EXECUTIVE SUMMARY

ES.1 Source Information

Duke Energy Progress, LLC (Duke Energy) owns and operates the Roxboro Steam Electric Plant (the Roxboro Plant, Plant or Site), located in Person County, near Semora, North Carolina. The Comprehensive Site Assessment (CSA) update was conducted to refine and expand the understanding of subsurface conditions and evaluate the extent of impacts from historical management of coal ash. This CSA update contains an assessment of site conditions based on a comprehensive interpretation of geologic and sampling results from the initial site assessment and geologic and sampling results obtained subsequent to the initial assessment.

The Roxboro Plant began operations in 1966 and continues to operate. Coal combustion residuals (CCRs) have historically been managed at the Plant's two on-site ash basins (surface impoundments): the East Ash Pond/Basin (EAB), which was constructed in 1964, and the West Ash Basin (WAB), which was constructed in 1973. Both ash basins are located within natural drainage basins impounded by earthen dams. CCRs were deposited in the EAB by hydraulic sluicing operations until the Plant was modified for dry fly ash (DFA) handling in the 1980s. An industrial landfill, permitted by the North Carolina Department of Environment Quality (NCDEQ)[1] Division of Waste Management (DWM) Permit 7302, was constructed partially in the waste boundary of the EAB for the placement of the DFA. The construction of the landfill isolated a section of the EAB, now called the EAB extension impoundment, where minor amounts of CCR material remain. The initial industrial landfill unit was unlined with lined phases constructed over portions of the unlined area in the EAB beginning in 2002. The WAB was modified in 1986 for additional storage capacity, including the installation of a filter dike that separated the southern end of the basin, now called the WAB extension impoundment, where minor amounts of CCR material are present. The WAB still receives bottom ash by hydraulic sluicing methods. CCR at the facility is managed:

- as DFA within the lined portion of the landfill constructed on the EAB,
- by hydraulically sluicing bottom ash to the WAB, or
- by transporting offsite for beneficial reuse.

A discharge canal constructed during the WAB modification receives waste streams from various on-site sources including: WAB effluent from bottom ash sluicing; EAB

[1] Prior to September 18, 2015, the NCDEQ was referred to as the North Carolina Department of Environment and Natural Resources (NCDENR). Both naming conventions are used in this report, as appropriate.

landfill leachate and drainage; storm water runoff from the two ash basins; discharge from the Flue Gas Desulfurization (FGD) Pond treatment process; cooling tower blowdown; domestic sewage treatment plant discharge; and surface water flow from the extension impoundment. Effluent from the WAB discharge canal passes through National Pollution Discharge Elimination System (NPDES) Internal Outfall 002 into the heated water discharge pond, which ultimately flows into Hyco Lake through NPDES Outfall 003 under Permit NC0003425. The EAB discharge canal is isolated from the EAB by the landfill and receives only surface water flow from the EAB extension impoundment, which discharges to the cooling water intake canal. NCDEQ is considering the applicable mechanism to provide coverage for this area in the renewed NPDES permit.

Assessment results indicate the thickness of CCR in the EAB is approximately 55 to 80 feet and in the WAB is approximately 80 feet with residual CCR present in the basin extension impoundments and the basin effluent discharge canals. Assessment findings determined that the CCRs that have accumulated in the ash basins are the primary source of impact to groundwater. The inferred general extent of constituent migration from the ash basins based on evaluation of constituent concentrations greater than both groundwater quality standards and background is shown on **Figure ES-1**. A detailed evaluation of constituent migration is included in the CSA update report.

ES.2 Initial Abatement and Emergency Response

Duke Energy Progress has not conducted emergency responses because groundwater impacts from the ash basins do not present an imminent hazard to public health or the environment that would require emergency action. No abatement or source removal activities have been conducted at the Roxboro Plant related to the ash basins other than converting from a wet to dry fly ash handling system in 1986. In preparation for closure of the ash basins, new retention basins and wastewater treatment systems are being designed and constructed.

ES.3 Receptor Information

In accordance with NCDEQ direction, CSA receptor survey activities include listing and depicting all water supply wells (both public and private, including irrigation wells and unused wells) within a 0.5-mile radius of the ash basin compliance boundary.

