on subgrades
- Geotextiles placed according to decommissioning plan specifications
- Riprap and aggregate placed according to decommissioning plan specifications
- Final soil layer placed on final grades

- Vegetative ground cover including seed, mulch and soil amendments applied to prepared soil surfaces on final grades

A temporary soil layer and vegetation will be installed and maintained during the construction work to manage erosion and sedimentation. Riprap and geotextiles will be utilized in temporary and permanent stormwater management structures. Aggregate will be utilized for site access and temporary haul roads during the construction work. Stormwater management structures will collect surface water runoff according to the decommissioning plan. The final ground cover for areas disturbed during the dam decommissioning and CCR removal activities will be vegetated and maintained with grasses.

2.1 Compacted Fill

Compacted fill to be used in the closure of the CCR facilities will be soil from excavation or grading activities. Soil materials used for compacted fill may classify as sand (SW, SP, SM, and SC), silt (ML), or clay (CL) under the unified soil classification system. Note that any fill classified as peat (PT), high plasticity silt or clay (MH or CH), or organic silt or clay (OL or OH) shall not be accepted as compacted fill for the project.

2.2 Geotextiles

Woven and non-woven geotextile fabrics to be used in the closure of the CCR facilities will consist of polypropylene material resistant to biological degradation and naturally occurring chemicals, alkalis, and acids. Applicable ASTM and AASHTO standards for geotextile properties as well as delivery, storage and handling requirements are provided in the specifications included with the decommissioning plan.

2.3 Riprap and Aggregate

Riprap to be used in the closure of the CCR facilities at the Plant may consist of imported Class A, B, C and Class 1 and 2 rock from a commercial quarry meeting the requirements of Section 1042 RIP RAP Materials in the NCDOT “Standard Specifications for Roads and Structures,” 2012 Edition and additional requirements provided in the specifications included with the decommissioning plan for riprap. Note that demolished concrete shall not be accepted as imported riprap for the project.

2.4 Final Soil Layer

The final soil layer to be used in the closure of the CCR facilities at the Plant will consist of topsoil or soil appropriately amended to support vegetation growth. The topsoil shall be spread 3 inches thick on final grades prior to application of seed, mulch and soil amendments and will be capable of sustaining vegetation to prevent erosion.

Soil preparation will be implemented according to the procedures included in the technical specification of the decommissioning plan. Finished grade surfaces will be prepared to promote positive drainage and support either a grass vegetative cover or future construction projects.

2.5 Vegetative Ground Cover

The vegetative ground cover to be used in the closure of the CCR facilities will consist of permanent and temporary seed mixes, nurse crops, mulch, and soil amendments. Unless directly superseded by the plans and specifications, preparation of subgrade and seeding shall be performed in accordance with the requirements of the North Carolina Department of Environmental Quality (NCDEQ) "Erosion and Sediment Control Planning and Design Manual" dated May 2013, or latest revision. Prior to seeding, soil surfaces receiving seed shall be scarified to a depth of two to four inches to aid seed germination and reduce loss of seed during stormwater runoff events. However, the vegetative soil layer will not be subjected to compaction requirements.

2.6 Stormwater Management System

The proposed closure of the CCR facilities is designed with a network of stormwater conveyances accounting for ash basin dam decommissioning, CCR removal and final closure conditions. Stormwater that does not come in contact with CCR materials during the closure will be treated as non-contact water. Non-contact water will be managed separately from water within the Ash Basins or that contacts CCR materials. Non-contact water may be used for dust control or other operational purposes during construction.

Upon final closure, stormwater will be directed across either vegetated finished grades or future construction projects and into riprap channels before discharging into stormwater culverts and/or wetland areas that ultimately discharge to the French Broad River. Final grading plans and details illustrating the stormwater management system are provided in the decommissioning plan drawings.

3. POST-CLOSURE OPERATIONS MAINTENANCE AND MONITORING PLAN

The Post-Closure OM&M Plan outlines the operations, monitoring, and maintenance activities required to be performed during the post-closure care period. During the post-closure period, the re-graded and vegetated areas of the former CCR facilities at the Plant will be monitored and maintained to sustain their integrity and effectiveness until permanent vegetation is established.