ES.3.1 Public Water Supply Wells

Three public supply wells are located within 0.5-mile radius of the ash basin compliance boundary – one is located at a building materials manufacturing facility (northeast of the plant cooling water intake canal) and the other two are located at Woodland Elementary School on Semora Road (southwest of the plant property). The building materials facility well is located approximately 2,500 feet northeast of the EAB beyond the cooling water intake canal. The Woodland Elementary School wells are located approximately 2,000 feet southwest of the WAB discharge canal, topographically and hydraulically upgradient of the WAB compliance boundary. Analytical data provided for the public water supply wells indicate constituent concentrations consistent with statistically determined background concentrations. Geochemistry data for the public water supply wells (cation/anion distribution) support no CCR impact.

ES.3.2 Private Water Supply Wells

No private supply wells are located within 0.5 mile downgradient of the ash basin compliance boundary. Approximately 102 reported or observed private water supply wells are located within a 0.5-mile radius of the compliance boundary upgradient of the ash basins, mostly along McGhees Mill Road, The Johnson Lane, Dunnaway Road, Archie Clayton Road, Daisy Thompson Road, and Semora Road. Particle track modeling indicates that well capture zones are limited to the immediate vicinity of the well head and do not extend toward the ash basins. None of the particle tracks originating in the ash basins have moved into the well capture zones. Available analytical data for the private water supply wells show detected concentrations below statistically derived background concentrations and geochemistry (cation/anion distribution) are not attributable to CCR impacts.

ES.3.3 Surface Water Bodies

Groundwater influenced by the ash basins flows toward various internal plant water features (the heated water discharge pond, the cooling tower pond, cooling tower intake pond, the water intake basin and the cooling water intake canal). Hyco Lake is beyond the plant water features. The surface water classification for Hyco Lake is Class B and WS-V waters (protected as a water supply that is upstream and draining to WS-IV or water used for drinking water supply purposes).

ES.3.4 Human and Ecological Receptors

A baseline human health and ecological risk assessment was performed in 2016 as a component of CAP Part 2 (SynTerra, 2016a) concluding no unacceptable risks to humans resulting from hypothetical exposure to constituents detected in the ash basins.

Based on review and analysis of groundwater and surface water data collected since completing the human health and ecological risk assessment in 2016, there is no evidence of potential risks to humans and wildlife at the Roxboro Site.

This update to the human health and ecological risk assessment supports a risk classification of "Low" for both basins.

ES.3.5 Land Use

The Site is bordered by industrial (a building materials manufacturing facility), agricultural (pasture), rural residential (R), wooded land and Hyco Lake. No change in surrounding land use is currently anticipated.

ES.4 Sampling / Investigation Results

The comprehensive site assessment included evaluations of the hydrogeological and geochemical properties of soil and groundwater at multiple depths and distances from the ash basins.

ES.4.1 Background Concentration Determinations

Naturally occurring background concentrations were determined using statistical analysis for both soil and groundwater. Statistical determinations of proposed provisional background threshold values (PBTVs) were performed in strict accordance with the revised *Statistical Methods for Developing Reference Background Concentrations for Groundwater and Soil at Coal Ash Facilities* (statistical methods document) (HDR and SynTerra, 2017). The background monitoring well (MW) network consists of wells installed within two hydrostratigraphic flow zones – transition zone and fractured bedrock. Background datasets used to statistically determine naturally occurring concentrations of inorganic constituents in soil and groundwater are provided herein. As of September 1, 2017, DEQ approved a number of the statistically derived background values, however others are still under evaluation and thus considered preliminary at this time. Background results may be greater than the PBTVs due to the limited valid dataset currently available. The statistically derived background threshold values will continue to be adjusted as additional data becomes available.

ES.4.2 Nature and Extent of Contamination

Site-specific groundwater constituents of interest (COIs) were developed by evaluating groundwater sampling results with respect to NCDEQ Title 15A Subchapter 02L.0200 Groundwater Classification and Standards (2L), Interim Maximum Allowable Concentrations (IMACs), PBTVs, and additional regulatory input/requirements. The distribution of constituents in relation to the ash management areas, co-occurrence with CCR indicator constituents such as boron and sulfate, and migration directions based on groundwater flow direction are considered in determination of groundwater COIs.

The following list of groundwater COIs has been developed for Roxboro:

Antimony	pH
Boron	Selenium
Chromium (Hexavalent)	Strontium
Chromium (Total)	Sulfate
Cobalt	Total Dissolved Solids (TDS)
Iron	Uranium
Manganese	Vanadium
Molybdenum	

At Roxboro, boron, sulfate and TDS are key indicators of CCR impacts in groundwater and are detected at concentrations greater than the 2L values downgradient of the ash basins. The CCR distribution in groundwater at concentrations greater than 2L is depicted in **Figure ES-1**.

<u>West Ash Basin</u> – Boron, sulfate and TDS are detected greater than the 2L values in bedrock monitoring wells underlying the WAB and in downgradient transition zone wells. Boron was not detected above background levels in the downgradient bedrock wells; however, sulfate and TDS were detected above 2L values in one downgradient bedrock well. The heated water discharge pond lies immediately adjacent to the WAB downgradient monitoring wells. CCR constituents are generally not detected in groundwater upgradient of the WAB, effluent discharge canal and the extension impoundment with the exception of two wells screened in deep bedrock fractures southwest of the ash basin. Assessment of the area further to the southwest and upgradient of this area in similar deep fracture zones indicates background conditions.

<u>East Ash Basin</u> – CCR constituents including boron, sulfate and TDS are detected above 2L in the bedrock monitoring wells underlying the EAB and in several downgradient saprolite/transition zone and bedrock monitoring wells, including wells downgradient and proximal to the gypsum storage area adjacent to the cooling water intake canal. No CCR constituents are detected upgradient of the EAB, effluent discharge canal and the extension impoundment.

ES.4.3 Maximum Contaminant Concentrations (Source Information)

The source areas at Roxboro include CCR material and pore water accumulated in the West Ash Basin and the East Ash Basin. Ash pore water samples collected from wells installed within the ash basins and screened in the ash layers have been monitored since 2015. The concentrations of detected constituents have been relatively stable with minor fluctuations. The ash basins are permitted wastewater systems; therefore comparison of pore water within the wastewater treatment residuals (ash) to 2B or 2L/IMAC is not required.

Soil samples collected below the ash/soil interface from seven locations within the ash basins indicate chromium, cobalt, iron, manganese and vanadium were detected greater than their respective PBTV and Preliminary Soil Remediation Goals (PSRG) Protection of Groundwater (POG) values.

ES.4.4 Site Geology and Hydrogeology

The subsurface at the Site is composed of regolith/saprolite, a transition zone and bedrock. The regolith/saprolite includes residual soils, fill and reworked soils, and alluvium. The transition zone is comprised of partially weathered rock that is gradational between saprolite and competent bedrock. The crystalline bedrock consists of gneiss or granitic gneiss/granite. Shallow bedrock is fractured; however, only mildly productive fractures (providing water to wells) were observed within the top 50 feet of competent rock.

Groundwater exists under unconfined or water table conditions throughout the Site. For the most part, saturated conditions are limited to secondary fractures within the underlying bedrock. Saturated conditions in residual soil (saprolite) and partially weathered rock are limited across the site and present in close lateral proximity to surface water features including the ash basins, Hyco Lake and, to a lesser degree, streams. The regolith/saprolite/transition zone, where it is saturated, acts as a reservoir for supplying groundwater to the secondary fractures in the bedrock.

Localized groundwater high elevations are centered around the ash basins, with radial flow in these areas. Recharge areas at the Site are located to the east and south. Each stream valley in which the ash basins were constructed is a distinct slope-aquifer system in which flow of groundwater into and out of the ash basins is restricted to the local flow regime. Groundwater and surface water from the ash basins flow north and west toward the Plant water features (heated water discharge pond, cooling tower intake pond and the cooling water intake canal).

ES.5 Conclusions and Recommendations

The investigation described in the CSA presents the results of the assessments required by the Coal Ash Management Act (CAMA) and 2L. Based on the data, a limited area of groundwater contamination is attributed to the CCR within the two ash basins. In the ash basin locations where soil samples were collected, analytical results indicate a few, limited detections of COIs greater than background and the PSRG POG values. The management of gypsum may be an additional, non-CAMA related source of risk to groundwater and surface water. The assessment investigated the Site hydrogeology, determined the direction of groundwater flow from the ash basins, and determined the horizontal and vertical extent of impacts to groundwater and soil sufficient to proceed with preparation of a CAP.