3.1 Monitoring Activities

Post-closure monitoring events will be conducted quarterly for the first two years and semi-annually thereafter until permanent vegetation is established on the former CCR facilities area, where applicable. Post-closure monitoring will include a review of the following:

- The condition of site security features such as gates and/or fencing
- Evidence of erosion, settlement, ruts, burrows and/or other disturbances within the closure areas
- Type and quality of vegetation within the closure areas

- Evidence of erosion and integrity of stormwater conveyance features

Example forms that may be used to document the monitoring events are included in Appendix I. The proposed grading profiles and final grades showing the limits of disturbance and stormwater features are presented in the decommissioning plan. As-built drawings will be prepared after the dam breach and following completion of the final grades on the former CCR facilities. The as-built drawings will be used to assist with post-closure monitoring. Completed post-closure forms will be maintained in the facility operating record.

3.1.1 Groundwater Monitoring

Post-closure groundwater monitoring requirements will be established in the Groundwater Monitoring Plan, to be submitted under separate cover. The Comprehensive Site Assessment (CSA) Report (SynTerra 2015) provides an interim groundwater monitoring plan to bridge the gap between completion of CSA Report activities and implementation of the pending Groundwater Monitoring Plan and Corrective Action Plan (CAP).

The Interim Groundwater Monitoring Plan presented in Section 16.0 of the CSA will be superseded by the updated Interim Monitoring Plan (IMP), and a post-closure Effectiveness Monitoring Program (EMP) described in Section 9.0 of Part 2 of the CAP, if and when the proposed remedial actions are accepted as proposed in Part 2 of the CAP.

3.1.2 Surface Water Monitoring

Post-closure surface water monitoring will be consistent with the NPDES permit for wastewater discharges (Permit NC0000396) for the Plant. The discharge permits should be consulted for a detailed description of the parameters and frequency of surface water monitoring required at the site. Following completion of the closure activities at the Plant, wastewater and stormwater discharge NPDES permits will require modification to reflect the discontinuation of certain discharges. Specifically, flow from the ash basin and dewatering liquids, as well as, several stormwater pipes and outfalls that will be removed during construction.

3.1.3 Reporting

In addition to the forms, reporting, and record keeping that will be done as part of the groundwater and surface water monitoring plans, the various notifications, reports, plans, and amendments associated with closure and post-closure of the CCR facilities will be placed onto Duke’s CCR website.

3.1.4 Modifying Monitoring Requirements

A request can be made any time during the post-closure care period to reduce the requirements for groundwater monitoring provided that sufficient justification exists for the periodic reduction. The request will explain the reason for reducing monitoring with justification from state and federal CCR rules, and be submitted to NCDEQ for regulatory approval.

3.2 Maintenance Activities

Maintenance activities will be conducted as soon as practical to address items of concern identified during monitoring events. Maintenance activities will be performed at the frequencies defined herein and are anticipated to include the following:

- Localized placement of fill to prevent ponding of water caused by settlement, erosion, ruts, burrows and/or other disturbances
- Mowing vegetation
- Vegetative cover shall be amended and fertilized as needed to maintain healthy vegetation
- Repair of stormwater conveyance measures

3.2.1 Post-Closure Stormwater Maintenance

Post-closure operations of the former CCR facilities shall not cause the discharge of a non-point source of pollution to waters of the United States, including wetlands, that violates any requirements of an area-wide or statewide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

Drainage stormwater features (i.e., diversion ditches, berms, dissipaters, retention ponds, discharge pipes, etc.) will be inspected at a minimum twice per year, and within 24 hours of rainfall events of 0.5 inches or greater until permanent vegetation is established. Any signs of damage, settlement, clogging, silt buildup, or washouts will be documented during these inspections. If necessary, repairs to stormwater features will be made as soon as possible following detection of a problem. Any disturbed areas will be seeded and soil amendments applied as necessary to establish a healthy vegetative cover.