Assessment results indicate groundwater impacts from ash basin CCR material pore water seepage is limited to beneath the ash basins, downgradient in areas between the ash basins and internal plant water features (the heated water discharge pond, the cooling tower pond, cooling tower intake pond and the cooling water intake canal) and a limited area southwest of the WAB. The comprehensive evaluation of groundwater flow characteristics demonstrates that groundwater flow is to the north and west toward the internal plant water features away from the topographically higher areas, south and east, where the water supply wells are located.

Roxboro Plant's ash basins are currently designated as "Intermediate" risk under CAMA, meaning that closure of the ash basins is required by 2024. The updated evaluation of risks has determined no changes from the previous risk assessment conclusion of no imminent risk to human health or the environment due to groundwater, surface water, or sediment impacts attributable to groundwater migration from the ash basins. Water supply wells located within a 0.5-mile radius of the Roxboro ash basins compliance boundary are not impacted by the ash basins. This conclusion is supported by the detailed characterization of groundwater chemistry including evaluation of CCR indicators and correlation evaluations. The results of the chemical correlation analyses indicate that, based on the different constituent clustering patterns from the ash basin pore water wells and the water supply wells, the source water for the water supply wells is not CCR-impacted groundwater. A pore water evaluation of the private and public water supply well data and the detailed statistical analysis of regional background groundwater data indicate that constituent concentrations in the water supply wells are generally consistent with background conditions. A "Low" risk classification and closure via a cap-in-place scenario is considered viable.

A preliminary evaluation of groundwater corrective action alternatives is included in this CSA to provide insight into the Corrective Action Plan (CAP) preparation process. For Roxboro, the primary source control (closure) methods anticipated to be evaluated in the CAP are:

Dewater the ash within the basins and cap the residuals with a low permeability engineered cover system to minimize infiltration;

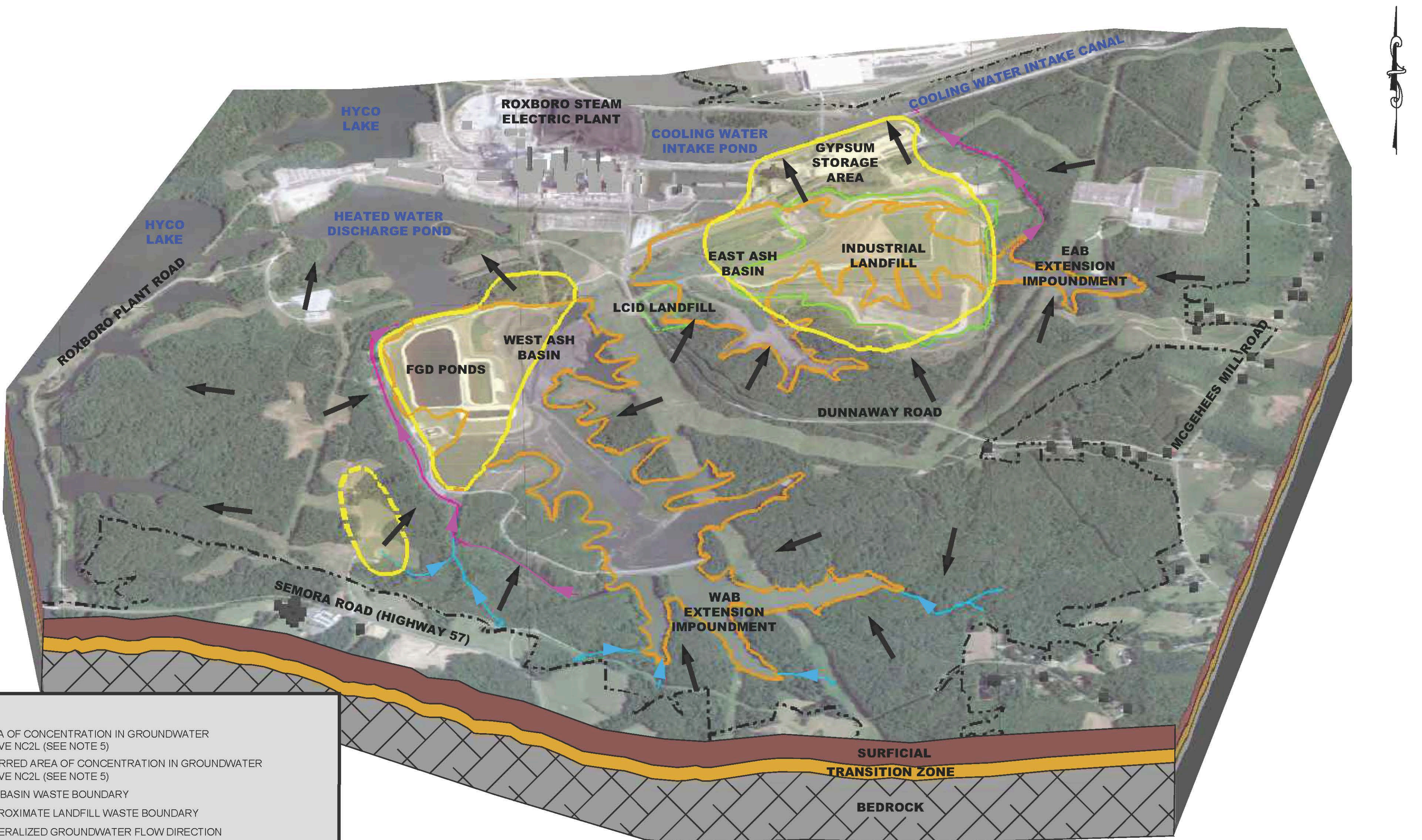
Excavate the ash to remove the source of the COIs from the groundwater flow system; and