3.2.2 Post-Closure Erosion and Sediment Control Maintenance

Erosion and sediment control during post-closure operations of the former CCR facilities will consist of monitoring and repairing stormwater features and surface erosion as described above. It is anticipated that post-closure erosion control measures at the site will include:

- Minimizing ground disturbances to the extent possible while mowing and performing other maintenance
- Seeding and mulching of disturbed areas commencing as soon as practically possible
- Employing erosion control matting or seeding and mulch on slopes and other erosion prone areas
- Use of earthen berms, wattles, silt fences, riprap, or equivalent devices down gradient of disturbed areas, and at intervals along grassed waterways, until such time as permanent vegetation is established

- Maintaining an adequate vegetative ground cover with a suitable seed mix and soil amendments
- Placement of riprap at the inlets and outlets of stormwater pipes

Adequate erosion control measures will be provided to prevent sediment from leaving the site. Stormwater features and slopes within the former CCR facilities will be periodically checked for erosion and vegetative quality, fertilized, and mowed. Slopes will be observed for erosion, cracking, sliding, sloughing, and seepage. Slopes identified as needing maintenance will be repaired as soon as practical and as appropriate to correct deficiencies. Repair activities may include re-shaping the slope, filling in low areas, and/or seeding.

3.2.3 Post-Closure Vegetation Maintenance

Vegetation maintenance during post-closure operations of the former CCR facilities will consist of periodic mowing at a minimum twice per year and other maintenance activities as needed until permanent vegetation is established and, where necessary, to enable access to stormwater and groundwater monitoring features during the post-closure period.

Post-closure maintenance may also include applying temporary seeding and installation of temporary erosion controls as required until a permanent ground cover is established. Post-closure mulching may be used to stabilize areas where final grade has been reached and/or vegetation is inadequate. Soil mulch materials may include wood chips, straw, hay, jute matting, and synthetic fibers. Mulches allow for greater water retention, reduce runoff and improve soil moisture and temperature conditions. Mulch will also help retain seeds, fertilizer and lime when it is applied. Steeper slopes (3:1 horizontal to vertical or steeper) should be protected with erosion control matting.

Temporary and permanent seeding will be applied as specified in the current Duke Vegetation Maintenance Implementation Plan (VMIP) using prescribed seasonal seed mixes or over-seeding mixes. Alternatively, seeding may be applied in accordance with the NCDEQ “Erosion and Sediment Control Planning and Design Manual” dated May 2013, or latest revision. Typical seed mix applications for permanent seeding are as follows:

Table 3.1: Permanent Seeding	
Fall to Early Spring - September through April	
Species	*Pounds per Acre*
Kentucky 31 Tall Fescue *(Festuca arundinacea)*	100
Rye Grain *(Secale cereale)*	50
Spring to Summer - May through August	
Species	*Pounds per Acre*
German Millet *(Setaria italica)*	50

Post-closure application of soil amendments including fertilizer and lime may be required to establish or improve the vegetative ground cover pursuant to soil sampling and testing results. North Carolina Department of Agriculture soil test(s) may be conducted to assess soil nutrient requirements. Typical soil amendment applications for permanent seeding are as follows:

Table 3.2: Permanent Seeding Soil Amendments

Soil Amendment	Pounds per Acre
Agricultural limestone	4,000
Fertilizer (10-10-10)	1,000
Mulch (straw)	4,000

3.3 Facility Contact Information

Duke will be responsible for post-closure maintenance and monitoring. Correspondence regarding the Asheville Ash Basins should be directed to:

Duke Energy Progress, LLC

Asheville Steam Electric Generating Plant

200 CP&L Drive

Arden, North Carolina 28704

(704) 263-3200

Station Sponsor for Ash Basins Operations or Environmental Professional

The physical address of the Asheville Ash Basins is the same as above.

3.4 Post-Closure Planned Use

The CCR facilities at the Plant will be vegetated following closure, except for the areas within the 1982 Ash Basin that are to be impacted by subsequent construction of the proposed Combined Cycle Plant. Site access to the public will remain restricted through closure and the post-closure care periods. The final long term disposition of the 1964 Ash Basin has not been determined at this time. The short term disposition of the site will be grading the site to drain, establishing the vegetative cover and maintaining the site in an undeveloped state. Duke Energy will obtain approval from NCDEQ if a proposed post-closure use is identified.

3.5 Certification

Within 60 days following completion of the post-closure care period, a notification will be prepared that the post-closure care has been completed. The notification will include the certification of a qualified professional engineer verifying that the post-closure care has been completed in accordance with the Removal Plan and the OM&M Plan. The notification will be placed in the facility Operating Record.

Appendix I: EXAMPLE POST-CLOSURE MONITORING FORM

DUKE ENERGY®

Duke Energy - Asheville Ash Basin Closure
Post-Closure Monitoring Form

Date/Time: ______________________
Observation Personnel: ______________________
Weather/Temperature: ______________________

Question	No	Yes	If yes, location	Description	Corrective Actions Recommended	Date Corrected
Is there evidence of erosion, settlement, rutting, or potholes?						
Is there evidence of vegetative cover intrusion (ruts, burrows, excavation or other disturbance)?						
Is there evidence of stressed vegetation or bare spots?						
Is there evidence of erosion or sedimentation in stormwater channels, pipes, or other stormwater features?						
Is there evidence of regular maintenance not being performed?						
Is there evidence of human encroachment (trash, fire pits, tire/footprints)?						
General Notes:						

Bednarcik Exhibit 8
Asheville SARP Appendix E
Docket No. E-2 Sub.1219
Page 1 of 7

APPENDIX E: DAM DECOMMISSIONING AND ASH REMOVAL PLAN DRAWINGS FOR THE 1982 ASH BASIN

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DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN

ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

PREPARED FOR:

DUKE ENERGY PROGRESS, LLC

LOCATION MAP

2000 0 2000 4000 FT

VICINITY MAP

500 0 500 1000 FT

SHEET LIST	
SHEET NUMBER	SHEET TITLE
C-0.0	COVER SHEET
C-1.1	SITE AERIAL
C-1.2	EXISTING CONDITIONS / UTILITIES
C-1.3	POST ASH REMOVAL GRADES
C-1.4	FINAL GRADES
C-1.5	PROFILES
C-1.6	PROFILES & DETAILS
~~E-1.1~~	~~EPSC PLAN~~
~~E-1.2~~	~~EPSC TYPICAL DETAILS~~

*SUPERCEDED BY NEW EPSC SUBMITTAL

SEAL 041903
LUKE C. WILLIAMS
6/16/16

PERMIT SUBMITTAL

PRELIMINARY
NOT FOR CONSTRUCTION

1	16	06	16	ISSUED FOR PERMIT/UPDATE SHEET TABLE	MEW	LCW
0	14	01	16	ISSUED FOR PERMIT	MDB	LCW
REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

CLIENT:
DUKE ENERGY PROGRESS, LLC
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM: NAVD 88
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: LCW
SCALE: AS NOTED

PROJECT: DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE: COVER SHEET - COVER SHEET

PROJECT NO.: 7810150250
REVISION NO. 01
DATE: 06-16-2016
DRAWING NO. C-0.0

Plotted By:Watkins, Miles E Sheet Set:N/A Layout:COVER SHEET June 16, 2016 04:15:22pm P:\CADD\Projects\7810\7810150250 Asheville Pond\110% Design Package Pond 1982 & 1964 Closure\Final Drawings\Cover Sheet.dwg

Bednarcik Exhibit 8
Asheville SARP Appendix E
Docket No. E-2 Sub.1219
Page 3 of 7

NOTE:
1. PROPERTY BOUNDARY WAS OBTAINED FROM BUNCOMBE COUNTY GIS DATA.
2. AERIAL PHOTO DATED 10-18-2015 SOURCE BY GOOGLE EARTH PRO.
3. BORING LOCATIONS DETERMINED FROM COORDINATES INCLUDED ON DRILL LOGS.

LEGEND
— — — — ASH BASIN LIMITS (APPROXIMATE)
- - - - - COVE AREA
◆ BORE HOLE
——— - ——— PROPERTY BOUNDARY

PERMIT SUBMITTAL

PRELIMINARY
NOT FOR CONSTRUCTION

SEAL 041903
ENGINEER
LUKE C. WILLIAMS
Luke C. Williams
6/16/16

0	14	01	16	ISSUED FOR PERMIT	MDB	LCW
REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

CLIENT:
DUKE ENERGY PROGRESS, LLC
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM: NAVD 88
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: LCW
SCALE: AS NOTED

PROJECT: DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE: SITE AERIAL

PROJECT NO.: 7810150250
REVISION NO. NA
DATE: 01-14-2016
DRAWING NO. C-1.1

Plotted By: Watkins, Miles E Sheet Set:N/A Layout:SITE AERIAL June 16, 2016 04:15:33pm P:\CADD\Projects\7810\7810150250 Asheville Pond\110% Design Package Pond 1982 & 1964 Closure\Final Drawings\Site Aerial.dwg