Potentially some combination of the above.

The source control (closure) options will be evaluated in the CAP to determine the most technically and economically feasible means of removing or controlling the ash and ash pore water as a source to the groundwater flow system. The evaluation will include predictive groundwater modeling to evaluate the cost-benefit associated with various options.

For basin closure, ash dewatering and reduction of the amount of water migrating from the basins to groundwater will have the greatest positive impact on groundwater and surface water quality downgradient of the ash basins based on preliminary fate and transport and geochemical modeling results. A well-designed capping system can be expected to minimize ongoing migration to groundwater after dewatering.

In addition to source control measures, the CAP will evaluate measures to address groundwater conditions associated with the ash basins. Groundwater corrective action by monitored natural attenuation (MNA) is anticipated to be a remedy further evaluated in the CAP. As warranted, a number of other viable groundwater remediation technologies such as phytoremediation, groundwater extraction, or hydraulic barriers may be evaluated based upon short-term and long-term effectiveness, implementability, and cost. Results of the evaluation, including groundwater fate and transport modeling, and geochemical modeling, will be used for remedy selection in the CAP.



LEGEND

- AREA OF CONCENTRATION IN GROUNDWATER ABOVE NC2L (SEE NOTE 5)
- INFERRED AREA OF CONCENTRATION IN GROUNDWATER ABOVE NC2L (SEE NOTE 5)
- ASH BASIN WASTE BOUNDARY
- APPROXIMATE LANDFILL WASTE BOUNDARY
- GENERALIZED GROUNDWATER FLOW DIRECTION
- RESIDENTIAL UNIT
- DESIGNATED EFFLUENT CHANNEL WITH FLOW DIRECTION
- STREAM WITH FLOW DIRECTION
- DUKE ENERGY PROPERTY BOUNDARY

NOTE:

1. OCTOBER, 2016 AERIAL PHOTOGRAPHY OBTAINED FROM GOOGLE EARTH PRO ON SEPTEMBER 27, 2017, DATED JUNE 13, 2016.
2. STREAM FROM WSP SURVEY, 2014.
3. GENERALIZED GROUNDWATER FLOW DIRECTION BASED ON APRIL 10, 2017 WATER LEVEL DATA.
4. PROPERTY BOUNDARY PROVIDED BY DUKE ENERGY.
5. GENERALIZED AREAL EXTENT OF MIGRATION REPRESENTED BY NCAC 02L EXCEEDANCES OF BORON, SULFATE, OR TOTAL DISSOLVED SOLIDS (TDS).

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DRAWN BY: ADAM FEIGL DATE: 10/09/2017
PROJECT MANAGER: CRAIG EADY
LAYOUT: ES1 - ROX

FIGURE ES-1
APPROXIMATE EXTENT OF IMPACTS
ROXBORO STEAM ELECTRIC PLANT
DUKE ENERGY PROGRESS, LLC
SEMORA, NORTH CAROLINA