LEGEND

— — — —	ASH BASIN LIMITS (APPROXIMATE)
—-—-—-—-—	PROPERTY LINE
————————	MSD SEWER LINE

NOTES

1. ASH REMOVAL IS CURRENTLY BEING PERFORMED FOR THE 1982 BASIN. SUFFICIENT STORM CAPACITY IS PROVIDED THROUGH THE AVAILABLE STORAGE IN THE BASIN.
2. DURING ASH REMOVAL IN THE 1982 ASH BASIN, TWO WET AREAS HAVE BEEN IDENTIFIED. FLOW FROM THESE WET AREAS WILL BE CONTAINED IN UNDERDRAINS OR DITCHES AS SHOWN ON THE FOLLOWING DRAWINGS.
3. EXISTING TOPOGRAPHY INSIDE LIMITS OF ASH EXCAVATION PROVIDED BY McKIM & CREED DATED 10/30/2015. OUTSIDE THIS BOUNDARY EXISTING TOPOGRAPHY PROVIDED BY DUKE ENERGY AND WSP FROM AERIAL PHOTGRAPHY DATED 4/17/2014 AND 7/24/2015.

SEAL 041903
LUKE C. WILLIAMS
6/16/16

PERMIT SUBMITTAL

PRELIMINARY
NOT FOR CONSTRUCTION

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
1	16	06	16	ISSUED FOR PERMIT/ADDITION OF BENCHMARKS	MEW	LCW
0	14	01	16	ISSUED FOR PERMIT	MDB	LCW

CLIENT LOGO:

CLIENT:

DUKE ENERGY PROGRESS, LLC
BUNCOMBE COUNTY, NORTH CAROLINA

Amec Foster Wheeler Environment & Infrastructure, Inc.
2801 YORKMONT ROAD, SUITE 100
CHARLOTTE, NC 28208
TEL: (704) 357-8600 FAX: (704) 357-8638
LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM: NAVD 88
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: LCW
SCALE: AS NOTED

PROJECT: DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE: EXISTING CONDITIONS / UTILITIES

PROJECT NO.: 7810150250
REVISION NO. 01
DATE: 06-16-2016
DRAWING NO. C-1.2

Plotted By: Watkins, Miles E Sheet Set:N/A Layout:EXISTING CONDITIONS - UTILITIES June 16, 2016 04:15:59pm P:\CADD\Projects\7810\7810150250 Asheville Pond\110% Design Package Pond 1982 & 1964 Closure\Final Drawings\Exist Conditions - Utilities.dwg

LEGEND

▬	LIMITS OF ASH EXCAVATION (APPROXIMATE)
—	EXISTING CONTOURS 2' INT.
—	EXISTING CONTOURS 10' INT.
- - -	ASH EXCAVATION CONTOURS 2' INT.
— — —	ASH EXCAVATION CONTOURS 10' INT.

NOTES

1. PROPOSED CONTOURS WERE DEVELOPED FROM AVAILABLE TOPOGRAPHIC INFORMATION BEFORE THE ASH BASINS WERE CONSTRUCTED AND REVISED BASED ON GEOTECHNICAL DRILLING DATA.
2. EXISTING TOPOGRAPHY INSIDE LIMITS OF ASH EXCAVATION PROVIDED BY McKIM & CREED DATED 10/30/2015. OUTSIDE THIS BOUNDARY EXISTING TOPOGRAPHY PROVIDED BY DUKE ENERGY AND WSP FROM AERIAL PHOTGRAPHY DATED 4/17/2014 AND 7/24/2015.
3. DURING ASH REMOVAL IN THE ASH BASIN, 2 WET AREAS HAVE BEEN IDENTIFIED. FLOW FROM THESE WET AREAS WILL BE CONTAINED IN UNDERDRAINS OR DITCHES AS SHOWN ON THE FOLLOWING DRAWINGS.

LUKE C. WILLIAMS
041903

Plotted By: Watkins, Miles E Sheet Set: N/A Layout: POST ASH REMOVAL GRADES June 16, 2016 04:16:31pm P:\CADD\Projects\7810\7810150250 Asheville Pond\110% Design Package Pond 1982 & 1964 Closure\Final Drawings\Post Ash Removal.dwg

PRELIMINARY
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REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
0	14	01	16	ISSUED FOR PERMIT	MDB	LCW

CLIENT LOGO:

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LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM: NAVD 88
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: LCW
SCALE: AS NOTED

PROJECT:
DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE:
POST ASH REMOVAL GRADES

PROJECT NO.: 7810150250
REVISION NO.: NA
DATE: 01-14-2016
DRAWING NO.: C-1.3

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Oct 30 2019

LEGEND

- ASH BASIN LIMITS (APPROXIMATE)
- EXISTING CONTOURS 2' INT.
- EXISTING CONTOURS 10' INT.
- ASH EXCAVATION CONTOURS 2' INT.
- ASH EXCAVATION CONTOURS 10' INT.
- PROPOSED UNDERDRAIN
- PROPOSED STORMWATER CHANNELS
- LIMITS OF ASH EXCAVATION (APPROXIMATE)

ASHEVILLE CONTROL POINTS

#	NORTHING	EASTING	ELEV.	DESC.
103	643,472.89	944,733.49	2,166.34	REBAR
105	642,914.75	944,765.60	2,164.94	REBAR

SEAL 041903
ENGINEER
LUKE C. WILLIAMS
6/16/16

PERMIT SUBMITTAL

Plotted By: Watkins, Miles E Sheet Set: N/A Layout: Final Grades June 16, 2016 04:17:01pm P:\CADD\Projects\7810\7810150250 Asheville Pond\110% Design Package Pond 1982 & 1964 Closure\Final Drawings\Plan View Basin 1982 Final Grade.dwg

PRELIMINARY
NOT FOR CONSTRUCTION

0	14	01	16	ISSUED FOR PERMIT	MDB	LCW
REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.

CLIENT LOGO:

CLIENT:
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BUNCOMBE COUNTY, NORTH CAROLINA

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LICENSURE: NC ENG: F-1253 NC GEOLOGY: C-247

DATUM: NAVD 88
PROJECTION: STATE PLANE 83
DRAWN BY: APT
REVIEWED BY: LCW
SCALE: AS NOTED

PROJECT: DECOMMISSIONING AND ASH REMOVAL PLAN
1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE: FINAL GRADES

PROJECT NO.: 7810150250
REVISION NO. NA
DATE: 01-14-2016
DRAWING NO. C-1.4

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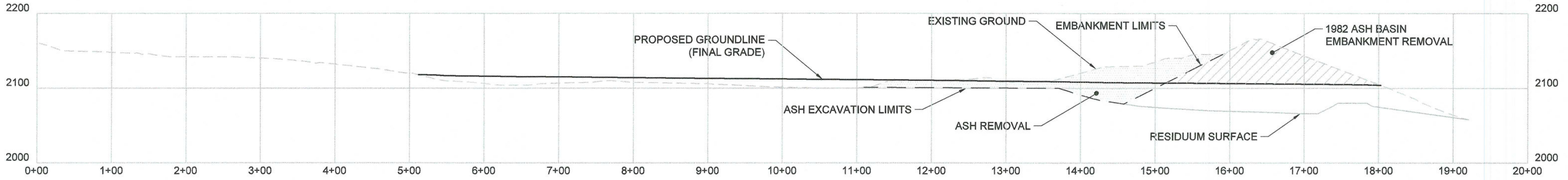
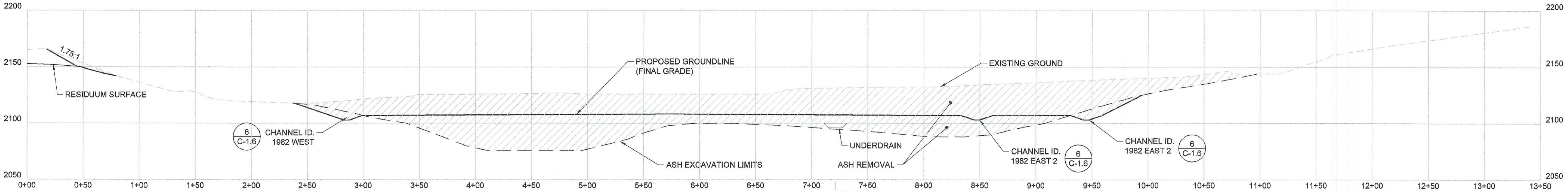
Oct 30 2019

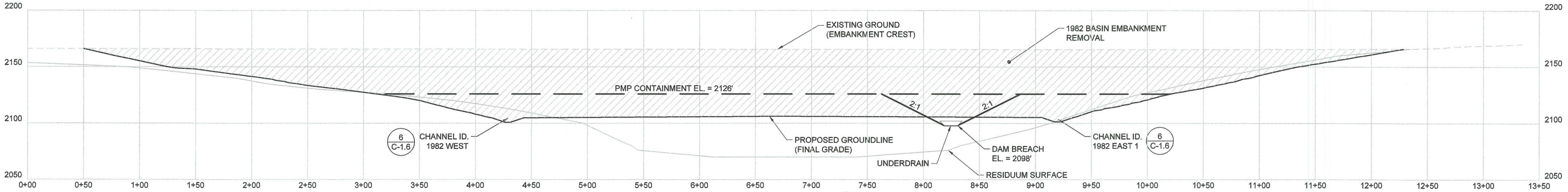
Plotted By: Watkins, Miles E Sheet Set: N/A Layout: PROFILES June 16, 2016 04:17:15pm P:\CADD\Projects\7810\7810150250 Asheville Pond\10% Design Package Pond 1982 & 1964 Closure\Final Drawings\PROFILES & DETAILS.dwg



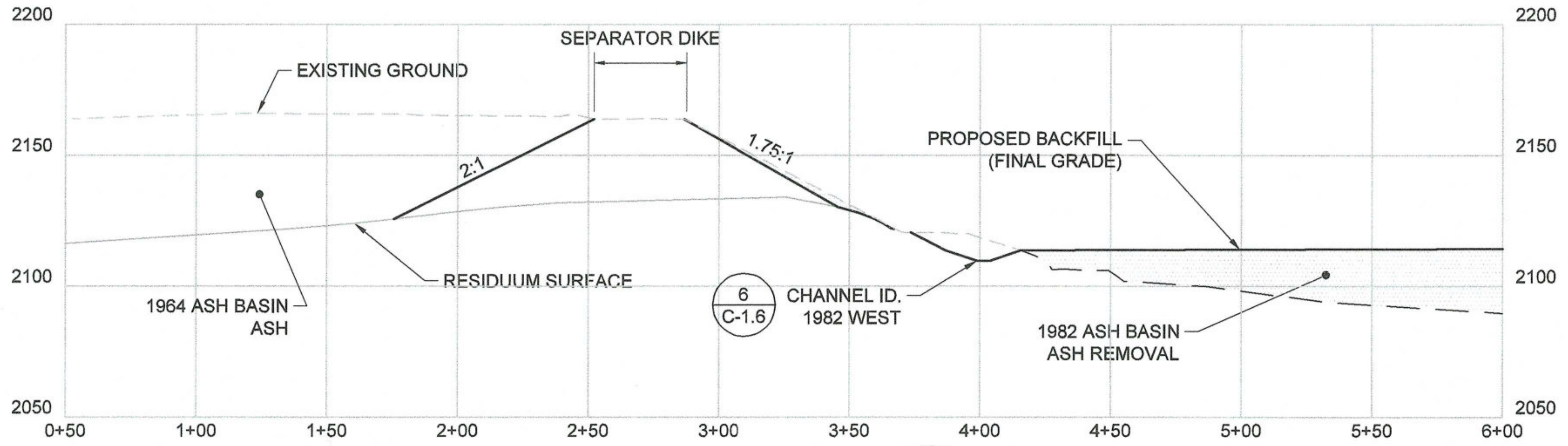
PROFILE 1
-



SECTION 2
-



SECTION 3
-



SECTION 4
-

LUKE C. WILLIAMS
SEAL 041903
6/16/16

PERMIT SUBMITTAL

PRELIMINARY
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1982 ASH BASIN
ASHEVILLE STEAM ELECTRIC GENERATING PLANT
BUNCOMBE COUNTY, NORTH CAROLINA

TITLE:
PROFILES

PROJECT NO.: 7810150250
REVISION NO. NA
DATE: 01-14-2016
DRAWING NO. C-1.5